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A PERFORMANCE AND FUNCTIONAL ANALYSIS TOOL FOR TESTING AND MAINTENANCE OF WEB-BASED APPLICATION FROM THE USER PERSPECTIVE

ALPER ASLAN

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Submitted by **Alper ASLAN**

Approval of the Graduate School of Natural and Applied Sciences, Çankaya University

Prof. Dr. Taner ALTUNOK
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Assist. Prof. Dr. Murat SARAN
Acting Head of Department

This is to certify that we have read this thesis and that in our opinion; it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

Assist. Prof. Dr. Murat SARAN
Supervisor

Examination Date : 07.01.2014

Examining Committee Members

Assist. Prof. Dr. Sadık EŞMELİOĞLU	(Çankaya Univ.)	
Assist. Prof. Dr. Erol ÖZÇELİK	(Atılım Üniv.)	
Assist. Prof. Dr. Murat SARAN	(Çankaya Univ.)	

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Name, Last Name : Alper ASLAN

Signature :

Date : 07.01.2014

ABSTRACT

A PERFORMANCE AND FUNCTIONAL ANALYSIS TOOL FOR TESTING AND MAINTENANCE OF WEB-BASED APPLICATION FROM THE USER PERSPECTIVE

ASLAN, Alper
M.Sc., the Department of Computer Engineering
Supervisor : Dr. Murat SARAN

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This thesis focuses on the performance stability score (PSS) of the Web-Based Application Workflow (WBAW) and gathers the automated virtual user response times, repeated with scheduled periods, to calculate the best successful response interval heuristically. The lack of server-side hardware, network and application resources can affect the end-user Internet browsing experience negatively. This kind of negative effects can be monitored only on the end-user web browser. The virtual user browser scripts can be used to monitor the problems. The name of the application, developed, is called “MyToolset”. It is designed and implemented by using the open source technologies. The research on this subject aims to monitor the performance degradation and failures on WBAW weekly, raise appropriate alerts and calculate the performance stability score. Furthermore, MyToolset reports the WBAW failures by taking the snapshot of the end-user browser perspective as evidence. The entire mathematical model is based on the calculation of this idea. Live graphics and comparable charts are used to report the results. After custom consecutive performance degradations and failures occur, MyToolset will raise the alerts. The thesis concludes that the

WBAW and PSS is used for monitoring, test automation and helping the capacity planning of server-side resources, WBAW works on, such as hardware, network and applications.

Keywords: Virtual User Simulation, Web Base Application Performance Score, Web Browser Simulation, and Real-time Statistical Performance Interval Calculation.

ÖZ

WEB TABANLI UYGULAMALARIN SANAL KULLANICI SIMÜLASYONU YARDIMIYLA BAKIM VE TEST AMAÇLI PERFORMANS VE FONKSIYONEL ANALIZ ARACI

ASLAN, Alper

Yüksek Lisans, Bilgisayar Mühendisliği Anabilim Dalı
Tez Yöneticisi : Yrd. Doç. Dr. Murat SARAN

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Bu tez, Web Tabanlı bir Uygulama İş Akışının (WTUİA) belli periyotlarla sanal kullanıcıya olan cevaplama sürelerine bakarak en iyi performans aralığını hesaplamayı ve performans stabilite skorunu bulmayı amaç edinmiştir. Geliştirilen uygulamanın adı “MyToolset” tir. MyToolset, sanal kullanıcı simulasyonunu kullanarak web sayfalarındaki süreç ve akışları izler. Olası sunucu donanım, yazılım, ağ ve uygulama tabanındaki hataların son kullanıcıya olan performans ve negatif etkilerini takip etmekte kullanılır. MyToolset, açık kaynak kodlu (Apache HTTP server, Tomcat server, struts library vb.) ve ticari teknolojiler (örneğin; Imacros Enterprise edition vb.) kullanılarak geliştirilmiş bir yazılımdır. Bu çalışma ile amaçlanan, bir hafta boyunca Web Tabanlı bir Uygulama İş Akışının kaç kez performans problemi yaşadığını ortalama

yanıtlama sürelerini de kullanarak matematiksel modeller ile hesaplayıp takip etmektir. Tüm raporlamalar, gerçek zamanlı grafik ve şemalarla desteklenmiştir. Performans stabilite skoru (PSS), uç kullanıcı simülatörü sonuçları kullanılarak hesaplanır. Bu çalışma sonunda özetle, Web Tabanlı bir Uygulama İş Akışların izlenmesi ve performans stabilite skoru hesabı; sistem monitörü, test otomasyonu ve kapasite planlanması için kullanılabilecek matematiksel bir yöntem önerilmektedir.

Anahtar Sözcükler: Performans Stabilite Skor, Web Tabanlı Uygulama Performansı, Sanal Tarayıcı Simülasyonu, İstatistiğe Dayalı Performans Hesaplaması.

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CHAPTER 1

INTRODUCTION

This section introduces the aim and significance of the study and implementation of the system called “MyToolset”.

1. Aim of the study

The aim of the study is to find the performance anomalies and failures on web-based applications from the user perspective by using a software system. This study uses the response times of each test activity and the Performance Stability Score (PSS) values (as explained in the “Mathematical Model and Algorithms” section) to observe automated end-user experience test results. This will allow the system administrators to find the performance anomalies and failures in the server resources so that they can solve the problems. The performance and failures of Web-Based Application depends on these resources (such as hardware, network, and applications). Employing a software system that tests each part of the Web Application can allow us to test these resources. For example, user login is one part of the e-commerce web applications. If we cannot login to the system during the test, this means that there is a problem in any of the server resources. Our software system captures the browser session and stores it in the file system as evidence. System administrators can examine this evidence and find the solutions accordingly.

2. Significance of the study

Web-Based Applications (WBA) are getting more and more important in our everyday lives, especially in e-commerce, e-banking, knowledge management, social networks, etc. We are using those Web-Based Applications not only one time but also very many times at every day. Lots of people are using Web-Based Applications at different age and at various skill levels. Web-Based Applications have the ability of serving web applications to the many people simultaneously. The markets on those Web-Based Applications and their alternatives are growing day by day. The end-user expects the services with the best Web-Based

Application performance, and without interruption and error. Thus, the business continuity on Web-Based Applications is getting more and more important for company managements and market shares nowadays. According to [1], the Internet User Percentage increases around 8% almost every year, and the Internet coverage on whole world is 34%. Table 1 shows the results of the study conducted by Kleiner, Perkins, Caufield, Byers (KPCB) research [1].

Table 1 KPCB Internet Usage Trend (2.4B Internet Users on Global Markets)

Rank	**Country**	**2008 – 2012 Internet User Additions (MMs)**	**2012 Internet Users (MMs)**	**Y/Y Growth** %	**Population Penetration** %
1	China	264	564	10	42
2	India	88	137	26	11
3	Indonesia	39	55	58	23
4	Iran	35	42	205	55
5	Russia	33	70	6	49
6	Nigeria	31	48	15	30
7	Philippines	28	34	32	25
8	Brazil	27	88	6	45
9	Mexico	19	42	9	37
10	USA	18	244	3	78
11	Argentina	17	28	57	68
12	Egypt	17	30	11	38
13	Colombia	14	25	39	54
14	Turkey	13	35	17	47
15	Vietnam	12	31	7	35
16	Top 15	654	1473	15	34
17	World	902	2406	8	34

The new hardware and software technologies are very sophisticated. They allow the engineers to design and implement faster and more reliable systems. If any

performance degradation occurs, then the end-users can choose another Web-Based Application hosting provider easily because there are very many different alternatives. The system administrators and the application solution engineers understand that Web-Based Applications should have performance or execution problems at minimum rate [2]. So they should monitor and they need to be warned immediately when the temporary or permanent performance and execution problems occur in Web-Based Applications. The Website failure causes and its percentages are listed on Appendix: Causes of Failures [3].

Web-Based Applications have some types; Flash based, Silver light based, HTML and JavaScript based. Although the examples in this thesis are on HTML Based Web-Based Applications, the calculations of the performance stability score are the same with the other types of Web-Based Application. Web-Based Application consists of some components such as; Web Browsers (WB), Web Servers (WS), Web Application Servers (WAS) and Database Management System (DBMS) [2]. Web Browser translates and runs the end-user client view of the Web-Based Application. The client views use some client-side technologies such as HTML, JavaScript, CSS, etc. The server-side components of the Web-Based Application are hosted on web application servers. Some of the widely used technologies are Java EE, Ruby on Rails, PHP, Perl, Python, and the ASP.Net. The Web-Based Application (WBA) is retrieving the necessary data from the Database Management System. Connection pools or some data service layers control the connection between the server-side application and DBMS. These components' performances depend on the hardware, software, system, and software design and programming skills. The requested data is sent back to the end-user's Web Browser from the server-side application components, running on the container of Web Servers, and Web Application Servers over Hypertext Transfer Protocol (HTTP). Hypertext Transfer Protocol is the common language of the modern global Internet. The Web-Based Application uses Hypertext Transfer Protocol to communicate with each other [4]. The Web Application Server has container, which runs the associated server-side application, fetches the relevant data from database management system and creates the response HTML or the data. Web Browser renders the appropriate response screen and the resultant web page will be displayed by the end-user Web Browser. Web-Based Application Workflow (WBAW) can respond to the excessive amount of simultaneous requests. This will cause the possible

resource limitations to respond to these requests. This is the interaction of each component on the Web-Based Application.

Performance Stability Score allows us to monitor the performance degradations and failures more intelligently and more easily. The Performance Stability Score also gives us the strong inputs for the capacity planning of server-side resources, and the faults on the old and new deployments of Web-Based Application. Performance Degradation is monitored and calculated by using the real time performance intervals. The real-time response times of the servers with respect to the end-user Internet browser requests are used to calculate the performance intervals. The system user can also give the boundary values of the performance intervals manually. If any Performance Stability Score is bigger than the maximum boundary value or it is less than the minimum boundary value, then the system will warn the authorized personnel by raising the alerts. In addition, the solution warns the responsible person when the Web-Based Application Workflow crashes and has no response to the end-users too. It is important to take note that Performance Stability Score is the live monitoring score of Web-Based Application Workflow from the virtual end-user perspective. The implemented solution that runs the macro data script, collects the response time values, calculates the Performance Stability Score, and raises alerts is called as “MyToolset”. Web-Based Application Workflow Performance depends on the load on the server for some periods. For example; end-users prefer to use Web-Based Application Workflow mostly on weekends. Mostly at night times, the Web-Based Application Workflow will not be used, and the system load is low, then the response times will be faster during the night hours. So the performance interval should be accuretely calculated in real time by the solution.

MyToolset is monitoring real-time performance and Web-Based Application failures. It is using end-to-end synthetic user transactions and automated end user experiences. MyToolset is supporting not only single site but also the multiple site of multiple workflow of the Web-Based Application. There are some similarities between this study and the study conducted by Dalal, S. *et al.* [13]. In their study, they analyze the response of each request of synthetic users similar to this study. In the present study, a mathematical model has been developed to calculate the real-time performance stability score of Web-Based Application by using some measurements as explained in the “Mathematical Model and Algorithms” section. Performance Stability Score can include failure response

time values or only successful performance response time values separately. This thesis includes the results of the experiments conducted with the synthetic (virtual) users on STM web site. In [14], web performance has been monitored in different geographical regions, and in different time intervals. On the other hand, MyToolset analyzes the web performance only in different time intervals, and it will be a future work to include different geographical regions to web performance analyzing process.

Although MyToolset is not directly focusing on the web services especially publishing streaming data, it can search the keywords on text streams to analyze the system failures and performances. Some researchers have conducted on these topics especially on binary and text stream data [15]. There are studies employing monitoring tools that are developed in the system, end-to-end, container, and log-analysis level [16]. In this study, we incorporated an end-to-end monitoring technique. End-to-end level monitoring will attempt to capture end-user actions, while they are accessing the web services. MyToolset is an end-to-end monitoring level solution that simulates the end-users. It gathers the performance data to help IT management staff, and business managers to identify the issues before it affects end-users and ongoing web business operations negatively [16].

There exist some free or licensed web solutions for profiling and performance analyzing, for example, HP Load Runner, GTMetrix, Paessler, Site24x7 and Pingdom. Each of them has some advantages and disadvantages. Table 2 shows the comparison matrix between some existing solutions and MyToolset.

Table 2 Comparison Matrix Between Existing Solutions and MyToolset

Feature	Existing Solutions	MyToolset
Test Automation	No	Yes
Telnet and Ping IP and Ports	Yes	Yes
Real User Browser Simulation	No*	Yes
Scripting Language	No	Yes
Taking Evidence Screenshots	No	Yes
Defining Simple Alert Rule Dependencies	No	Yes
Collecting the Response Time	Yes	Yes
Customizing Waiting Count	No	Yes
Alert by using Email and SMS	Yes	Yes
Scheduling Hundreds of Alert Rules	No	Yes
URL Content Check	Yes	Yes

*HP Load Runner (http://www8.hp.com/us/en/software-solutions/software.html?compURI=1175451) includes real user browser simulation

CHAPTER 2

RELATED LITERATURE

The concepts related to this study are explained in detail as follows;

1. Hyper Text Markup Language

HTML is a markup language to create the platform independent documents. HTML can represents not olnly the text contents but also media, audio, news and scripting languages. It has been used by World Wide Web global information initiatives since 1990 [5]. Performance degradation happens when WB renders the big sized web pages – big sized images, long source codes and some multimedia content, videos, etc. to display the web page.

2. Hypertext Markup Protocol

HTTP is the protocol that works as request and response model. This model contains one request and its related response. Client sends request to the web server and it sends back the response content to the client over a connection with it. The response content consists of status of response, message, error code and body content with respect to the MIME type. MIME types determine the content type of the response. It is working on the network between Web Browser and Web Server, Web Application Server. The client submits a Hypertext Markup Protocol request message to the server over Hypertext Markup Protocol. The communication over HTTP is mostly initiated by the clients and finished by the server responses [6]. The client uses the Uniform Resource Locator (URL) address of the server to identify the server location on the network. Hypertext Markup Protocol is slow when excessive amount of parallel and big sized data transferred over it. Some of the Hypertext Markup Protocol i.e. gzip compression techniques are making the transferred data foot print small and so the transfer over network performance is better.

3. Web Browser

WB is a software application to find and display the web responses. It uses the URL address of the web content and it renders as comprehensible HTML, XML or Javascript responses over HTTP. Each resources such as text, media, audio or script based content are requested one by one over the network. After each requested contents are downloaded, it shows the rendered page on its canvas. Every end-user requests such as clicking buttons, navigate to link, mouse over content etc. on WB can initiate another request and response communication [7]. Web pages are linking with each other by Hyperlink. The Hyperlinks give the end-user to call the other web pages without entering its Uniform Resource Locator by clicking on them. This will allow the end-user to navigate to other related web pages. There are several types of the browsers such as text browsers, graphical browsers and multimedia browsers. The most known web browsers are Internet Explorer, Firefox, AOL, Opera, and Safari [7]. The web page performance is directly related to the web browser retrieving, rendering and displaying performance.

4. Web Server

WS is the software application to serve the static or dynamic content to the World Wide Web (WWW). It can serve content, such as images, files, scripts and configuration files so on. WS hosts these contents on its file system. The dynamic content is produced by the server with respect to the each client requests. In static content, WS serves the same content to the each client. WS serves the contents to clients across the internet or intranet. HTTP communication is used to send the files by the WS and URL is used to locate the WS by the clients. [8]. It serves the contents to very many users simultaneously. Thousands of end-users can submit the requests and wait to retrieve the response contents from Web Server at the same time. The caching and the configuration settings of the Web Server are making web servers slow or fast to serve. Some of the web servers behave likely the application servers. They are running the scripting languages and serve the results of them to end-user Web Browser. This ability gives them serving the dynamic content to the end-user with respect to the data that the clients sent by Web Browser. If heavy request loads from Web Browser occur simultaneously then the web server can possibly cause a single point of failure of performance problems.

5. Web Application Server

WAS is the software application that is interpreter and container of server-side web applications. It also acts as Web Server too. Web Application Server has built-in security, performance, clustering, fail-over, load balancing, and connection pooling mechanisms to host the server-side scripts and web applications. So, the usages of the Web Application Server for the Web-Based Application Workflow solutions give the developers focus only on the business logic. WAS is running the server-side scripts, such as PHP, Perl, JSP, Servlet and Javascript, and sends the outputs to the client. WAS uses the distributed computing model to run business logics more effectively [9]. Distributed computing model is allow to run the each part of the application on the different WAS installations. The Web-Based Application Workflow (WBAW) should be deployed on the application server or the web server, which is the capable of running server-side software technologies such as C#, ASP.NET, J2EE, PHP, PERL, PHYTON, etc… The main role of the Web Application Server is to be the container of running Web-Based Application Workflow. Programming mistakes causes the performance degradation of Web-Based Application Workflow. It is even the reason of the crashing the container.

6. Database Management System

DBMS is the software application that stores the data, executes query on this data, controls the access of the information and manages the data easily and effectively [10]. If the server-side application is running on the Web Application Server container then the container manages the connection between the server-side application and database management system. The performance issues are directly causes overall system performance problems. So, Database Management System performance is crucial for the Web-Based Application Workflow. The information is in the form of the tables. Tables are the two-dimensional logical data storage that has columns and the rows of data, stored in the table. Tables are related with each other as a relationship, referential integrity to save the data integrity on the Database Management System. Database performance tuning includes all the performance improvement activities on Database Management System. The local or network file system storage stores the data files of Database Management System. So the hardware performance is

directly affecting the Database Management System data file Input and Output performances.

7. Asynchronous JavaScript and XML

AJAX is the asynchronous javascript web development technology to create more effective and interactive web pages. It allows the each part of the web pages independently. It prevents to retrieve the data of the whole page [11]. The main importance of this technology is that the whole web page does not need to submit while the server-side data came from. AJAX has some frameworks and all of them doing the same thing at the base, but their approaches are different. AJAX has the text based request and response data so it can be compressed over HTTP then it will be more per formative. Actually, AJAX reduces the network traffic between client-side and server-side so it is more per formative not to refresh the whole web page at every submission or surfing over the page. Heavy AJAX usage can cause longer page loading, rendering and running. Sometimes the heavy AJAX usage can cause the crashing of the Web Browser.

8. Adobe Flash

AF is used for rendering and displaying the rich client applications on a webpage. It has capability of animation effects and mote interactive application running in the web browsers [12]. AF is not supported by Safari Web Browser running on the IOS. Thus, Rich Client Interfaces can be run over the Web Browser, for example; attractive chart and maps etc. Some of the programming problems or the very big footprint of the Web Browser's add-on flash has some performance degradation when it is downloading to the client-side and heavy usage of user interface components.

CHAPTER 3

METHOD

This section contains the technology used for the implementation, development methodology and mathematical model and algorithm of the study.

1. Technology Used in MyToolset

MyToolset was developed by using the n-tier architecture that includes robust, well-proved web technologies. These technologies are mainly open source technologies. Especially, the Apache Foundation based products were used. MyToolset technology infrastructure is presented in Figure 1.

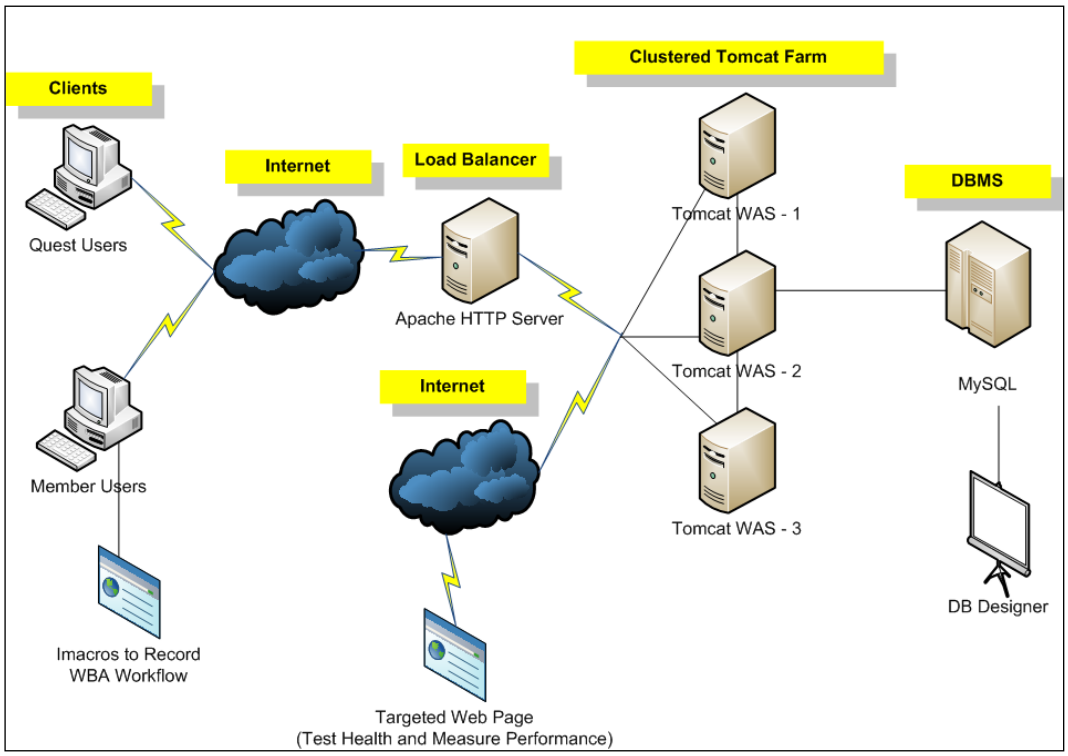

Figure 1 MyToolset Infrastructure and its Technologies

MyToolset Technology Infrastructure is made up of n-tier web development technologies. These are listed as follows;

- Apache Struts Web Application Framework [17].
- Quartz Based Job Scheduler [18].
- FireStorm Data Access Objects (DAO) Based Database Components for the Database Access Layer [19].
- Oracle MySQL Community Edition Database Management System [20].
- IOPUS IMacros Automated Web Testing for generating Virtual User Browser Scripts [21].
- MyEclipse is used as Integrated Development Environment (IDE) [22].
- Apache Tomcat Web Application Server is used for Web Application Server [23].
- Database Designer is used for the Database modeling [24].
- Custom Developed Scrender Server was used for the snapshot of Web-Based Application Workflow anomalies.
- The Code Standards are adapted from Oracle Java Code Standards [25]. It is developed by the Java to Enterprise Edition (J2EE) based server-side application and Ajax Based Web 2.0 user interfaces. Figure 2 shows the brief description of how MyToolset works.

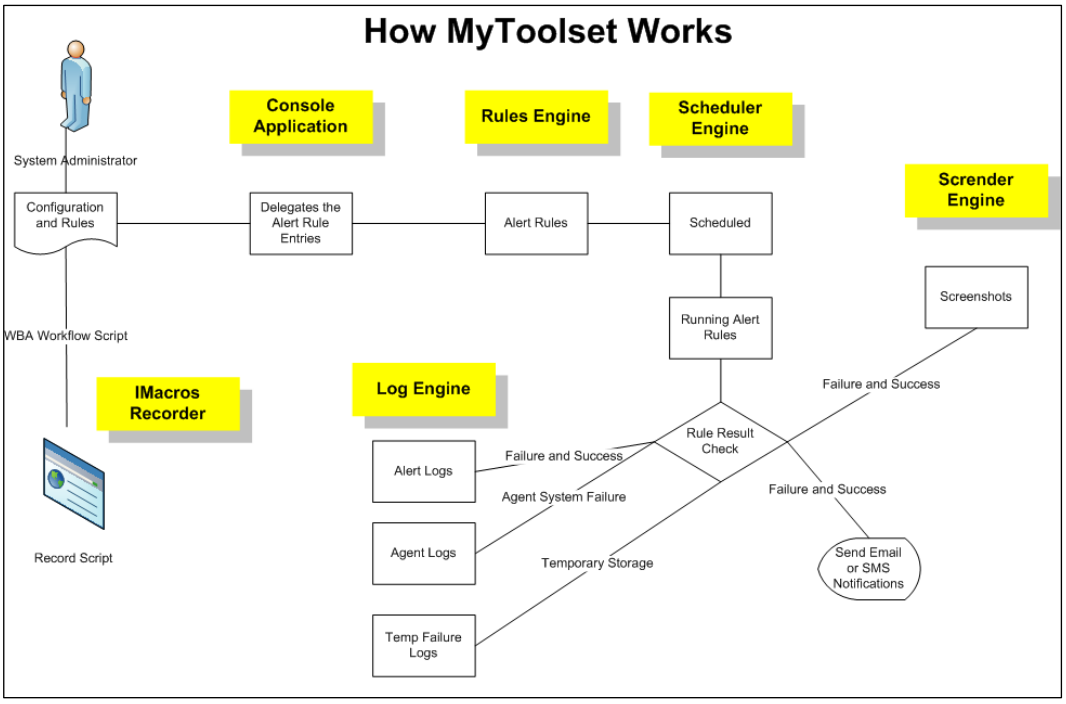

Figure 2 Brief Explanation of the MyToolset

MyToolset works following the steps below;

1. The system administrator creates the Configuration and Alert Rules by using MyToolset web based Administration Console.

2. He/she uses the IMacros Macro Recorder to record and generate the macro data script to simulate the virtual user browser experience.

3. The administration console application delegates the Alert Rule Entries to the Alert Rule Engine to store the Alert Rule and Macro Data Script.

4. The Rule Engine component is responsible to store and complete the creation of the Configuration and Alert Rules. It also sends the scheduling information to the Scheduler Engine.

5. Scheduler Engine is responsible to schedule and execute the Alert Rules, store the response time values after executing the Alert Rules. Scheduler Engine contains the queue engine to queue the jobs as Alert Rule execution. Scheduler Engine sends the Email or SMS alerts after executing the Macro Data Script.

6. Scrender Engine is responsible to take the screenshot of the failure and successful monitoring results. It stores the screenshots as image files and MyToolset uses this to show it on the evidence screen.

7. Log Engine is the heart of the MyToolset because the asynchronous monitoring results are recorded by the Log Engine. It logs temporary failure logs and failure and success Alert Event Logs. These logs are listed in the Alert Event Log Table on the MyToolset Admin Console.

2. Development of MyToolset

MyToolset is developed by using object oriented analysis and development methodology. This section presents analysis, design, and development phases in detail.

a. Object Oriented Analysis and Design Phase

Object-oriented analysis (OOA) is the analysis method to derive the classes and objects from the vocabulary of the relevant domain. In addition, Object-oriented design (OOD) is the design method to gather the logical, physical, dynamic, and static models of the system under design. The outcome of the object-oriented design will be the input of object-oriented programming [26].

The most common use of Unified Modeling Language (UML) is in the analysis and design of software solutions [27]. “What the system does” is the main focus on the OOA, “How the system does it” is main focus on the OOD.

b. Object Oriented Analysis Phase

OOA is collections of like-minded requirements modeling and analysis techniques for software systems [28]. The Use Cases and Activity Diagrams (UML Diagrams) were first adopted by Jacobson *et al*. (1992). The Use Cases and Activity Diagrams are the UML diagrams types that are used in the analysis phase. Use Case modelling is prepared to understand the functional requirements of the system before being designed and implemented. Use Case modelling is made up of actors and use-cases. An actor is the external system or the role entity that interacts with the system. An use-case represents the actions that are initiated by the actor to success a specific goal [29].

Use Case diagram of MyToolset shows that the Actors and the Use Cases that the actor expects from the MyToolset. There exists 4 system parts such as Home Page, Configuration, Alert Rule, and Alert. There are two types of Actors such as Guest User and Administrator

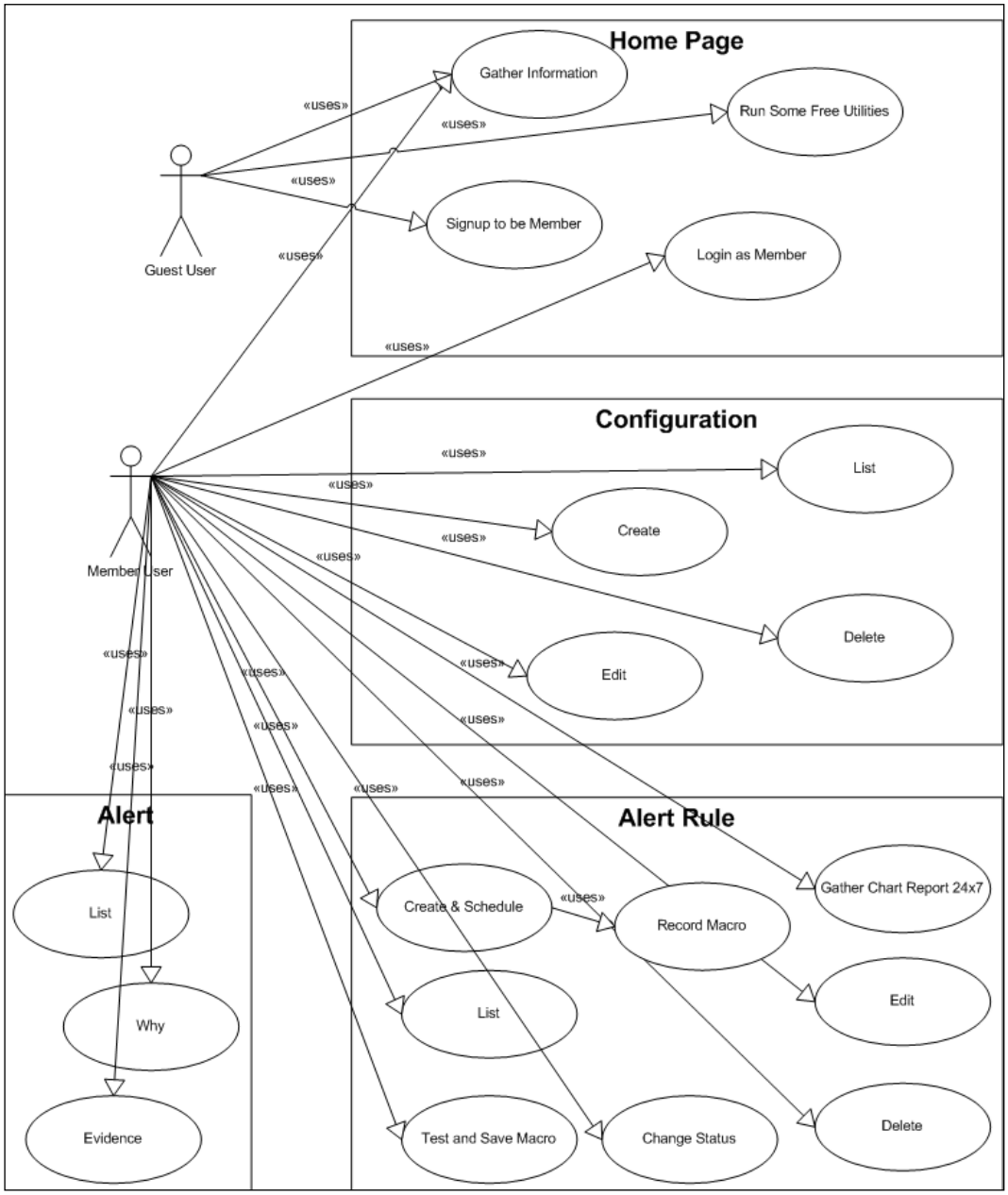

Figure 3 Use Case Diagram of MyToolset

Activity modeling resembles the control flow and object flow models. It includes action that resembles the lover-level behaviors. The execution of the actions depends on the other execution of completion. Because, actions need to have the objects and data become available [30]. Figure 4 shows the “Test and Save” activity diagram.

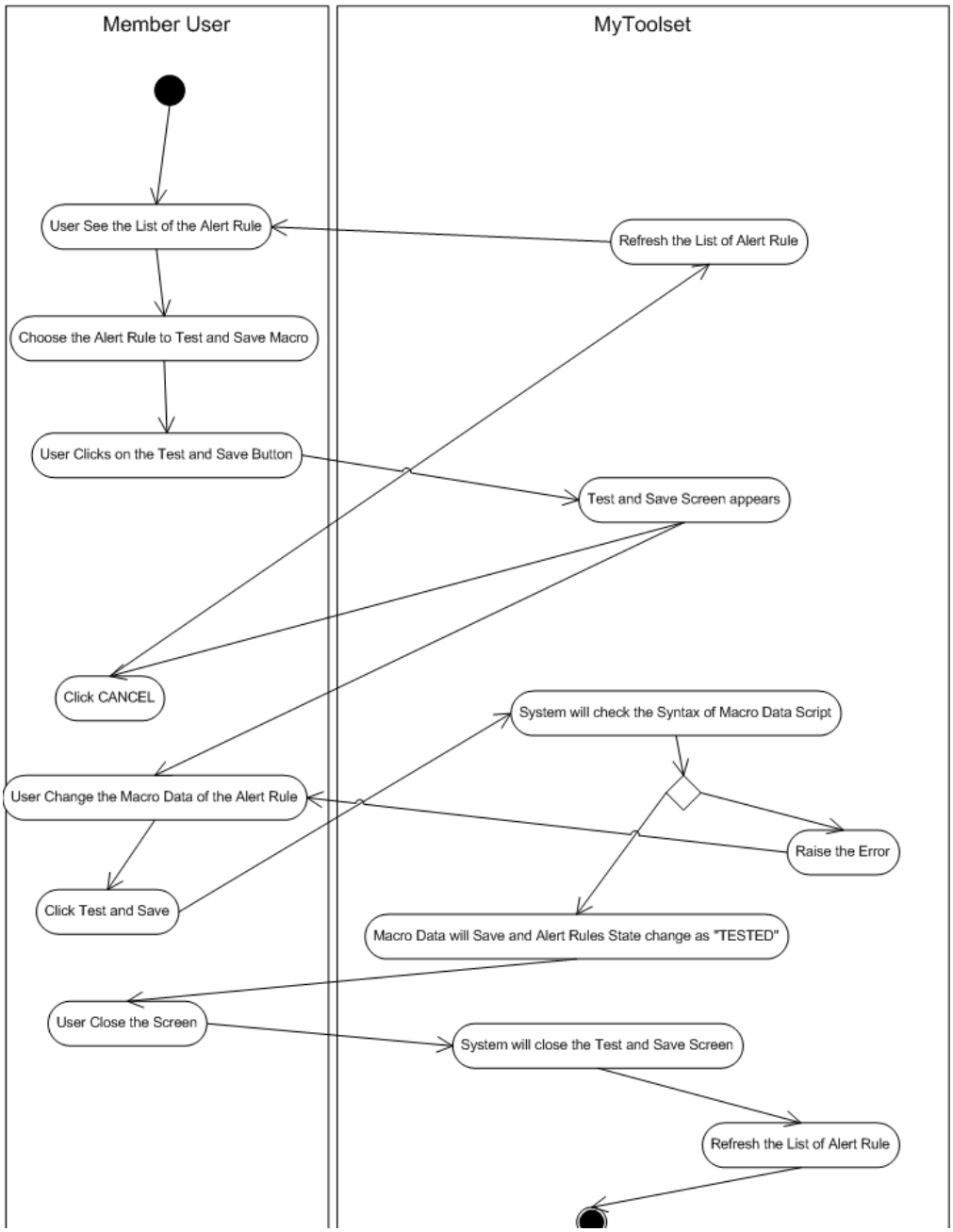

Figure 4 Example Activity Diagram: Activity Diagram of Test and Save [30]

The Activity Diagram of MyToolset defines each Use Case's screen and business function call flows. Each Activity can be detailed by the Sequence Diagram, Class Diagram, and Extended Entity Relationship (EER) Diagram. Each of the use case is detailed with activity diagrams. The activity diagrams are given at APPENDIX A.

c. Object Oriented Design Phase

OOD is the invention and adaption process. The outcome of the OOD is used by the development team to create the abstractions and software methods. OOD uses the outcome of the analysis of system's behavioral requirements [31]. "How the system does it" is main focus on the OOD.

In software engineering, a class diagram is used to subtract the logical classes that are used by the business people. Rock bands, CD, radio play, and car loans are some example of the logical classes. A class diagram can also be used to get implementation class diagram. These implementation classes can be the same as logical classes. The implementation classes resemble the attribute and the methods [32]. The Class Diagrams (see Figure 5) of MyToolset show the object states, methods, and object relations between classes.

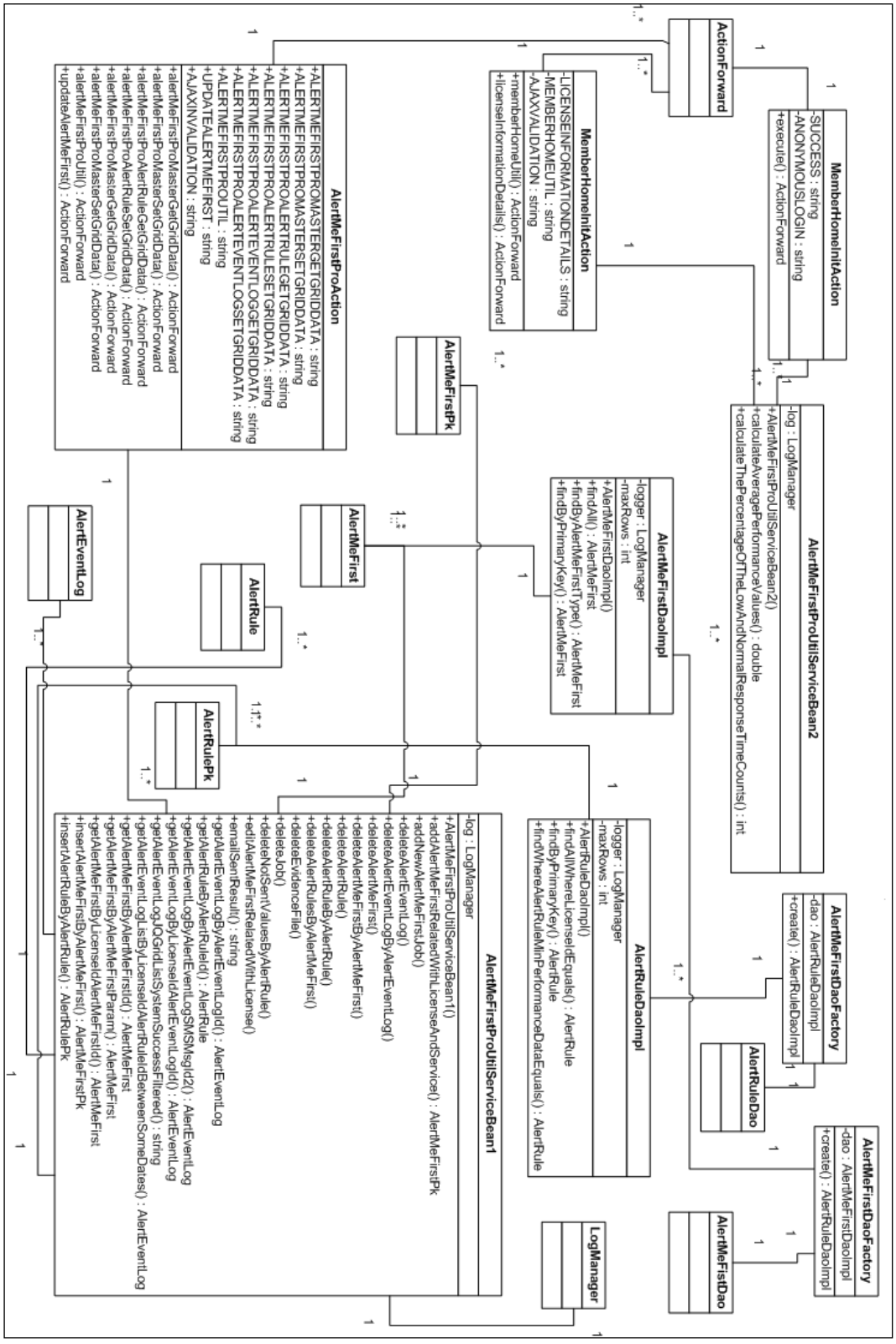

Figure 5 Class Diagram of MyToolset

The Sequence Diagram is the kind of interaction diagram. The sequence diagram focuses on the message interchange between lifelines. The message of the occurrence specification on the lifelines creates an interaction [30].

Sequence Diagram of MyToolset shows the objects and the messaging between them. Sequence diagrams include more detailed information in each of the Activity on Activity Diagrams. For Example; “Creating Configuration” activity diagram has the Activities. Their names are as follows; “User Login to Member Page Screen”, “User See the list of the Configuration”, “Create the Configuration”. The sample sequence diagrams were given at Figure 6-7-8.

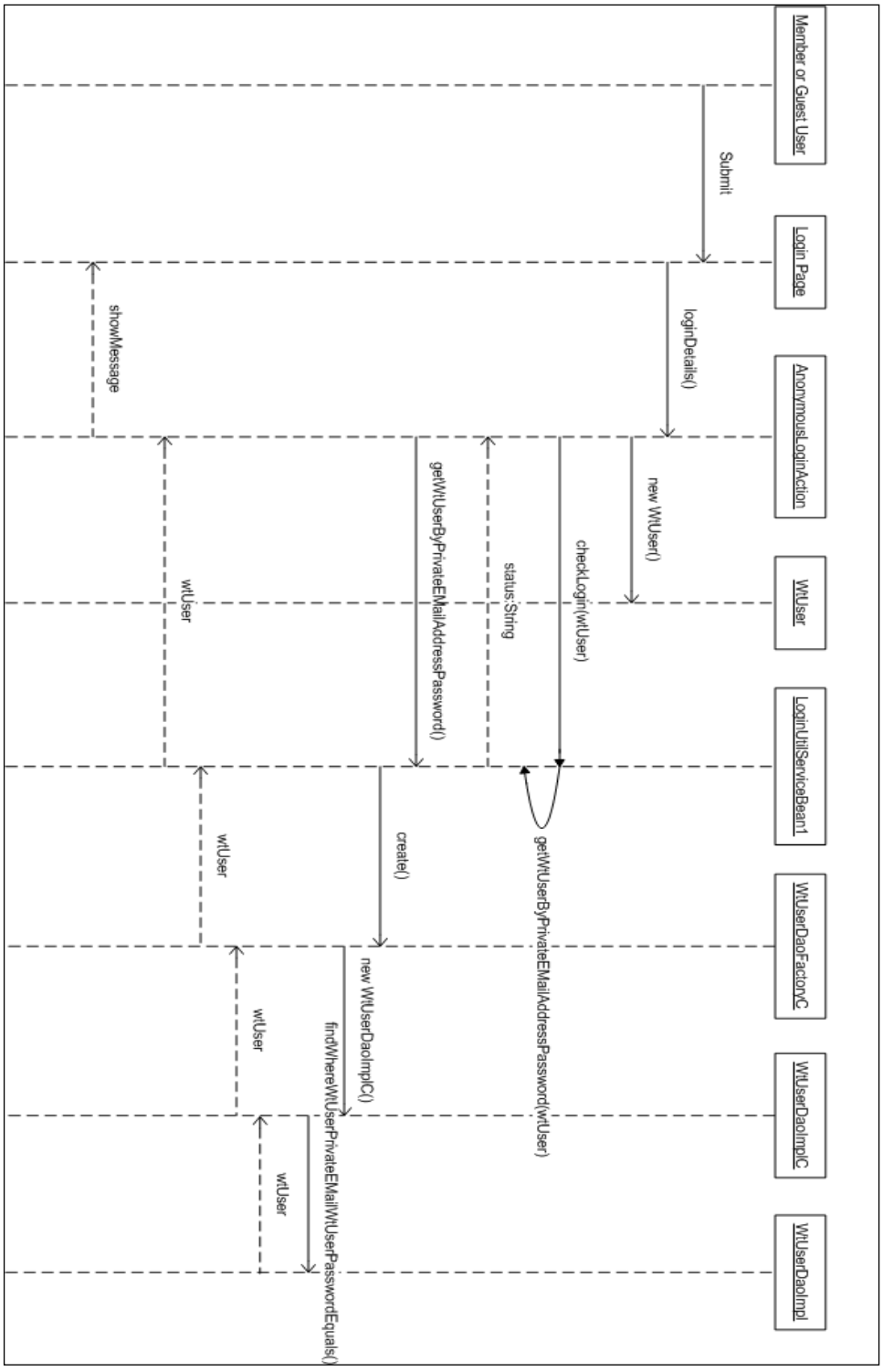

Figure 6 “User Login to Member Page Screen” Sequence Diagram

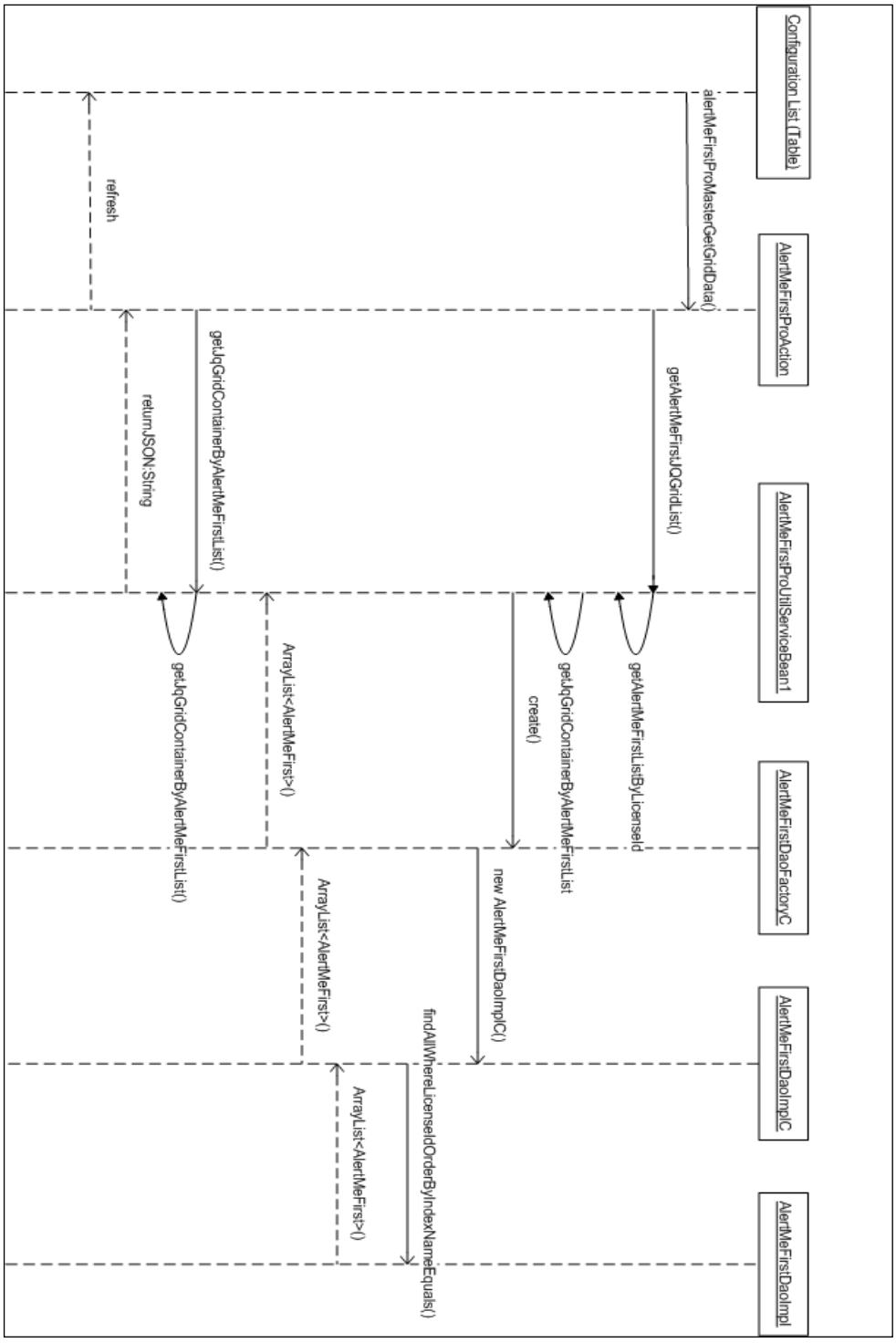

Figure 7 “User Notice the List of Configuration” Sequence Diagram

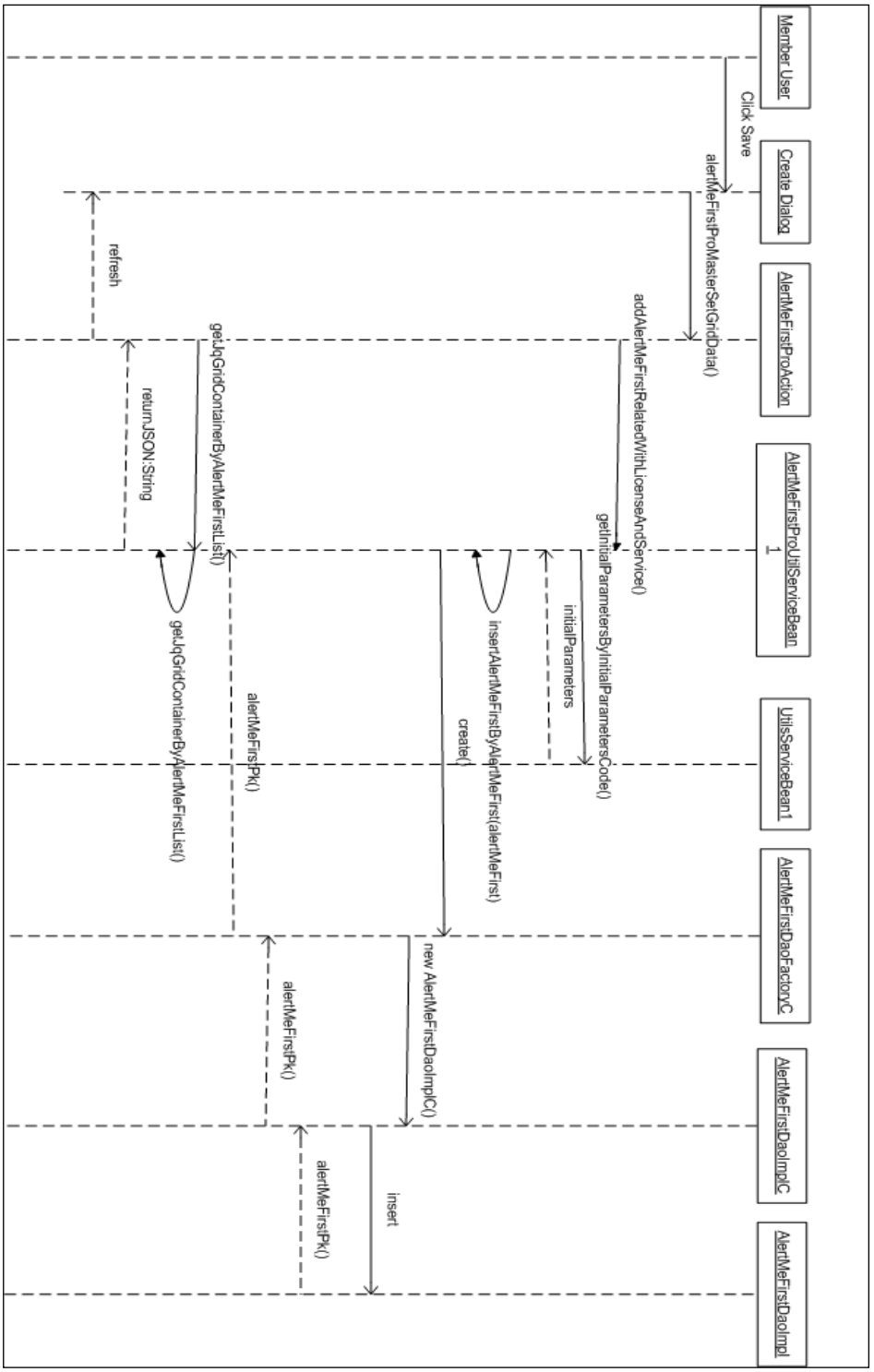

Figure 8 “Create the Configuration” Sequence Diagram

Relational Database model and its referential integrities were modeled on Extended Entity Relationship (EER) Designer. The Extended Entity Relationship Diagram of MyToolset is presenting at Figure 9.

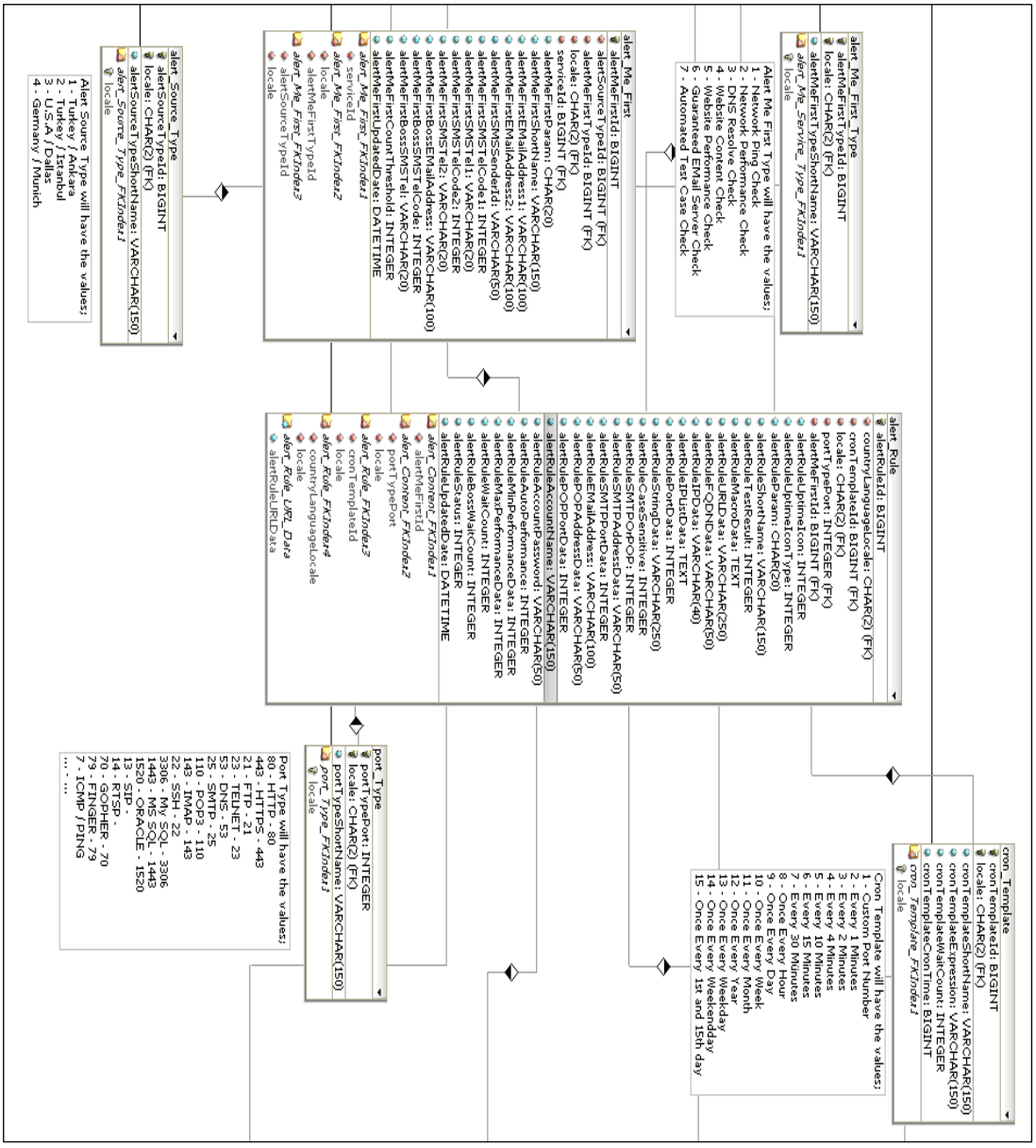

Figure 9 EER Diagram of the MyToolset Database

The Database Model is the third normalized form of relational database model. It includes the entire primary and foreign key constraints and cascading delete relations. The Database Designer tool is used for the Database Model creation. This tool allows creating the reverse engineer and forward engineering the model to and from the database. In addition, Database Model includes the enumeration text notes and indexes on each table. Alert Me First Pro Database model has the main table as Alert Me First. It contains each configuration of the Alert Rules. It has the relationship with the Alert Configuration Type and Alert Service Type.

Alert Service Type includes which agent and location will be used to check the Web-Based Application Workflow. For example, it can be locally check the Macro Data Script runner or the different agent can be chosen to check the remotely Macro Data Script runner. This will be good to check the different networks can have the trouble to connect and simulate the virtual users on that area. Sometimes the virtual users can have performance degradation to connect and simulate the Web-Based Application Workflow at one location while the other locations have the fast connection to use the Web-Based Application Workflow.

3. Mathematical Model and Algorithm

MyToolset reports the Web-Based Application Workflow (WBAW) and its performance failures by taking the snapshot of the end user perspective as evidence. The entire mathematical model is based on the calculation of this idea.

Response times of each virtual end-user browser are stored on Database Management System tables for a week? Firstly, the mean value of the response time is calculated as weekly. This gives us the successful execution performance stability interval. In addition, the standard deviation of the response time is calculated as weekly. Calculation of the Performance Stability Interval begins with calculating the minimum value of the interval, such as subtracting the weekly standard deviation value from the weekly mean value and ends with calculating the maximum border values by adding the weekly standard deviation to the weekly mean value. The Performance Stability Interval (PSI) is much more accurate in weekly basis than the daily one. Total Dynamic Failure Point (TDFP) is increasing by one at each below the min value and above the max value. If the Total Dynamic Failure Point (TDFP) reaches the threshold value, customized by the MyToolset administrator, the alert will be raised. If it has the value between the min and max performance stability interval, then the Total Dynamic Failure Point (TDFP) is reset to the 0. Total Dynamic Success Point (TDSP) is the performance values between PSI values. It is used to calculate the PSS with Failure (PSSWF) and PSS without Failure (PSSWOF). The Alert Raised Indicator (ARI) resembles total count of consecutive response time, which is out the boundary of the Performance Stability Interval (PSI). If the response time is still outside the Performance Stability Interval (PSI) then Alert Raised Indicator (ARI) will be increased by one. If the Alert Raised Indicator (ARI) is bigger than the

consecutive number of Custom Wait Count (CWC), the Low Performance Alert (LPA) will be raised. When the next first response time is in the boundary of the Performance Stability Interval (PSI), then The Normal Performance Alert (NPA) will be raised and the Alert Raised Indicator (ARI) will be set to 0. The formulas and the algorithms are presented at below part.

All of the calculations are necessary to find the dynamic performance intervals and raise the alert when performance degradation and web-based application failures.

The Calculation of the PSI Min and Max Border Values;

MinPSSint is equal to minimum boundary value of the normal performance interval. When the response time is less than this value means increased the ARI and TDFP by one. MaxPSSint is equal to maximum boundary value of the normal performance interval. When the response time is greater than this value means increased the ARI and TDFP by one.

Min PSSint = $\sum Avg\,\mathrm{Re}\,spTime - \sum Stdev\,\mathrm{Re}\,spTime$

Max PSSint = $\sum Avg\,\mathrm{Re}\,spTime + \sum Stdev\,\mathrm{Re}\,spTime$

The Calculation of the Total Dynamic Failure Point (TDFP);

TDFP is equal to total of all failure points. The caluclation of PSS uses TDFP.

For every Response Values;

Begin

Total Dynamic Failure Point (TDFP) =

Case When RespTime > MaxPSSint **Then** TDFP+1

Case When RespTime < MinPSSint **Then** TDFP+1

End;

The Calculation of the Total Dynamic Success Point (TDSP);

TDSP is equal to total of all success points. The each of the calculations of PSS uses TDSP.

For every Response Values;

Begin

Total Dynamic Success Point (TDSP) =

Case When RespTime <= MaxPSSint **Then** TDSP+1

Case When RespTime >= MinPSSint **Then** TDSP+1
End;

The Calculation of the PSSWF and PSSWOF;
There exist two kinds of PSS calculations such as PSSWF and PSSWOF. The calculation of PSSWF includes failure points and PSSWOF does not include.

PSSWF = TDSP / The total number of execution points (Weekly)
PSSWOF = TDSP / (TDFP + TDSP)

The Calculation of Alert Raised Indicator (ARI);
ARI is equal to alert raise indicator. This means that MyToolset uses this indicator to raise alert by comparing with custom wait time.

Alert Raised Indicator (ARI) = **Case When** RespTime > MaxPSSint **Then** AI+1 **or Case When** RespTime < MinPSSnt **Then** AI+1.

The Condition of the Low Performance Alert (LPA);
LPA is equal to low performance alert. MyToolset uses this indicator to raise alert by comparing with custom wait time and alert raised indicator. If Alert raised indicator exceeds the custom wait time then the email and/or sms alert will raise.
If ARI = CWC **Then** MyToolset raises warning to standard output (Alert is not raised yet).
If ARI > CWC**Then** MyToolset raises alert.

The Condition of the Normal Performance Alert (NPA);
NPA is equal to normal performance alert. MyToolset uses it to raise the successful performance alert.
If the first response time is in the boundary of the PSI **Then** MyToolset raises it.

We used the results of the experiments to define the formulas. Firstly, three weeks of test response values were collected and try to undersdand their successfull performance interval. The values show that the best mathematical model of the maximum boundary value of the PSS interval and minimum boundary value of the PSS interval. After those boundary values were gathered, then the custom waiting time used to compare with the alert raise indicator to

raise the email or sms alert. Response values were gathered by execution of the Imacros workflow macro scrtips in realtime.

CHAPTER 4

APPLICATION RESULTS

In order to show the test results of MyToolset, some examples are explained step by step. The usage of the STM A.S. company website was permitted by the software department manager of STM A.S. The relevant permission letter is presented in Appendix B. The results were given below with the appropriate screenshots and result values.

1. Test Environment

“STM - Savunma Teknolojileri Mühendislik ve Ticaret A.Ş.” company website was used for WBAW performance degradation. In addition, Apache Tomcat default examples (jsp-example) were used for application failure tests.

Test Virtual Server Configuration is as follows;

- VMWare Client version 8.0.4
- Windows XP OS – Virtual OS
- 3.2 GB Ram
- 4 Core and 2 HT each 2.2 GHz : total 8 2.2 GHz vCore
- 100 GB SCSI HDD space

2. Creating test monitoring

This section explains the step by step creation of the test configuration and test rules on MyToolset.

Step 1 - Adding New Configuration

Firstly, System administrator logs in to MyToolset and it creates the “STM Company Website” configuration. He/she clicks “Add” button on the configuration list table and enters the appropriate information such as; the title of the configuration, alert type as “Automated Test Case Performance”, alert source as “Turkey / Ankara” and the targeted email address to raise the performance or the

Web-Based Application Workflow failure alerts. After that, he/she clicks on the “Submit” button (see Figure 10).

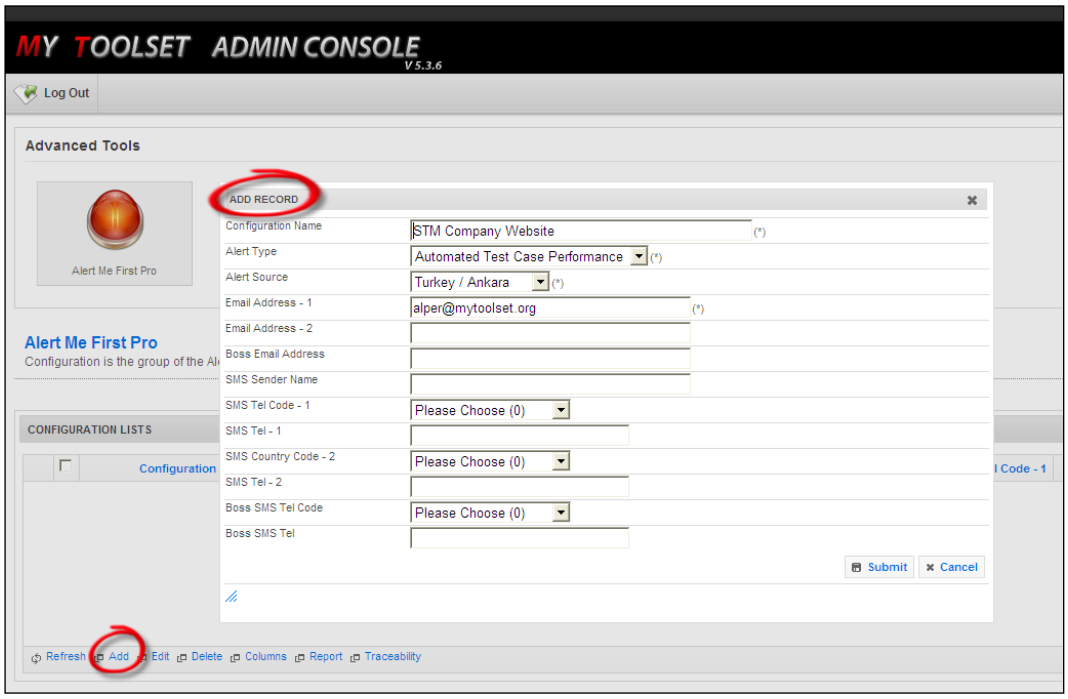

Figure 10 Adding new configuration

This will add the newly created configuration to the “Configuration Lists” table. It is presented in Figure 11.

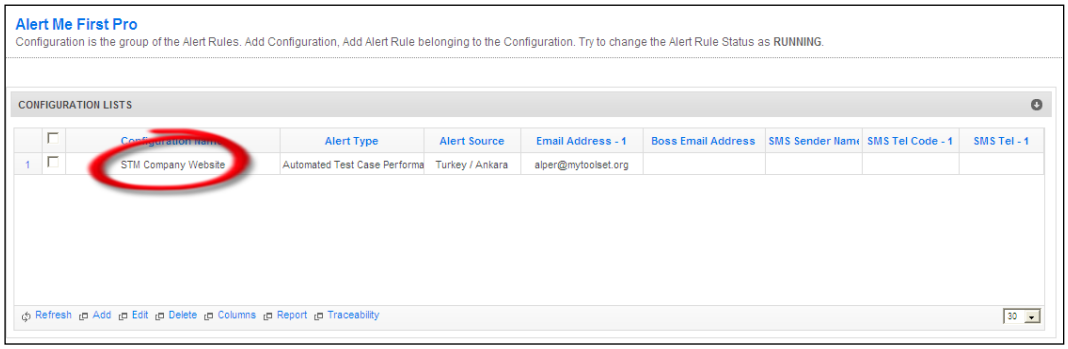

Figure 11 Addition of the Configuration Lists

This configuration lists includes all of the Alert Rules, that has the type of Web-Based Application Workflow performance check. If any performance degradation occurs then MyToolset will send the alert emails to the entered email addresses.

Step 2 – Adding Alert Rule

To create the Alert Rule (see Figure 12) that belongs to the “STM Company Website” configuration, firstly choose the configuration on the table.

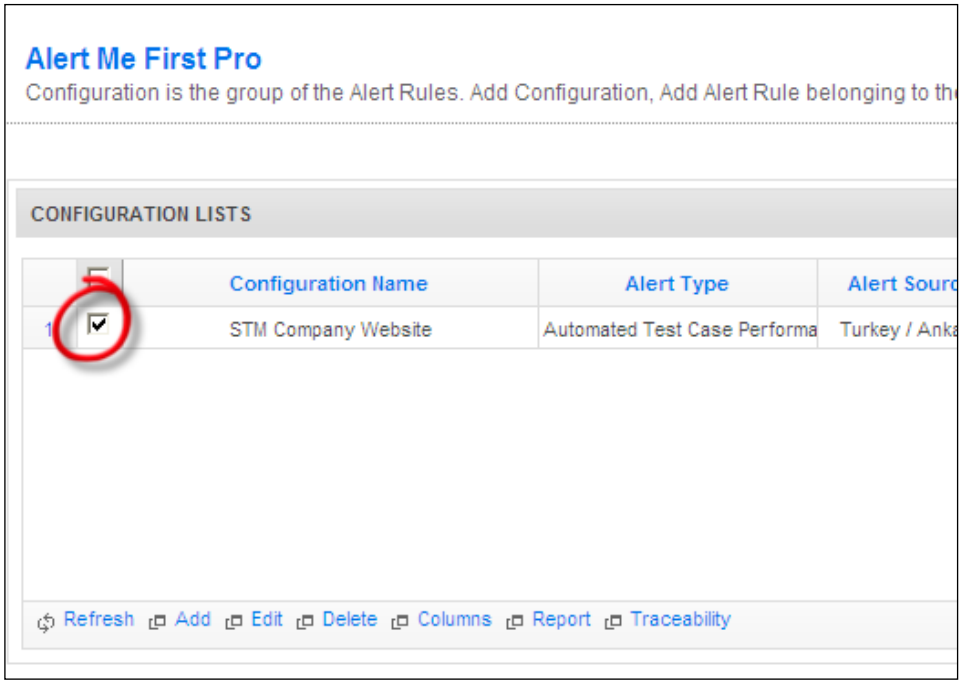

Figure 12 Checking the “STM Company Website”

After choosing the configuration, “Alert Rule Lists” table will be expanded relevant to the chosen configuration list. It is given at Figure 13.

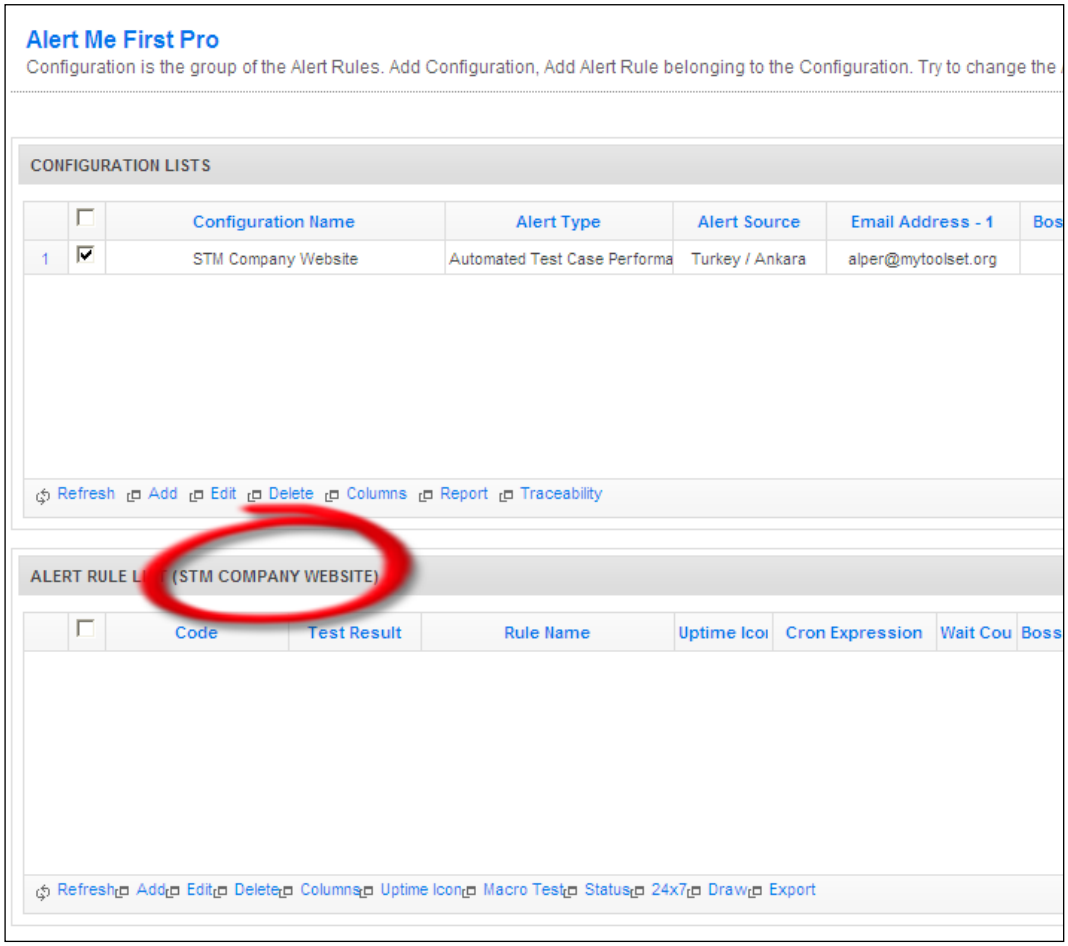

Figure 13 Expansion of “Alert Rule Lists” table

He/she clicks the “Add” button on the “Alert Rule Lists” table to add the STM Company Website performance monitoring (see Figure 14).

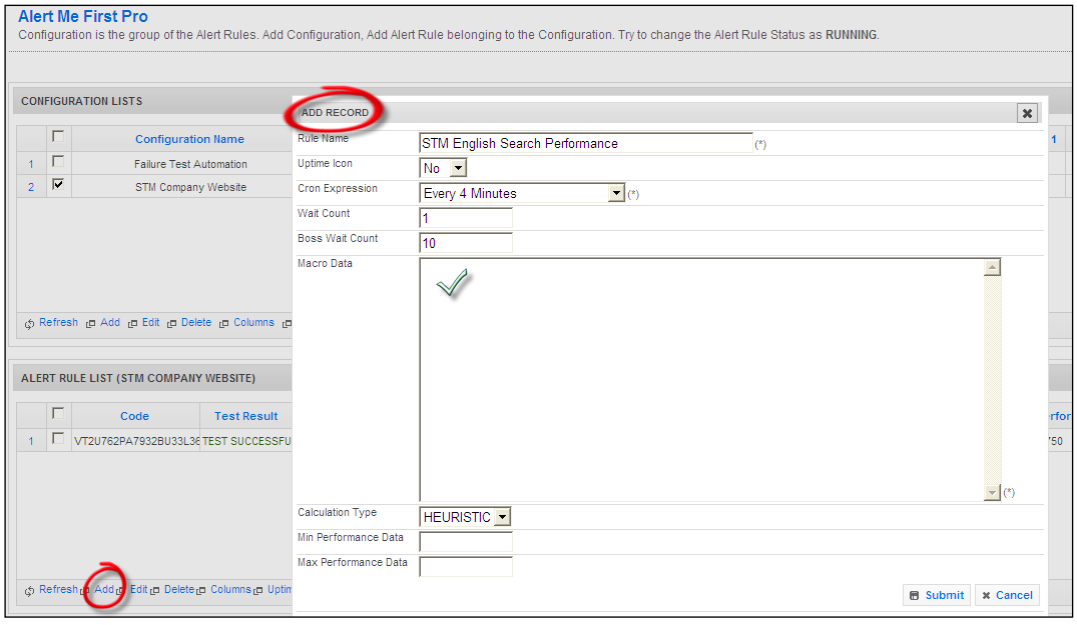

Figure 14 Addition of Alert Rule

He/she enters the rule name text field as “STM Search Performance”. This unique name will be written on the alerts, which are related with this alert rule. Choose the execution of the interval on cron-expression combo-box as “Every 4 minutes”. This is the time of the macro execution interval. MyToolset will run the macro data at every 4 minutes and collect the response time of the macro data running at every 4 minutes. Wait time is the delay period of the alert mechanism. It is waiting one time before raising the alert. This is used to reduce the false positive alerts. The Boss Wait Count is used to wait before raising the alert to the boss email address or the SMS receiver. Choose Calculation Type as “HEURISTIC”. This indicates that the performance interval will be calculated by automatically by using the mathematical model of MyToolset. Please do not close this window. In Step 3 and 3.1, the generated macro data script will be added to Macro Data memo pad to complete the addition of the Alert Rule.

Step 3 – Generating Macro Data Script

The Macro Data section will be added by using IMacros Macro Data Script Recorder editor. IMacros Macro Editor can be opened by pressing the IMacros icon on the Internet explorer task bar (see Figure 15).

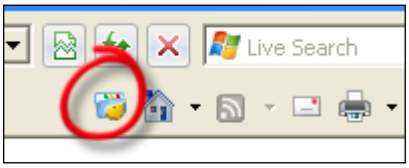

Figure 15 Execution of IMR

After executing IMacros Macro Recorder (IMR), he/she has to write the STM Company Website on the Address by and presses “Enter” button. IMacros Left Menu and the main body screen and the company website will be opened (see Figure 16).

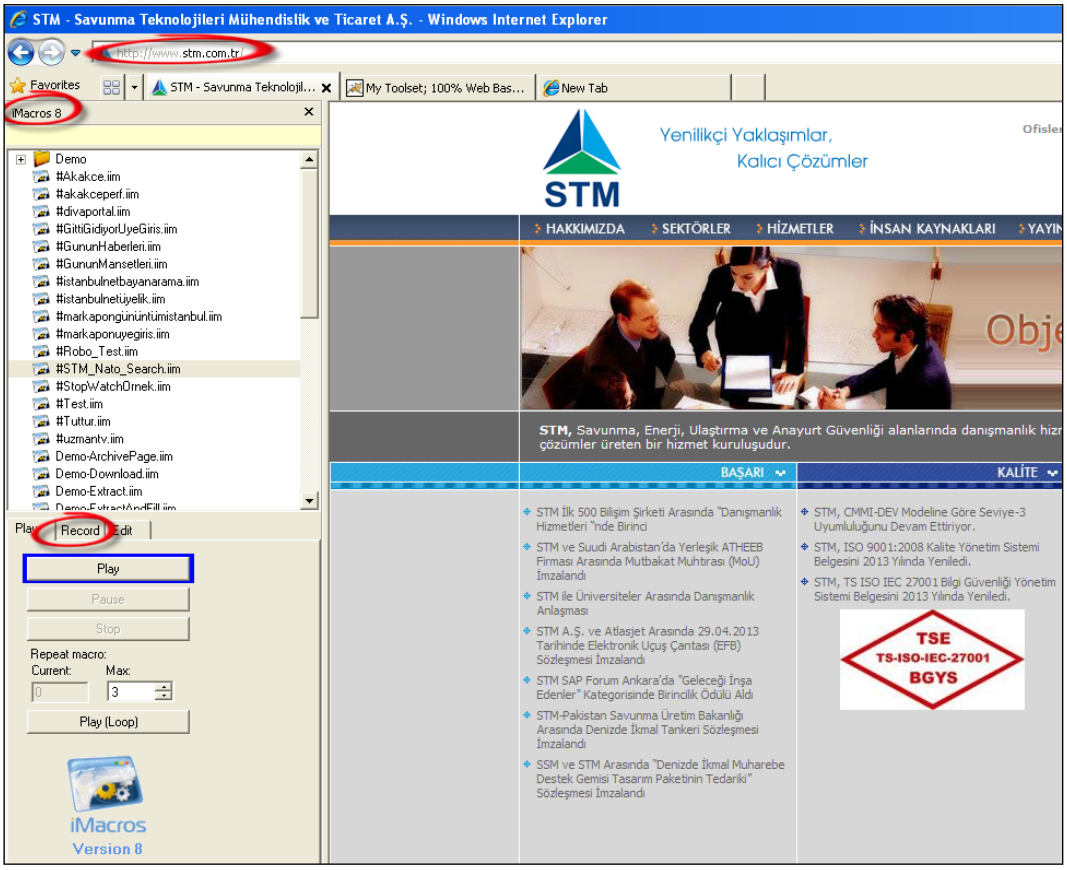

Figure 16 IMacros Recorder

After opening the screen, “Record” tab should be pressed to open the recorder commands tab (see Figure 17).

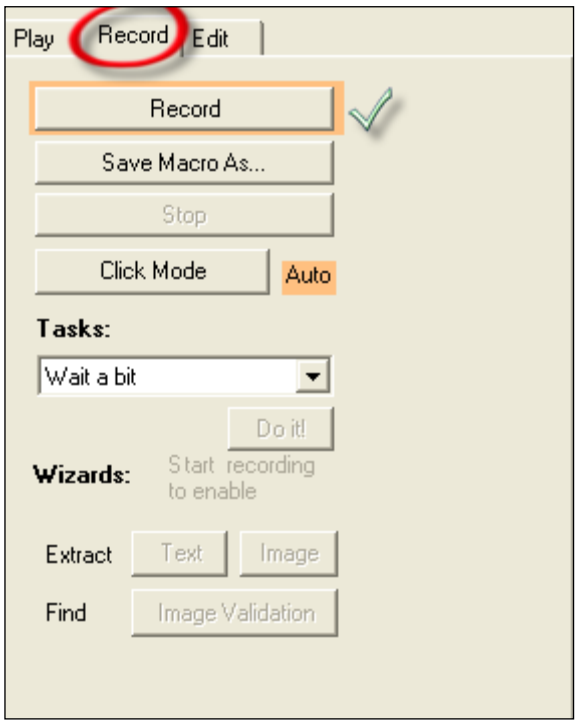

Figure 17 IMR Tab Commands

"Record" button should be pressed to start the Macro Recording session immediately. In this session every movement and every usage of the STM Company website will be recorded as IMacros Data Script (see Figure 18). The generated script is placed in the script recording memo pad.

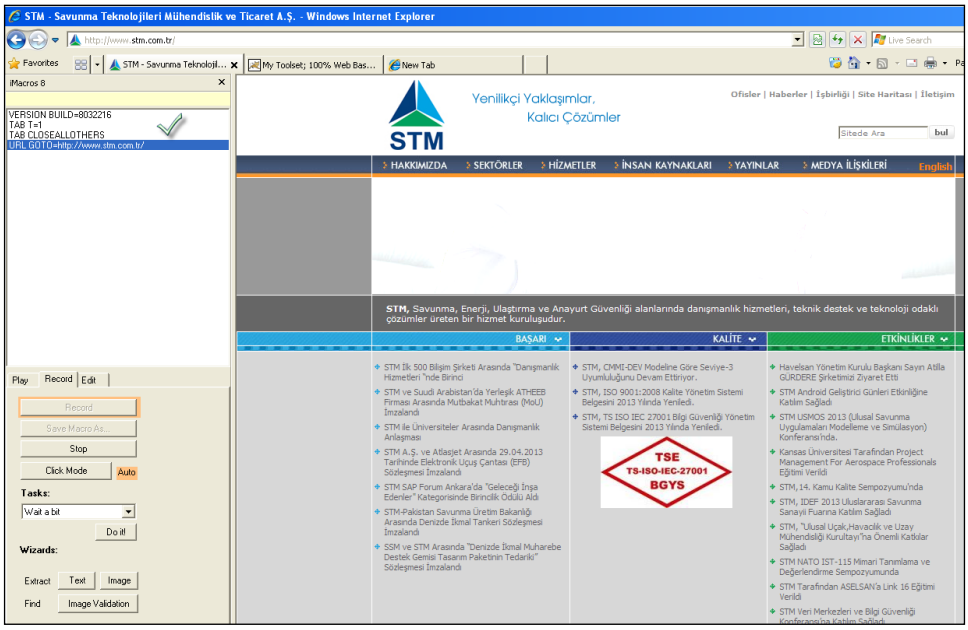

Figure 18 Generated Macro Data Script in Memo Pad

After this, the English content link should be pressed (see Figure 19), because company website of STM A.S has multi language feature.

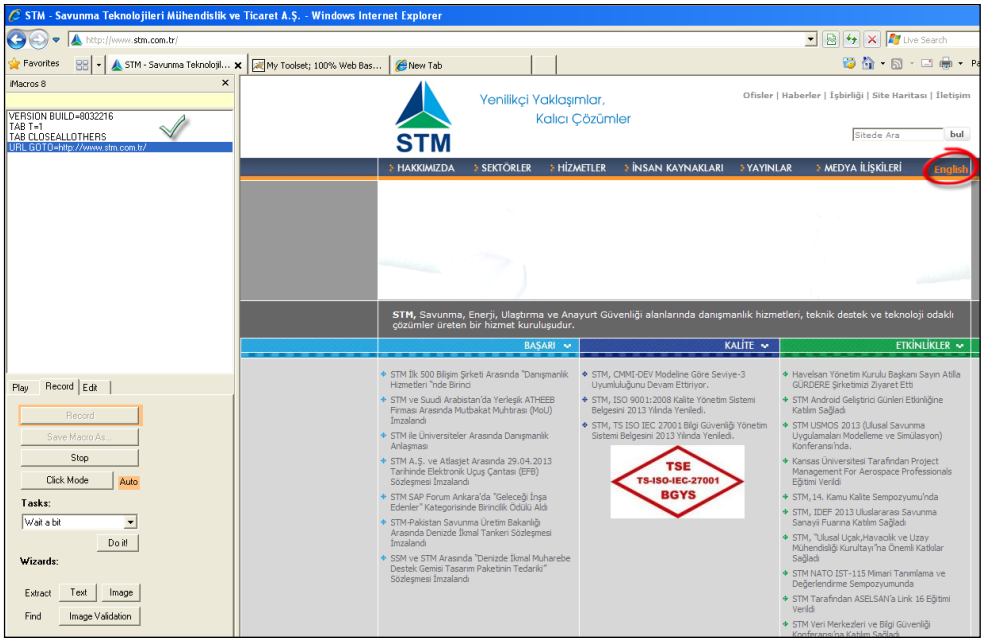

Figure 19 English Site HTML Link

It can be seen the new entry in the Macro Data Script memo pad (see Figure 20).

Figure 20 Generation of New Line

After entering the word, “NATO” and pressing the “find” button, the website search engine will search this word on the Company Internet (see Figure 21).

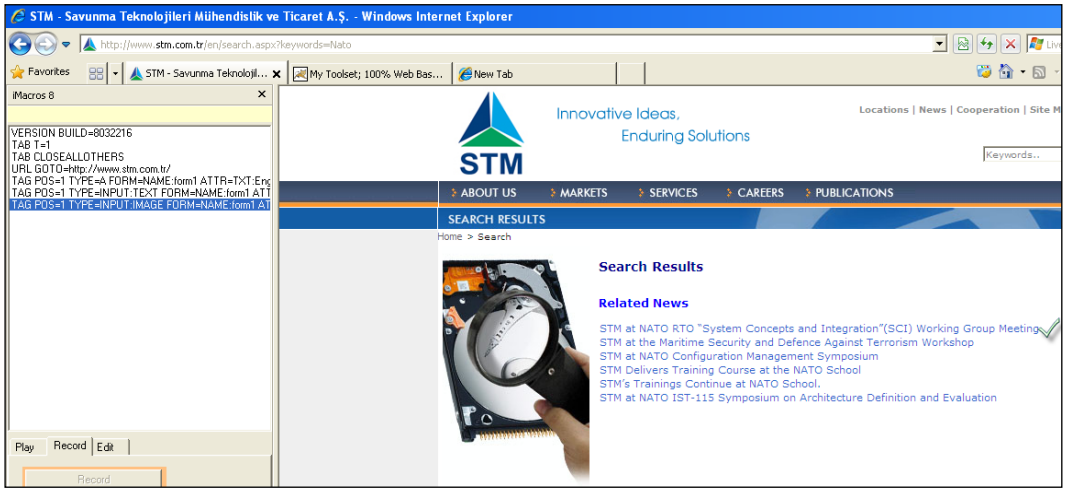

Figure 21 Search Result of "NATO" word

The first link that has the title as "STM at NATO RTO Concepts and Integration (SCI) Working Group Meeting." can be clicked to open the link content on the STM Company Website (see Figure 22).

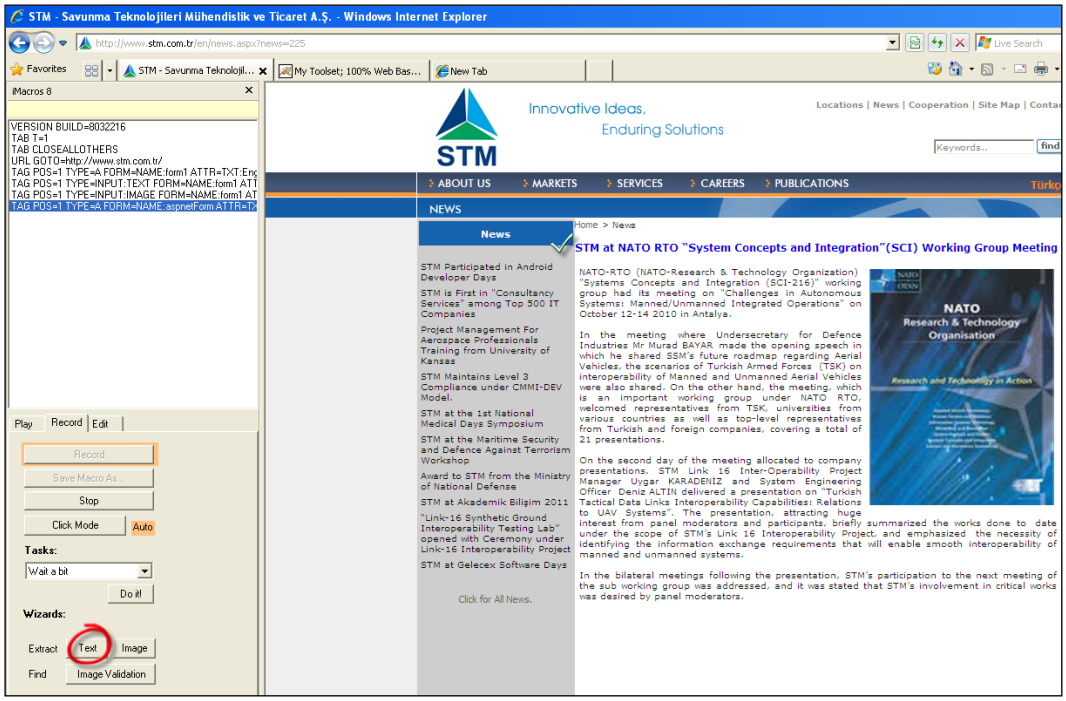

Figure 22 HTML Link Content

After opening the search result, "Text" button should be pressed and this will open the result extraction command screen. This command is used to verify the targeted screen includes the same word or the sentence or not. If the same

screen is not displayed, then this means that there exists the problem with the expected screen. So may be the application system is not running stable, configured properly or the application was not executed correctly. Any text in the screen can be selected. After clicking the text, this will be displayed on the Extracted memo pad. So, IMacros Macro Recorder (IMR) will search this text at this screen to check the performance and stability of the search engine. Click on “Add command” button to add this text extraction as Macro Data script (see Figure 23).

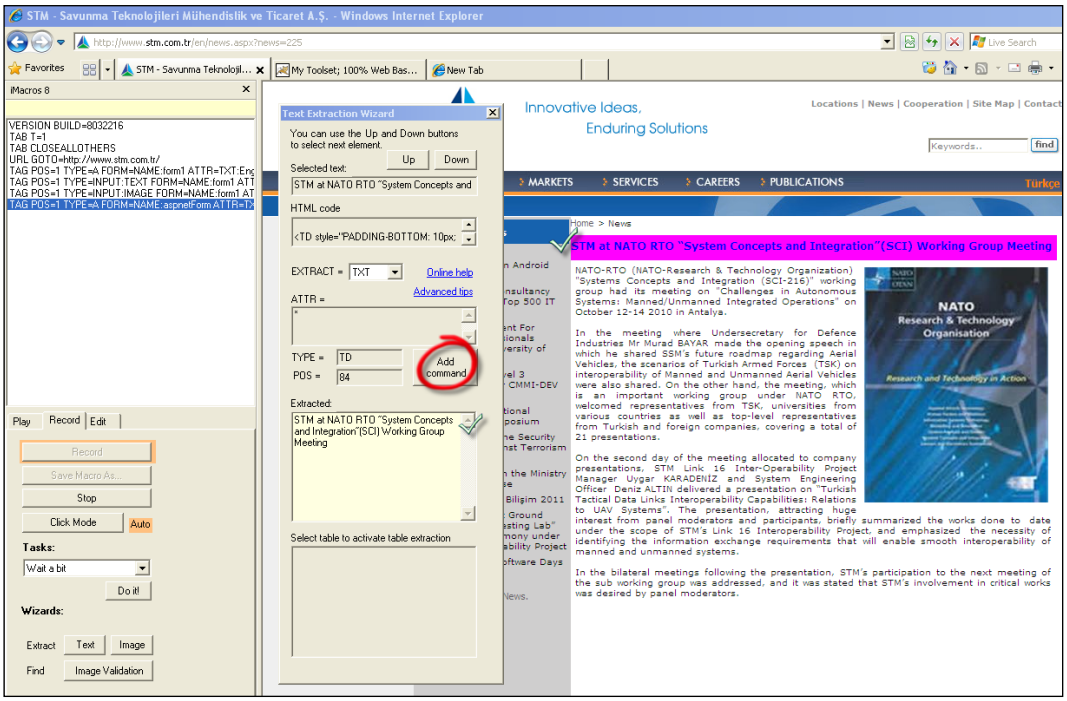

Figure 23 Extraction of the Page Title

After adding the command the resulting memo pad can be checked and the IMacros Macro Recorder (IMR) can be stopped to start the copy of the Macro Data Script details from the IMacros Editor (see Figure 24).

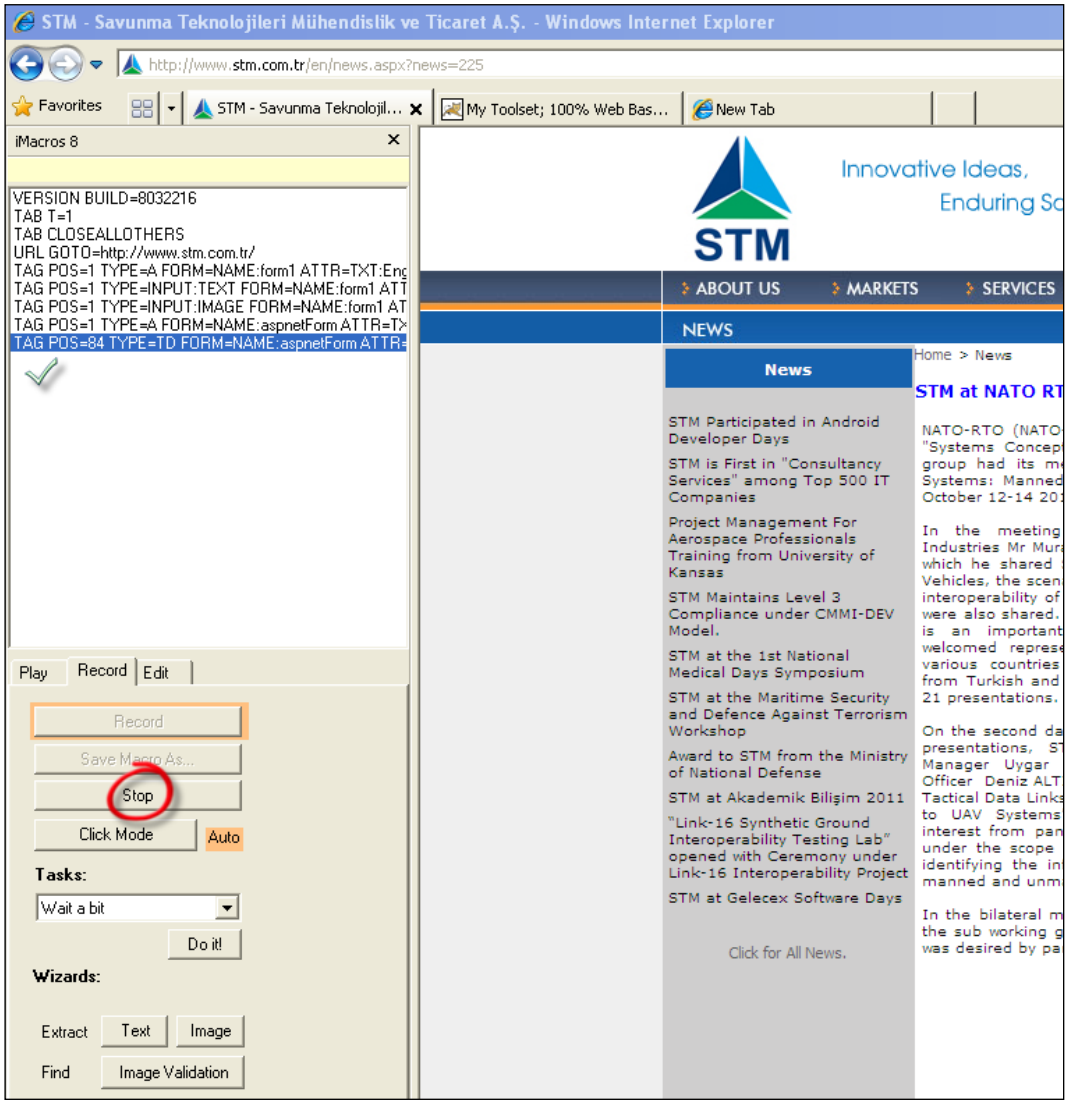

Figure 24 Stopping the Macro Script Recording

Step 4 – Adding Macro Data Script to the Alert Rule

After stopping the recording session, IMacros Macro Recorder (IMR) will create the new macro script file, named “Current.iim” to copy. Right click on the “Current.iim” and choose the “Edit Macro” menu item. This will open the IMacros Macro Editor (see Figure 25) to copy the content of the Macro.

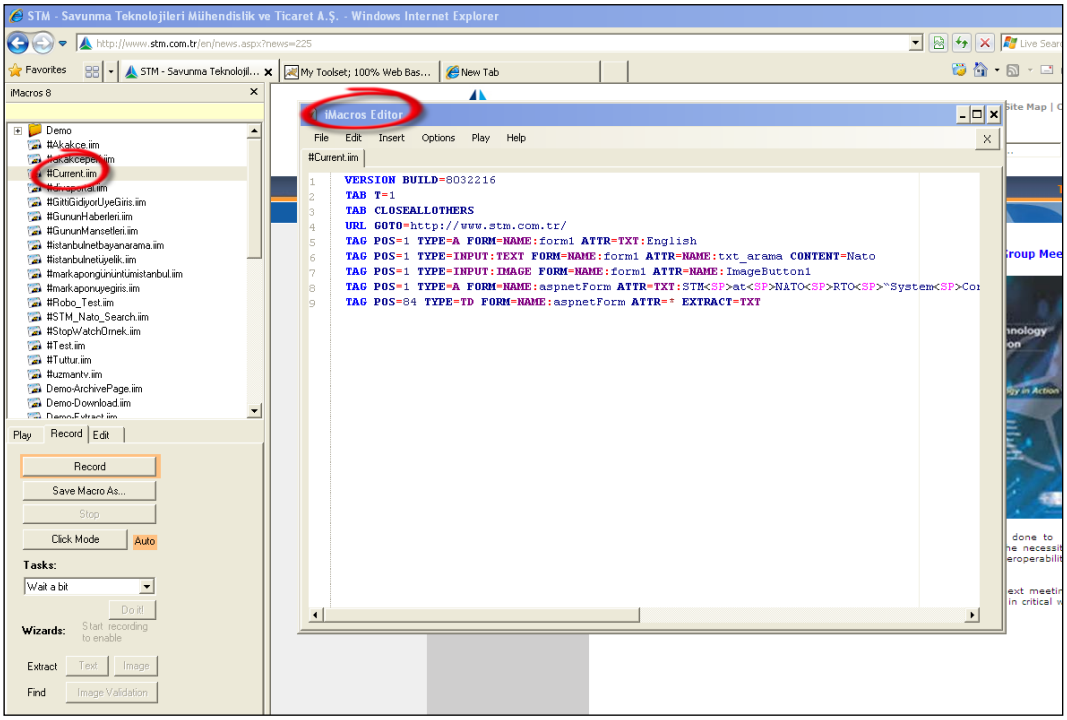

Figure 25 Macro Editor

“Ctrl+A” can be used to select the entire Macro Data Script to copy the content of the recorded macro data script. This will be paste to the Macro Data of newly created Alert Rule named “STM English Search Performance” (see Figure 26).

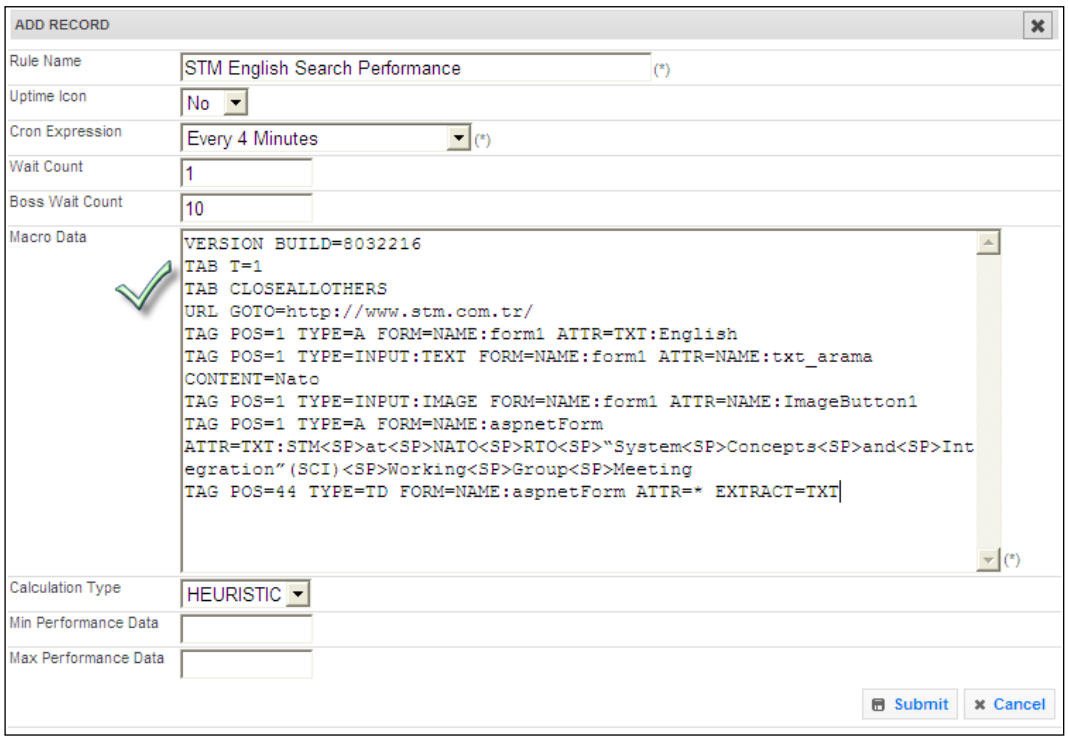

Figure 26 Addition of the Alert Rule Macro Data

After pasting the Macro Data Script to the Alert Rule press "Submit" button to create the Alert Rule. The Alert Rule list will be updated with the addition of the new Alert Rule named "STM English Search Performance". It is presented in Figure 27.

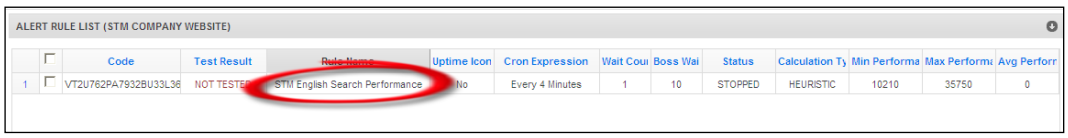

Figure 27 Alert Rule in the Alert Rule List

Step 5 – Testing and Changing the Status of Alert Rule

The status of the newly created Alert Rule is "Stopped" (see Figure 28). This means that the monitoring activity was not started yet. To start the monitoring activity firstly macro data script should be tested. This is necessary because it is a kind of validation of the syntax of the Macro Data Script to run properly.

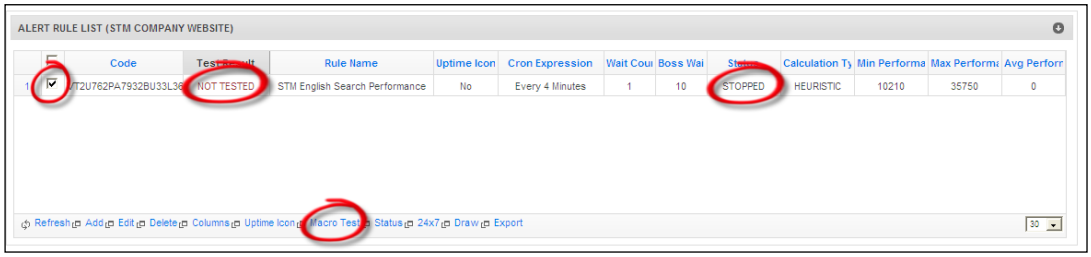

Figure 28 Examining Alert Rule Status and Test Status

After choosing the Alert Rule to be validated, press the “Macro Test”. Macro Test Screen is presented in Figure 29.

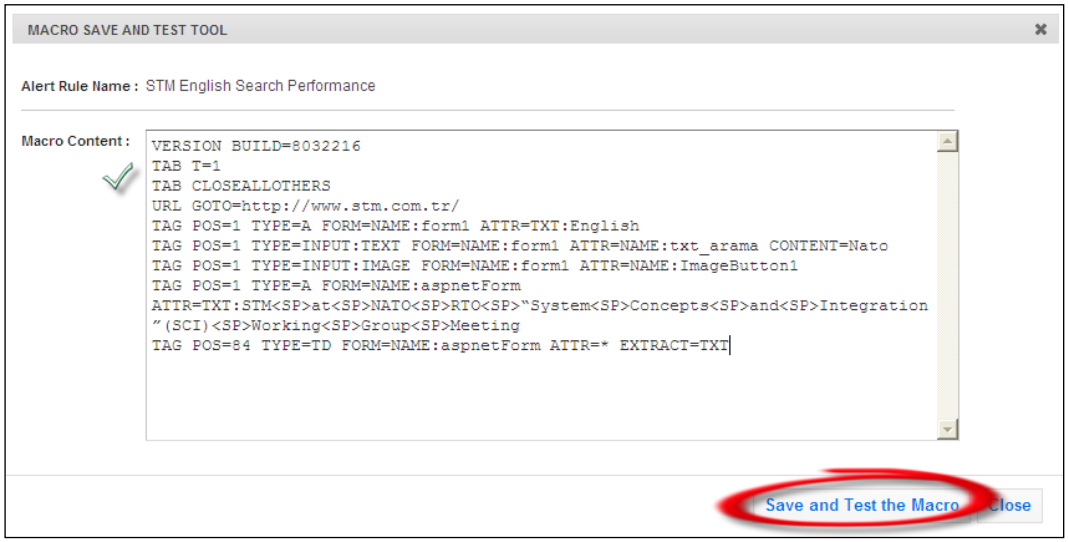

Figure 29 Testing the Macro Data Script

The Macro Editor will validate the syntax of the macro and it is running state. If there exists no error (see Figure 30), it will be saved and it testing state will be marked as “TESTED” so press “Save and Test the Macro” button. It will check and show the result of the validation of the script.

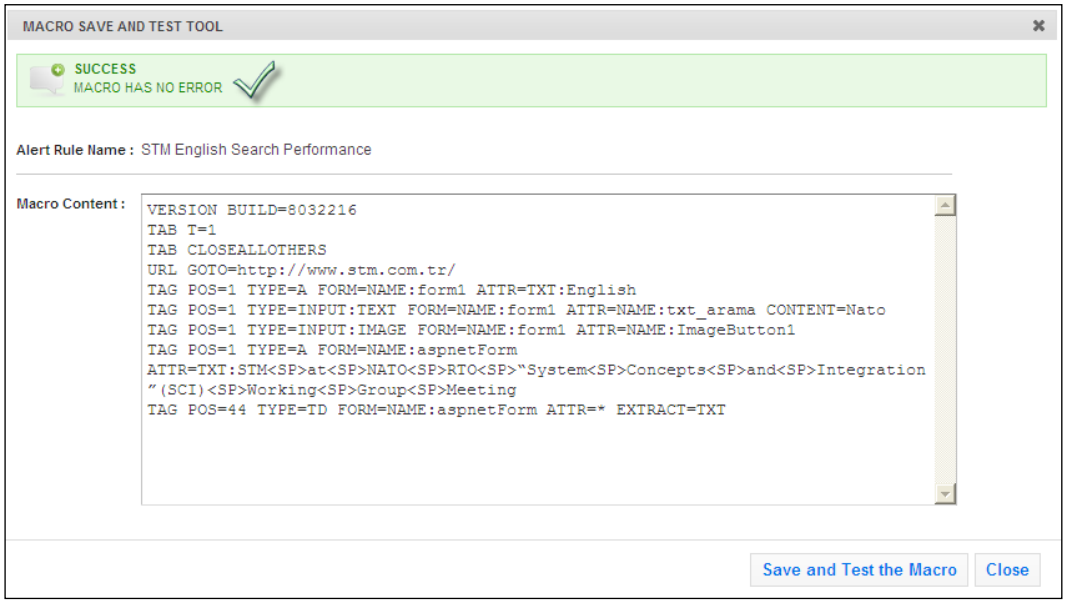

Figure 30 Validating the Test Result

After successful testing and validating the script, it is ready to make its status running to collect performance data to monitor the WBAW performance. After successful testing, “Macro Save and Test Tool” inner window can be closed to look at the Test Status of Alert Rule in the Alert Rule List. It should be changed to “TESTED” status in the list (see Figure 31).

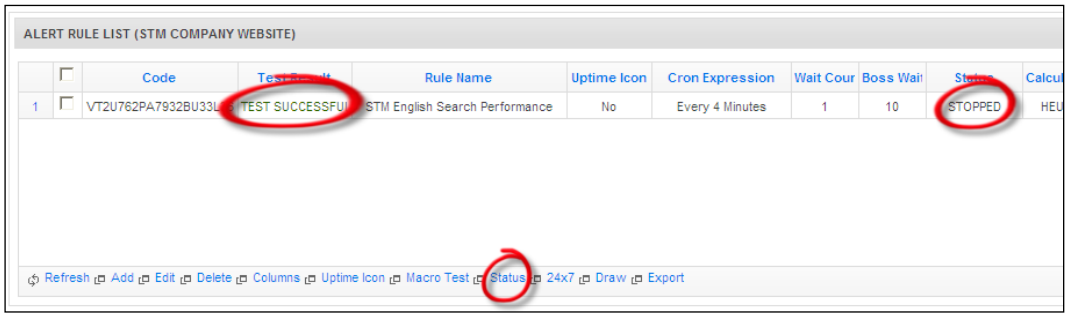

Figure 31 “TESTED” Alert Rule Test Status

Alert Rule can be chosen and clicked on “Status” button to change the status of the newly tested Alert Rule. This will open the “Change Status” screen. Alert Rule status can be changed to “RUNNING” status and clicked on the “Change” button (see Figure 32).

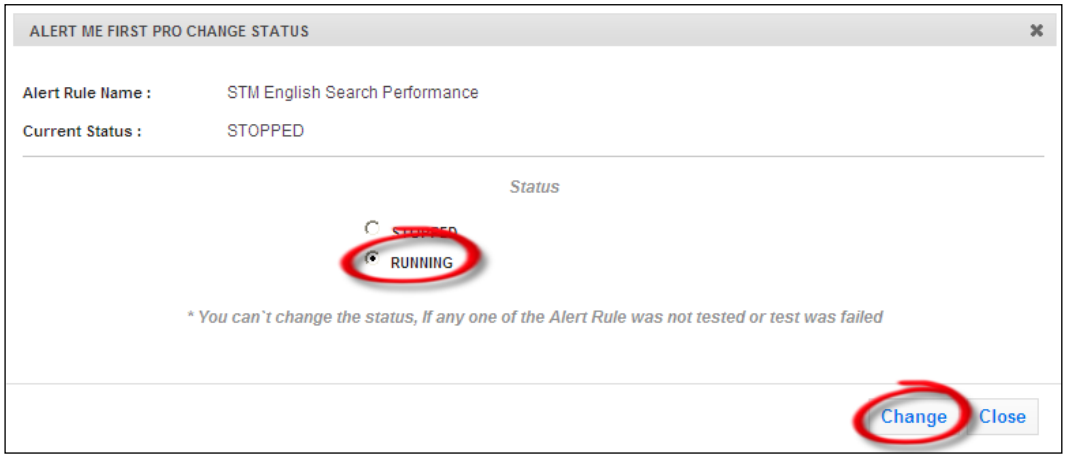

Figure 32 Changing the Status of the Alert Rule

After changing status the Alert Rule will collect the Web-Based Application Workflow (WBAW) response time values and trace the performance degradations and the sharp performance changes by using the appropriate MyToolset mathematical model. Alert Rule's status can be seen as "RUNNING" (see Figure 33).

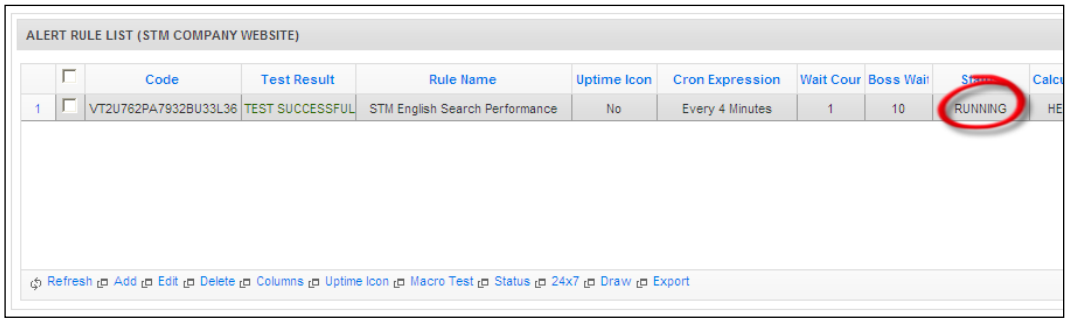

Figure 33 "RUNNING" Alert Rule Status

Step 6 – Checking Alert Event Log and its Evidence

After running the "STM English Search Performance" for one-week period, it collects performance values and we get the performance for this Alert Rule. "STM English Search Performance" is planned to run every minute. Alert Rule raises some Alert Log Entries. This can be seen on the Alert Event Logs when the "STM English Search Performance" Alert Rule is selected. Alert Event Log List Table contains the Alert Rule Execution Result and Content (see Figure 34). It also includes the Email that is sent to notify the responsible person or not. It is given below.

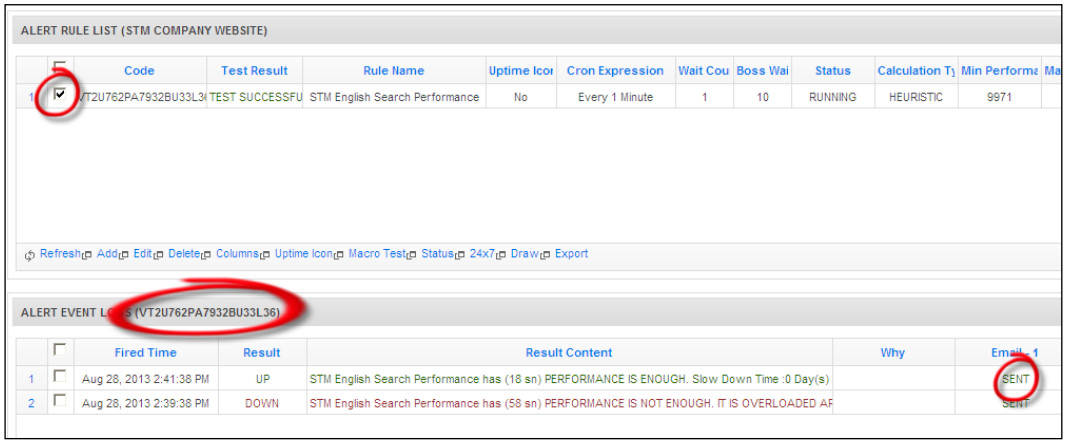

Figure 34 Alert Event Logs, belong to the Alert Rule

Alert Event Log contains the screenshot of the failure as evidence of the performance failure, for example; the evidence screenshot that the search results cannot be taken, because the Web-Based Application Workflow is too slow to send the response screen. When the user double clicks on the Alert Event Log entry to display the evidence screenshot, the evidence screenshot will be displayed in the browser when the performance degradation occurs (see Figure 35).

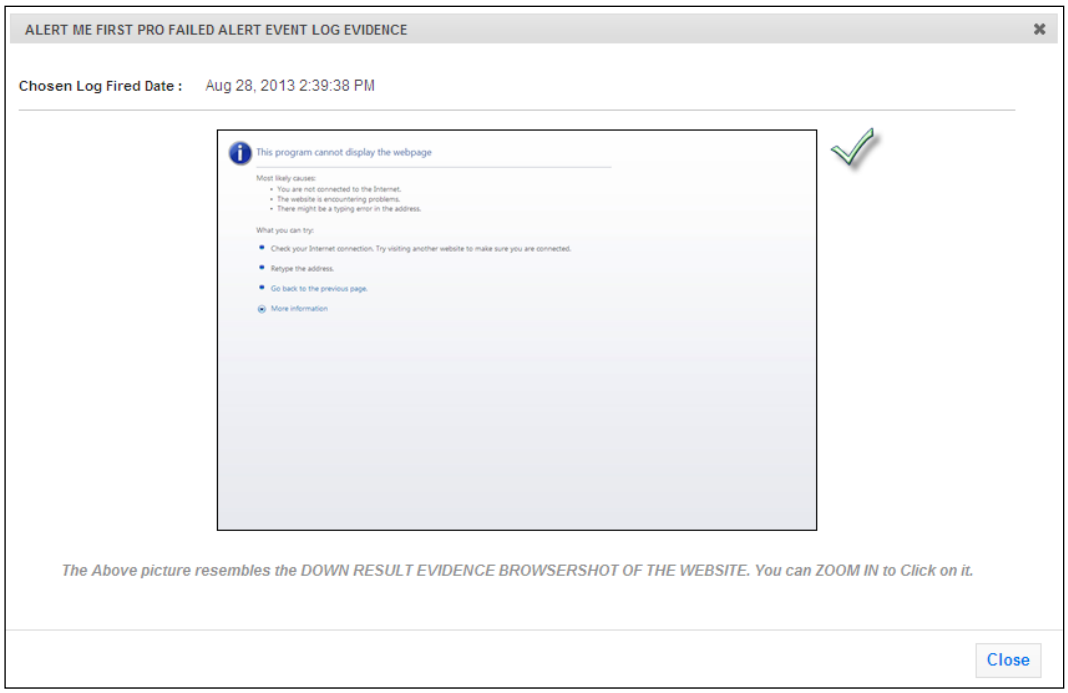

Figure 35 WBAW Failure Screenshot

Step 7 – Receiving Failure and Success Alert Emails

The system sent the performance degradation email alert to warn the responsible person. If it was set the SMS alert, MyToolset would send the SMS alert as well as Email alert. The sample Email alert can be seen in Figure 36.

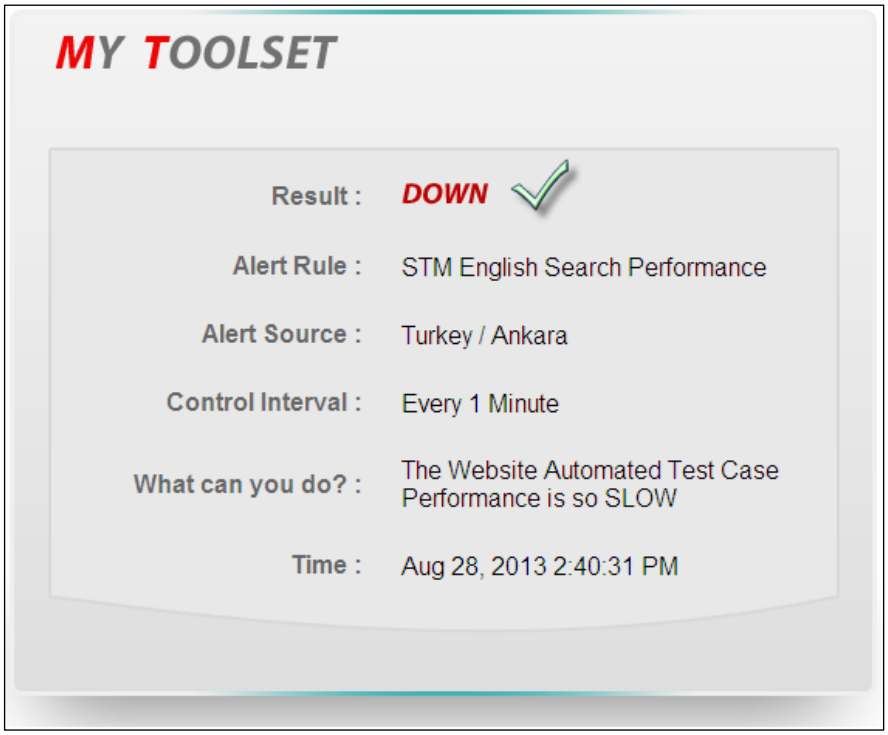

Figure 36 Failure Email Alert

The successful evidence screenshot is taken if performance values are inside performance stability interval, i.e. the normal performance interval. This can be seen in Figure 37. This evidence screenshot shows that the performance of the Web-Based Application Workflow is at the 18sec response.

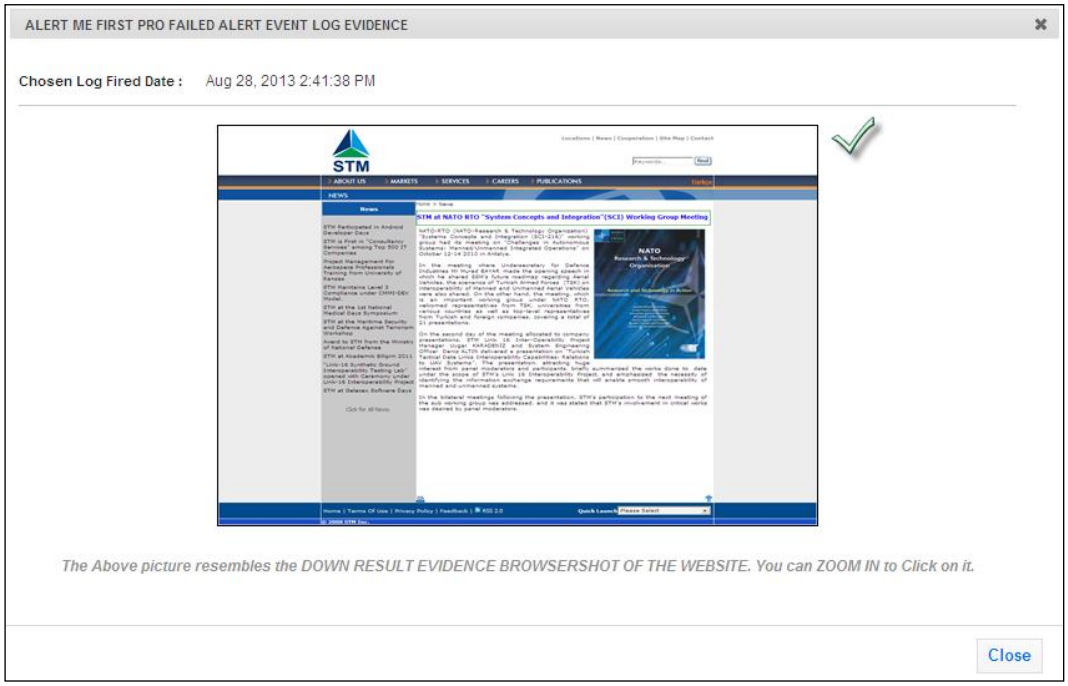

Figure 37 WBAW Success Screenshot

If Performance response time is again in the performance stability interval then MyToolset will send the successful Email Alert (see Figure 38).

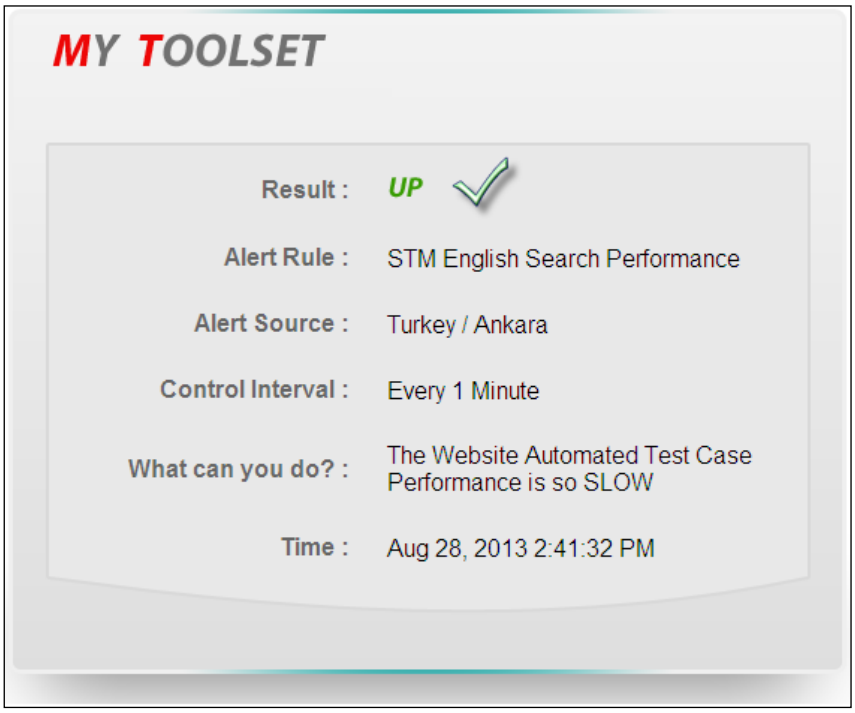

Figure 38 Success Email Alert

Step 8 – Overview of Performance Chart

MyToolset produces the chart report by using the response time values. These values are obtained by running the Macro Script Data at chosen period. It can be seen that performance degradation has occurred (see Figure 39). Performance Stability Interval can be displayed as green colored and it has the label name as “Normal” on the figure. If the average consecutive response values of the system are outside this interval, then this means that the performance degradation has occurred. It can be checked that the performance degradation occurred at 14:30 and the performance degradation alert was raised at 14:32, indicated by 1.It is the place of the failure alert has occurred. It has success performance value at 2 point. Because the response time at 14:36 is in the boundary of normal performance interval (see Figure 39).

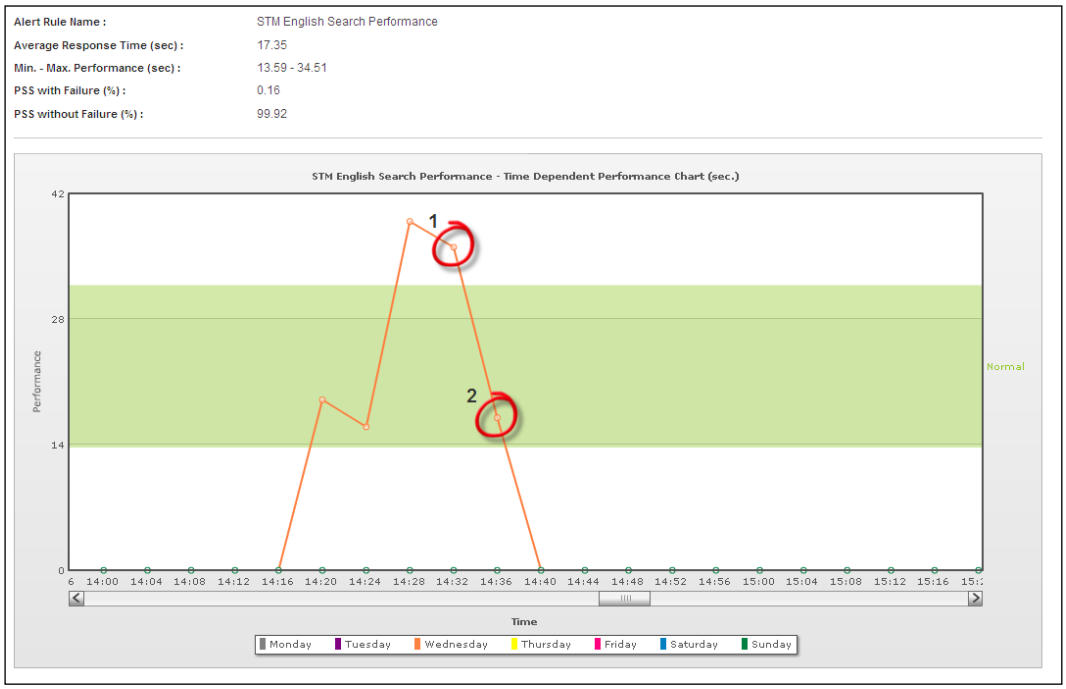

Figure 39 Performance Degradation, reported in the Chart

The wait count was set as 1 for the Alert Rule “STM English Search Performance”. It is waiting total 2 times. It can be asked that “if waiting count was set 1 time, then why it is waiting total 2 times to start to raise the alert?”. It can be expected that one performance degradation count is enough to raise the alert. However, MyToolset is waiting to raise alert one time by default. It is the built-in functionality. It can be seen in Figure 40, point, which is labeled as 1,

performance degradation is for the built-in wait count. This first control is necessary for alert accuracy. Because of the temporary network latency and the load on the servers, it is not trustful to get the exact server response by IMacros Engine. The point, which is labeled as 2, is for the wait count, which has already been set while Alert Rule is creating. 2 point is for the raising the alert event because it is equal or more than 1 default + 1 for wait count. The point, which is labeled as 3, is for the performance degradation was finished and everything is normal.

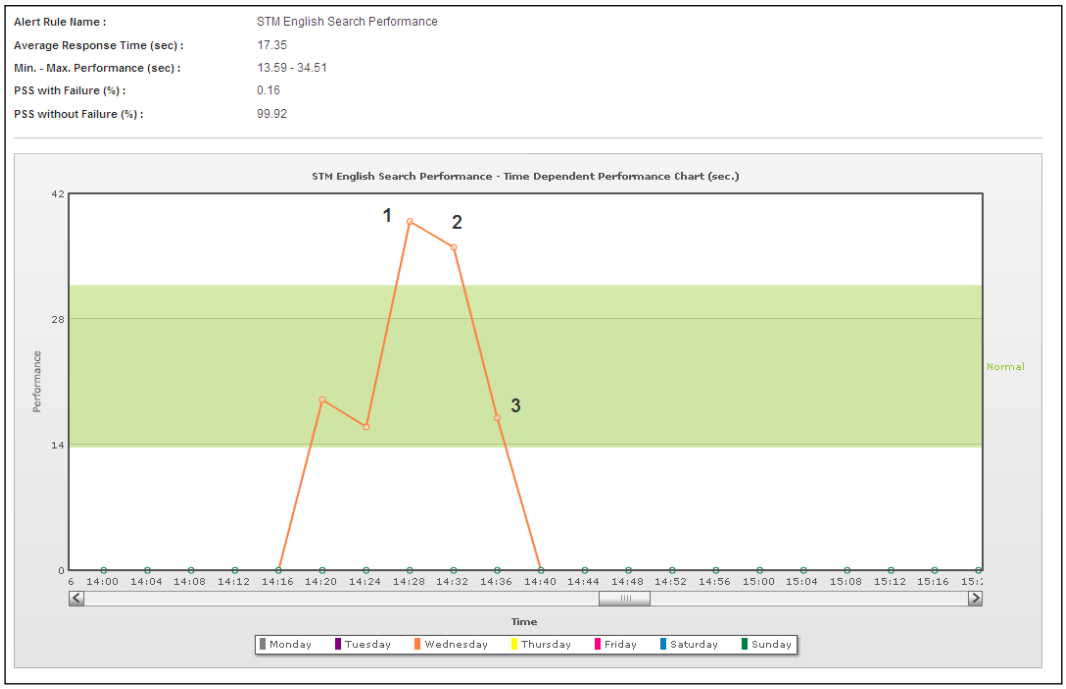

Figure 40 Performance Degradation in the Chart

MyToolset has examined that it is raising the failures (execution of the Web-Based Application Workflow or the performance degradation) accurately. While MyToolset server loads and Internet connection instabilities, the alerts can be raised incorrectly. So, there should have been stable Internet connections and the stable CPU execution was necessary to run the MyToolset components. MyToolset is omitting the IMacros Macro Execution failures because of the error in the macro data script or the IMacros Executer Engine.

Step 9 – Performance stability score (PSS) generation

"Mathematical Model and Algorithm" section contains Performance Stability Score (PSS) calculations. It consists of calculation. They have names respectively Performance Stability Score with Failure (PSSWF) and Performance Stability Score without Failure (PSSWOF). PSSWOF doesn't include failure points. PSSWF is calculated as 0.16% (see Figure 40) and it is increasing while normal response time occurs weekly. This was calculated with Mathematical Model of MyToolset as described before. PSSWOF calculated as 99.92% normal performance changes occurred weekly. Both of the calculation is starting from the last Monday of the current week. If there is no performance degradation on Web-Based Application Workflow, then its Performance Stability Score without failure points will be 100% and it means Web-Based Application Workflow has high availability.

Step 10 – Preparing the WBAW Failure Environment

Although it is not related to the performance directly, it will be shown below the failure tests can be done on MyToolset too, because, the failure is related to the performance of the Web-Based Application Workflow. If any of the Web-Based Application Workflow instance is not running or well deployed, how can it be told about the performance stability? Apache Tomcat JSP Examples will be used for Web-Based Application Workflow failure tests. So, one more Tomcat Application Server was installed and it is running on the 8080 port (http://localhost:8080). This is presented in Figure 41.

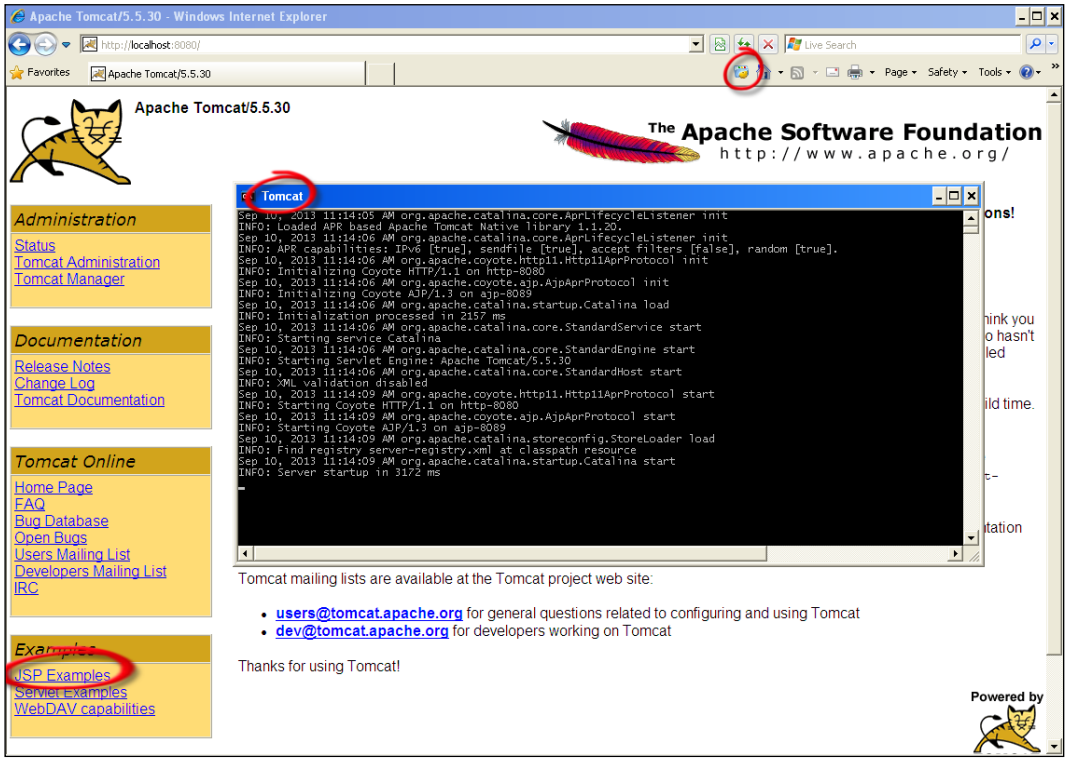

Figure 41 Tomcat Instance running on port 8080

JSP Examples will be used to simulate the Web-Based Application Workflow failures. It has the link on the Tomcat Web Application Server home page. Tomcat Command Line Window is displaying the startup information. We will use the IMacros Macro Recorder (IMR) to record the Web-Based Application Workflow failure tests. The IMacros Macro Recorder is given on the above screenshot. After IMacros Macro Recorder window is opened and “JSP Examples” link is clicked. The “Numberguess” application, which is Java Server Pages (JSP) based web application, will be used. Record should be chosen (see Figure 42).

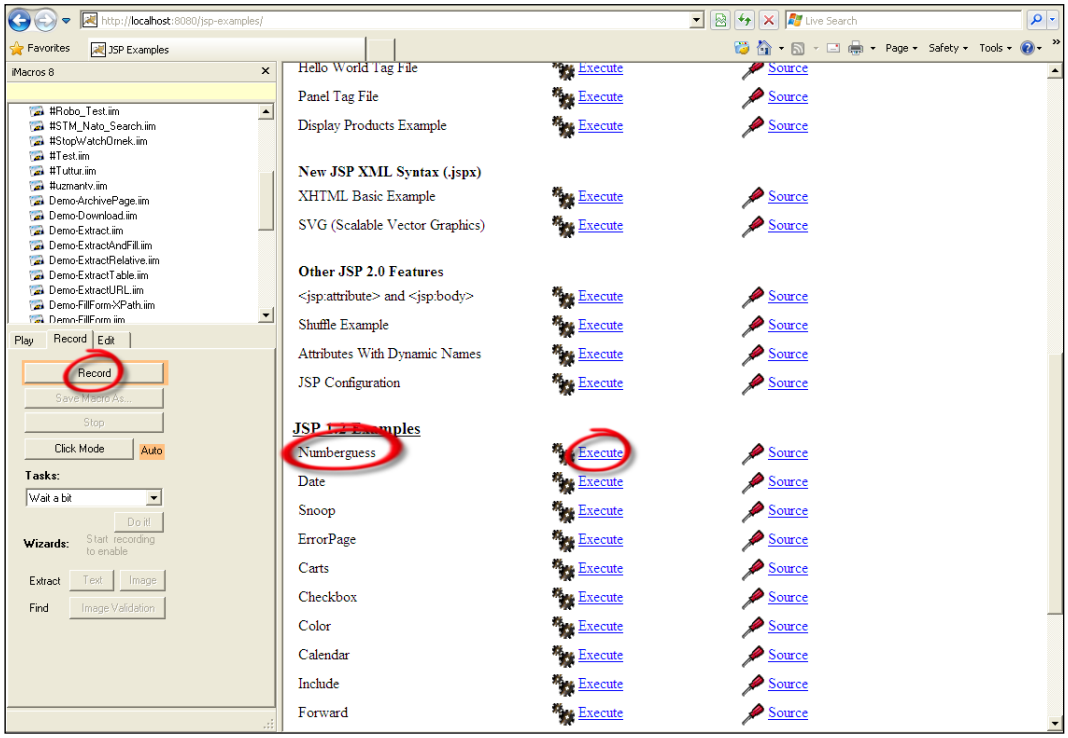

Figure 42 Numberguess Application Execution

It should be clicked on the “Execute” (see Figure 42) to run the “Numberguess” application. The “Numberguess” application will be using to check the application working properly or not. Tomcat server that hosts the “Numberguess” application will be stopped to achieve this goal. After stopping the Tomcat server, it is expected that MyToolset will catch the Web-Based Application Workflow failure and raise the alerts, configured with the relevant wait time. Firstly the “Numberguess” application home page should be recorded. The Add Command is used to create the appropriate line of script (see Figure 43).

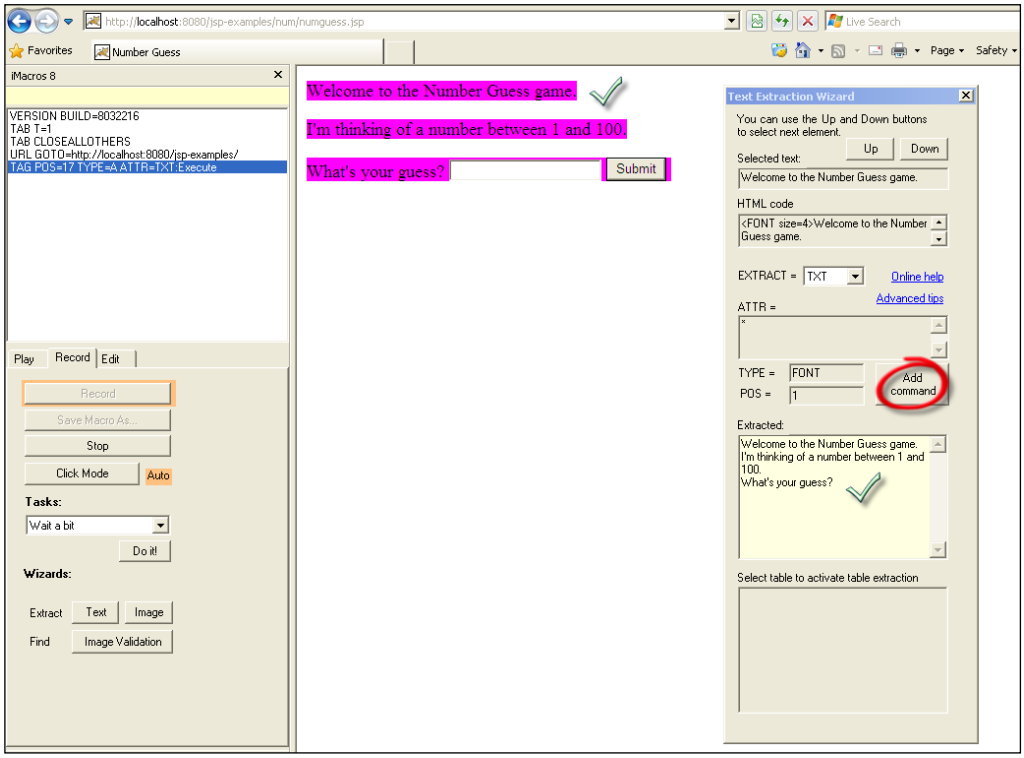

Figure 43 Execution of the Numberguess application

After this, the IMacros Macro Recorder (IMR) should be stopped and play the script that it should be tested correctly or not. When it is correctly recorded it will be completed its execution like in Figure 44.

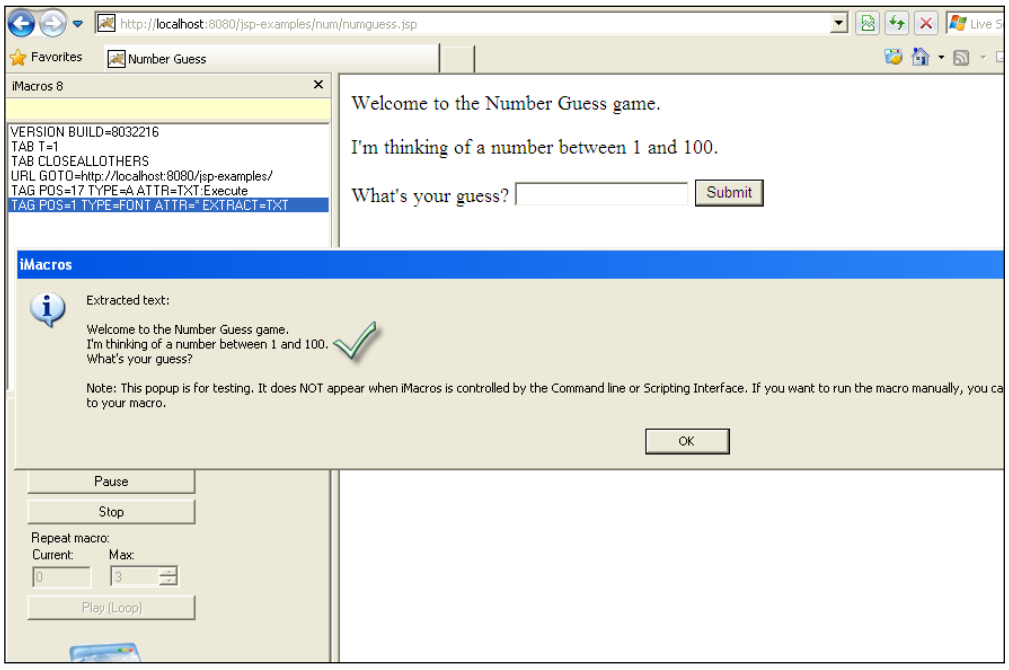

Figure 44 First Page of the Numberguess Application

Step 11 – Creating the WBAW Failure Configuration

It is time to create the appropriate “Failure Test Automation” configuration (see Figure 45) and its relevant “Numberguess Application Failure Test” alert rule.

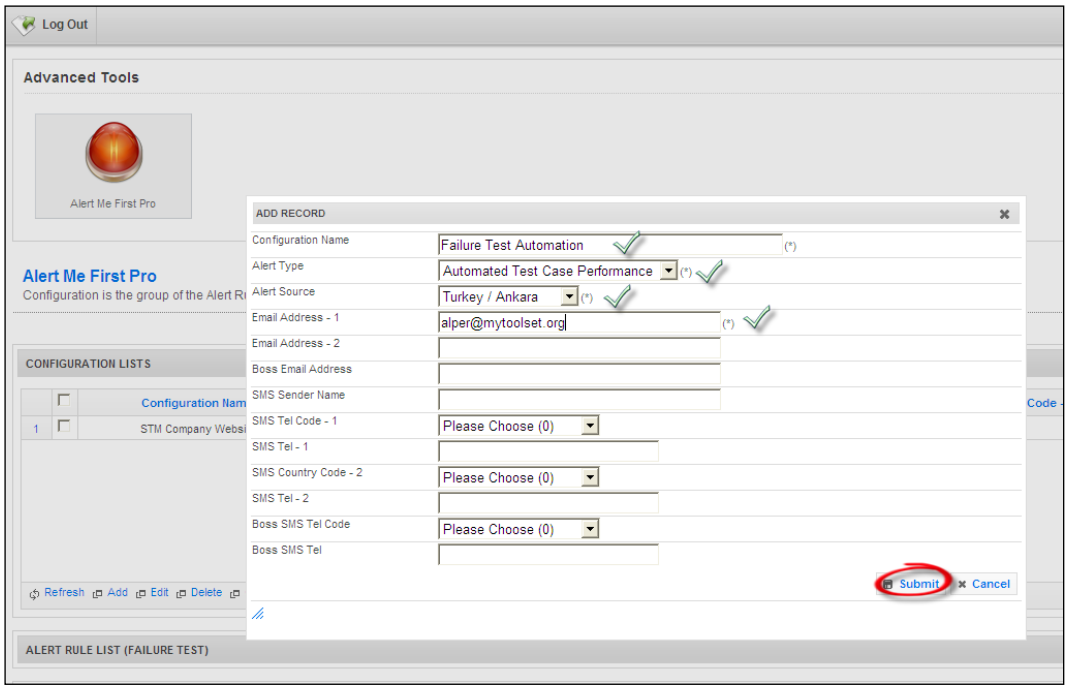

Figure 45 Creation of the Configuration

Step 12 – Adding the WBAW Failure Alert Rule

After selecting “Failure Test Automation” configuration in the list, the “Add” command button is clicked the “Add” button to add the “Numberguess Application Failure Test” alert rule. “Submit” button will be clicked to save the alert rule (see Figure 46). It should be tested by using the “Macro Test” button.

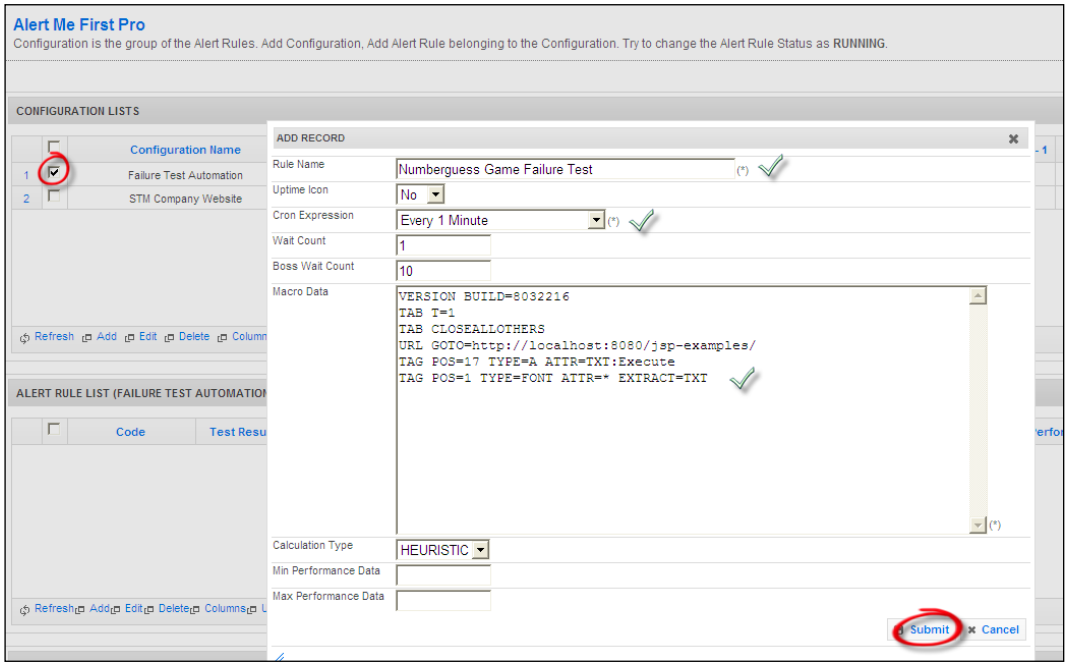

Figure 46 Creation of the Alert Rule

If it passes the Macro Test successfully, then the status can be run to be able to execute the Alert Rule at every 1 minute. “Status” button can be used to run the Alert Rule at the given period.

Step 13 – Generating the Web-Based Application failure

Now the Web-Based Application Workflow (WBAW) failure can be started to test. The second tomcat that is running on port 8080 (see Figure 47) should be stopped to create the Web-Based Application Workflow failure. The Tomcat command line window should be clicked to close to operate the Tomcat App Server Instance.

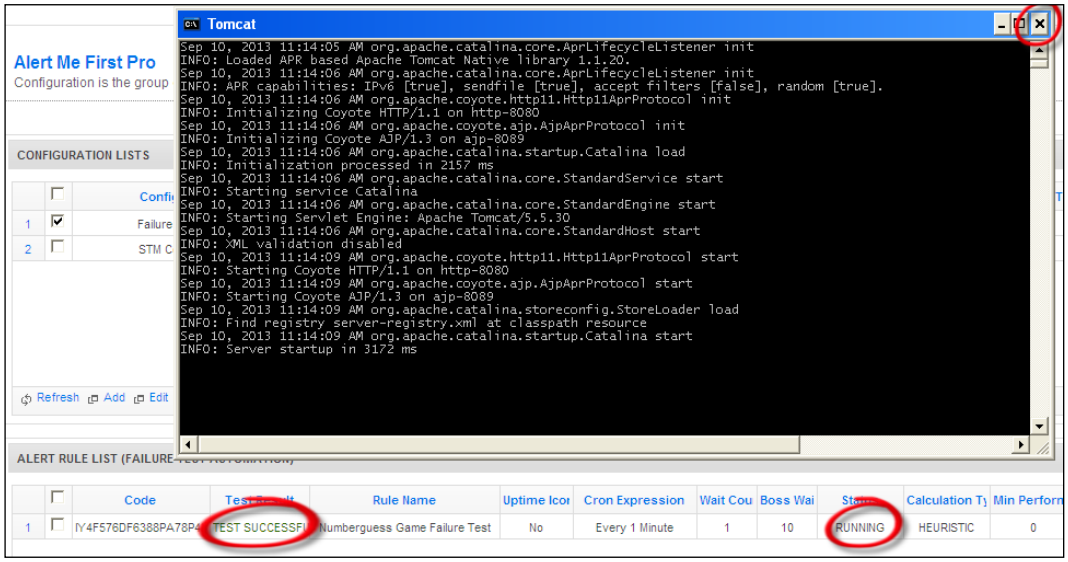

Figure 47 Apache Tomcat, hosts the “Numberguess” Application

After killing the Tomcat 8080 process, MyToolset will wait to raise the alert. The IMRun cannot navigate the Web-Based Application Workflow. So, this will cause the Web-Based Application Workflow failure. What the Tomcat log indicates can be found in Figure 48.

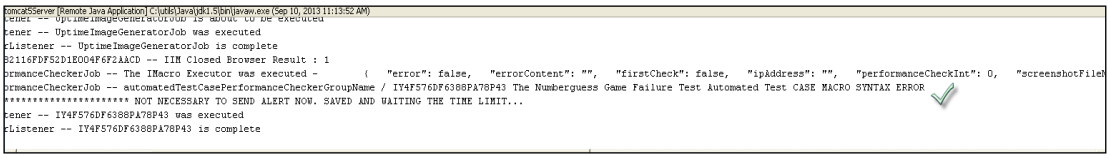

Figure 48 Log of the First Failure Alert

The failure alert is raised and the evidence screenshot is created. Log content, which is including “THE CREATED EVIDENCE FILENAME IS XXXX.png IS ID 140” line, was logged. “THE TIME LIMIT BEING REACHED TO SEND FAILED MESSAGE” means that it is time to send raised alert (see Figure 49).

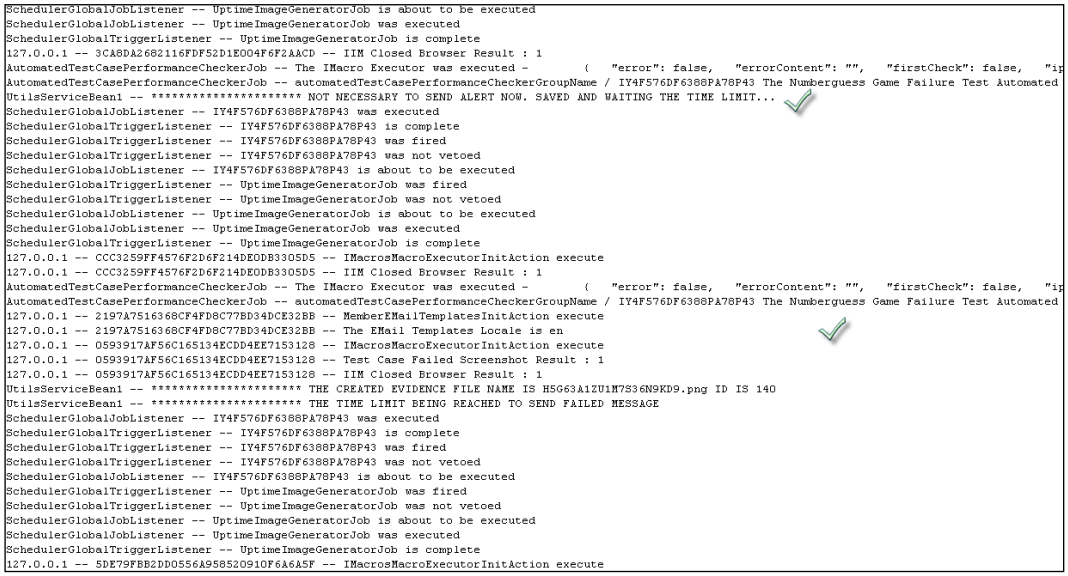

Figure 49 Log of Raised Failure Alert

Step 14 – WBAW Failure in Performance Chart

In addition, these Web-Based Application Workflow failures do not affect the PSS. The marked value is the Web-Based Application Workflow failure value. It is given as first circle in Figure 50. Web-Based Application Workflow will start to work again to get the statistics, after starting Tomcat 8080 again. It is shown as a second circle in the figure.

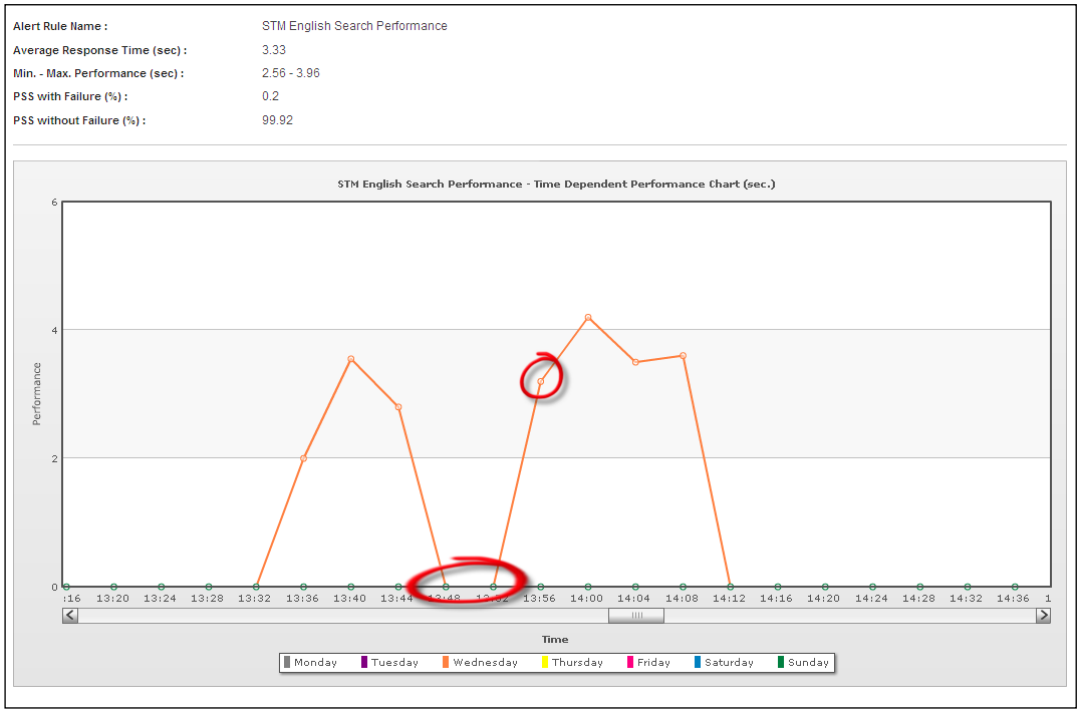

Figure 50 Application Failures and Performance Degradation

It proves that MyToolset monitoring will not be stopped to check the "Numberguess" application during Web-Based Application Workflow failure. The failure and success email alert screenshots are given in Figure 51-52.

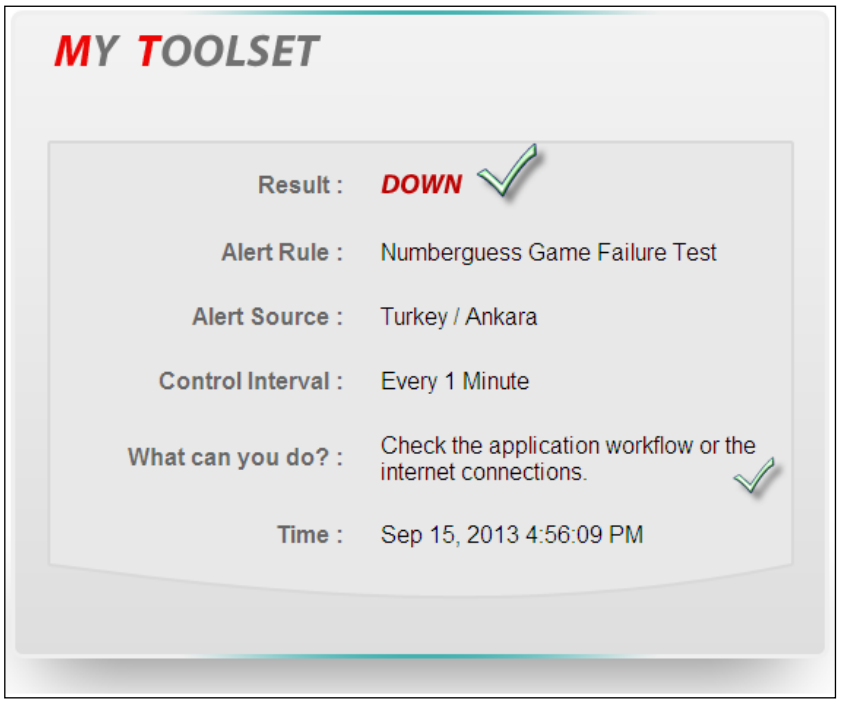

Figure 51 Failure Email Alert

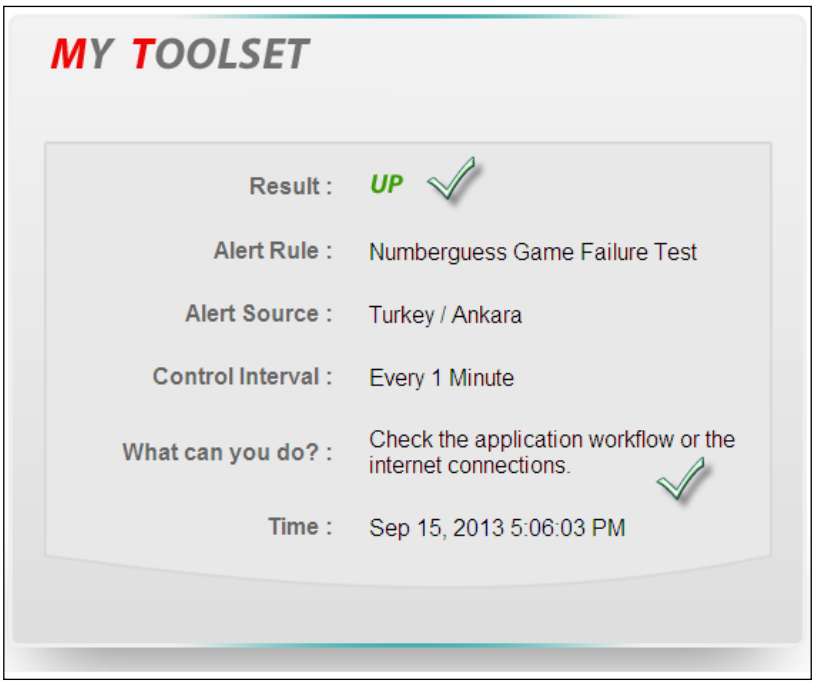

Figure 52 Success Email Alert

The evidence files were taken when the Web-Based Application Workflow failure and success were happened. It can be noticed that the failure evidence file contains the screenshot when the browser tries to connect to the failed Web-Based Application Workflow. There is error screenshot at below. The success evidence file contains the fixed Web-Based Application Workflow evidence file.

Step 15 – Examining the Success and Failure Evidences

MyToolset takes the screenshot of the failure and success (see Figure 53-54). These screenshots can be used to prove the failure and the fixed the problem and everything is normal.

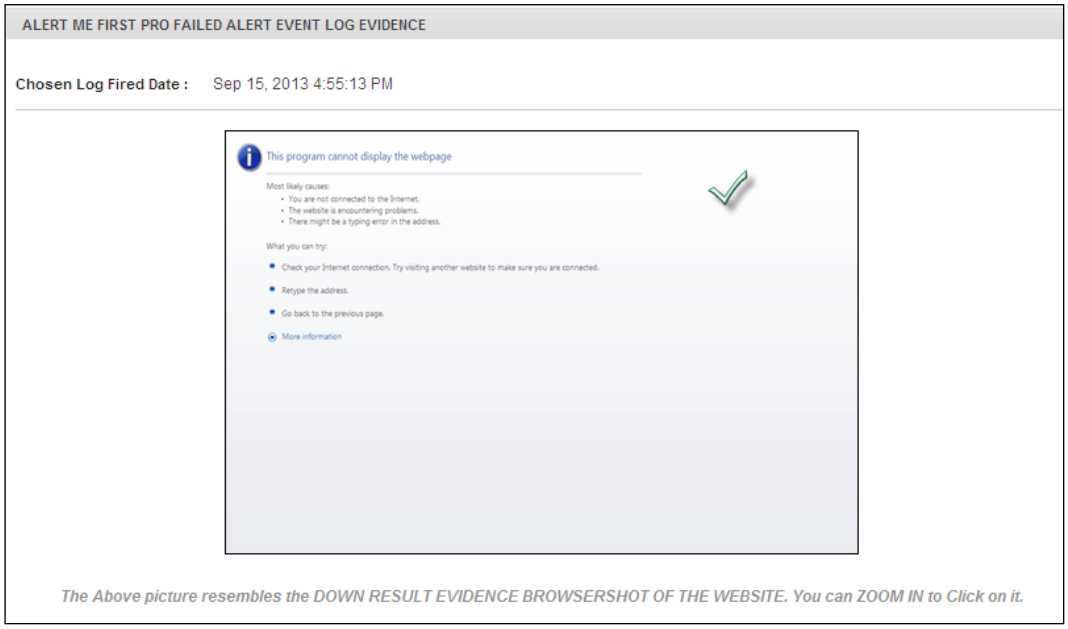

Figure 53 Failure Evidence Screenshot

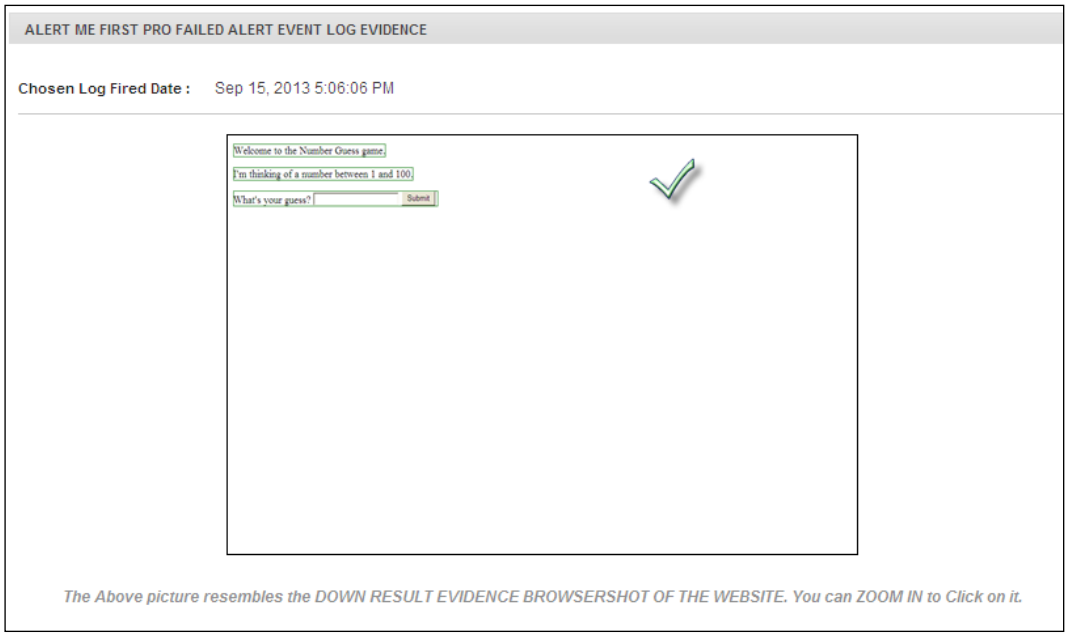

Figure 54 Success Evidence Screenshot

CHAPTER 5

DISCUSSION AND CONCLUSION

Web-Based Application Workflow testing, monitoring, and its Performance Stability Score can be used to monitor the whole system, test automation, and make the capacity planning of server-side resources such as hardware, network and applications. This section discusses the successes accomplished when the MyToolset has been used, and presents possible advantages and disadvantages of MyToolset. In addition, suggestions and recommendations for the future works are presented.

1. Successes

MyToolset can be used to monitor the Web-Based Application Workflow performance and test the WBAW failures. The MyToolset mathematical model contains how-to calculate the dynamic performance interval. Web-Based Application Workflow user loads change time to time and MyToolset can detect those changes dynamically. So, it is not necessary to monitor and configure the Performance Interval all the time. This will prevent to raise false positive performance alerts. For example; Some Web-Based Application Workflow has the heavy user loads on weekends and rare user loads on weekdays. So, the performance interval max and min boundary values should be calculated by using the average and standard deviation values in the mathematical model on the fly. MyToolset can take the evidence screenshot when the failure occurs and also screenshot is taken when the performance degradation is no longer continue or the Web-Based Application Workflow failure was resolved.

MyToolset can handle and simulate successfully on the HTML- JavaScript based, Silverlight and Flash based virtual user browser surfing abilities. So, very many types of the Web-Based Application Workflow can be tested or monitored by MyToolset.

2. Advantages

Web-Based Application Workflow Tests can be a big problem time to time, because Web-Based Application Workflow has some instability between deployments, bug resolutions and the new feature developments. So, the regression tests, which are done for all changes and their impact on the Web-Based Application Workflow, which should be handled carefully, and the creation of regression tests will cause very much works and stress on the test team. MyToolset can test the Web-Based Application Workflow and the regression tests will be done periodically and automatically or the manually started whenever the test team wants. Some changes will be handled automatically with their impacts while MyToolset is running the tests. In this way, test automation will be handled without running hundreds of test cases again and again.

It is good for the boss or the managers to follow-up the Web-Based Application Workflow failures and performance degradations which are still not fixed. It means that MyToolset saves the investor's money to have profitable business. How many seconds, minutes or hours even days Web-Based Application Workflow interruption will be reported with the accuracy of day, hour, minute, and second. In addition, the development and deployment teams can use MyToolset after deploying the fixes to test the failures and performance automatically.

MyToolset supports the well-known browsers for automation such as; Internet explorer, Firefox, and Google Chrome. It can be the real evidence of the failure to prove the technical team that there is a problem or performance degradation on the Web-Based Application Workflow system.

3. Disadvantages

MyToolset VM Servers need to establish 7x24 fast and reliable Internet connections. It also needs to transfer many data on the wire to execute macro data. So, the quota on Internet connections will not be suitable for running the MyToolset, either. It is using the reliable online email and SMS configuration to warn the persons when it encounters the performance degradation and failure or the Web-Based Application Workflow bugs. These investments are the extra costs of maintain the MyToolset.

If you upgrade the client side code or library, used by the Web-Based Application Workflow, then this can cause browser specific restrictions. So, MyToolset browser specific macro runner can fail even your application is working on the current new version of the browsers. MyToolset supports only Internet Explorer, Firefox or Google Chrome. The Flash Chart component cannot support the one-minute time intervals, it supports at least four minutes during twenty-four hours on each day. So when fail or success alert is raised in consecutive four minutes (i.e. four times one minute) period then it cannot be shown as failure even the failure alert raised.

All of the calculations and monitoring activities are running on those servers. So, the job server and the Tomcat application server farm should be hosted at a minimum four cores and four GB memory.

4. Suggestions

MyToolset can raise false positive alerts, if you have no stable Internet connections. These network performance waves create the instability on the mathematical model even though the mathematical model uses mean and standard deviations to find the best performance interval. It is recommended to be careful to use the browser specific features on the client side implementations. Wait count of the Alert Rule should be given by trying the best value. Most probably, it is not effective to give the wait count as 0. Even, MyToolset includes the built-in one wait count.

5. Future Work

Different geographical locations have different network connection latencies to connect to the Internet. Alert agents can be implemented to run the Macro Data Scripts on different geographical locations. This will help MyToolset to detect network problems even though the Web-Based Application Workflow is working properly.

MyToolset can use server agents. These server agents can run the rules like the Macro Data Script rules. These rules can fix the server side problem, for example; restarting the server or application instances, killing the processes and

deleting some log files and so on… This feature allows the system administrations to resolve the issues on the nights and even system admin on vacations even they are not in front of the remote server connections.

MyToolset network analyzer can be added to detect the MyToolset server network connection problems and connection speed degradations more accurately. More stable sites can be monitored to check the availability of the network connection and its performance.

MyToolset can be integrated with ticket systems. The interruption on systems can be forwarded as a new work item on ticket systems to follow the solutions easily.

Mobile version of the administration console and reports can be created. SMS and mobile based managed the systems will improve the mobility and usability of MyToolset.

Alert Rule dependency can be added to MyToolset. Sometimes, one Alert Rule is the execution result dependent to another. For example; if you check the shopping basket work flow execution, it is dependent of running the home page of the Web-Based Application Workflow. Shopping basket Alert Rule will not raise alerts After Alert Rule of Home Page execution fails because if Home Page is unresponsive it is not necessary to raise the shopping basket alert rule failures. Actually, this will prevent the unnecessary failure alerts, to be raised.

Parallel job execution mechanisms and Macro Data Runner core can be used to design massively running load and stress test tool. This will give the ability to web application owners to simulate the real customer, member or the end-user Web-Based Application Workflow usage behavior in the future.

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ACRONYMS AND ABBREVIATIONS

1. Web-Based Application Work Flow (WBAW)
2. IMacros Macro Recorder (IMR)
3. Performance Stability Score (PSS)
4. Hypertext Transfer Protocol (HTTP)
5. Web Browsers (WB)
6. Web Servers (WS)
7. Web Application Servers (WAS)
8. Database Management Systems (DBMS)
9. Hyper Text Markup Language (HTML)
10. World Wide Web Consortium (W3C)
11. Extended Markup Language (XML)
12. Uniform Resource Locator (URL)
13. Local Area Network (LAN)
14. Mobile Network (MN)
15. Wide Area Network (WAN)
16. Asynchronous JavaScript and XML (AJAX)
17. JavaScript Object Notation (JSON)
18. Extended Entity Relationship
19. Integrated Development Environment (IDE)
20. Java to Enterprise Edition (J2EE)
21. Object-oriented analysis and design (OOAD)

22. Unified Modeling Language (UML)

23. Object-oriented analysis (OOA)

24. Object-oriented design (OOD)

25. IMacros Macro Runner (IMRun)

26. Adobe Flash (AF)

27. Performance Stability Interval (PSI)

28. Total Dynamic Failure Point (TDFP)

29. Alert Raised Indicator (ARI)

30. Custom Wait Count (CWC)

31. Low Performance Alert (LPA)

32. Normal Performance Alert (NPA)

33. Java Server Pages (JSP)

34. Integrated Development Environment (IDE)

35. Web-Based Application (WBA)

36. Standard Generalized Markup Language (SGML)

APPENDIX A - LIST OF ALL ACTIVITY DIAGRAMS

Each of the usecases has relevant Activity diagrams. Activity Diagrams show that work flow and the relationship between each of object. The list of All Activity Diagrams are given at below.

“Signup to be Member” activity diagram shows that Firstly creating an activity flows (see Figure 55).

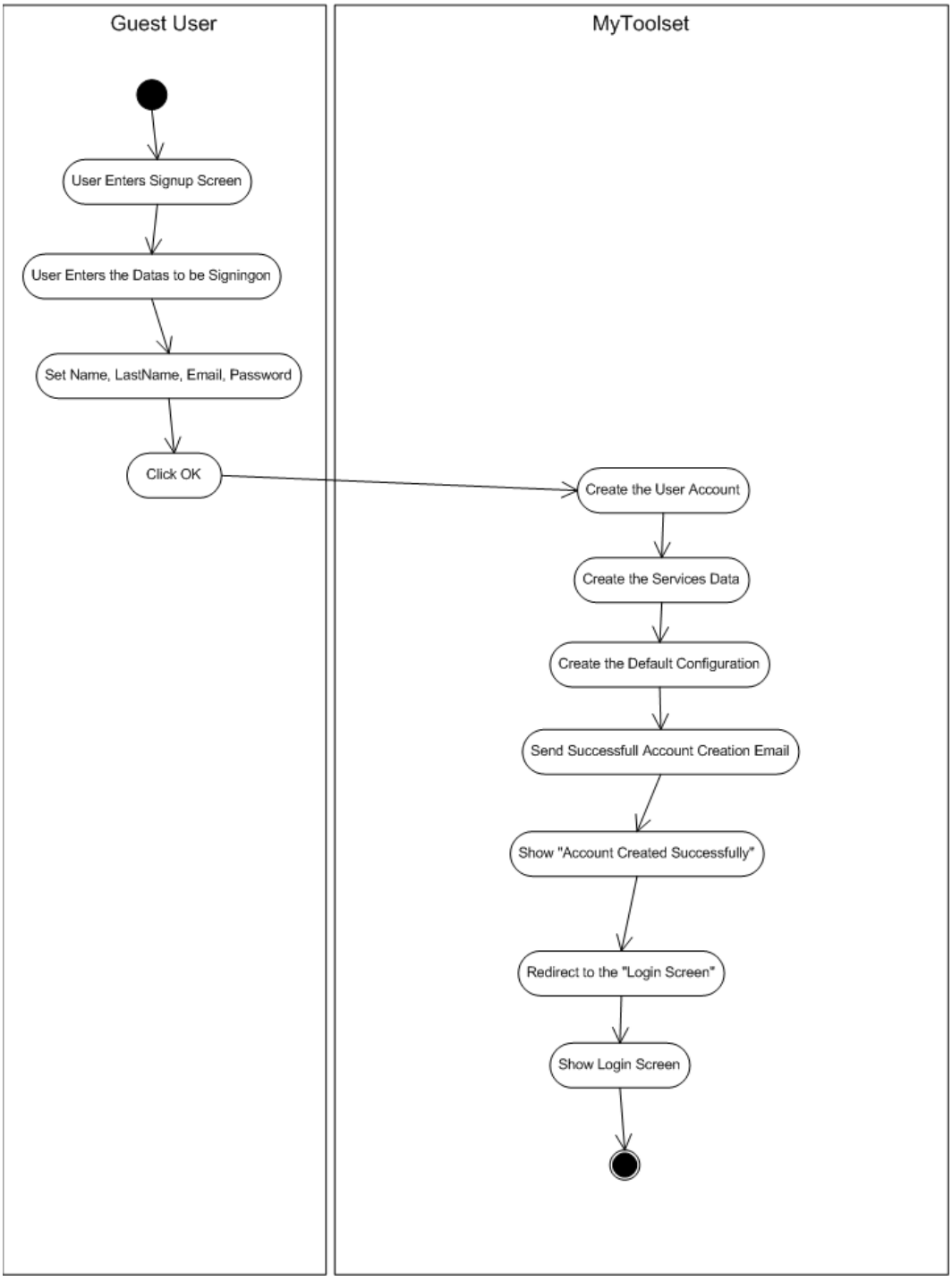

Figure 55 Activity Diagram of "Sign up to be a Member"

“Login as Member” activity diagram shows that it checks the account validity and initiates the first page of the Member Area to enter the member area (see Figure 56).

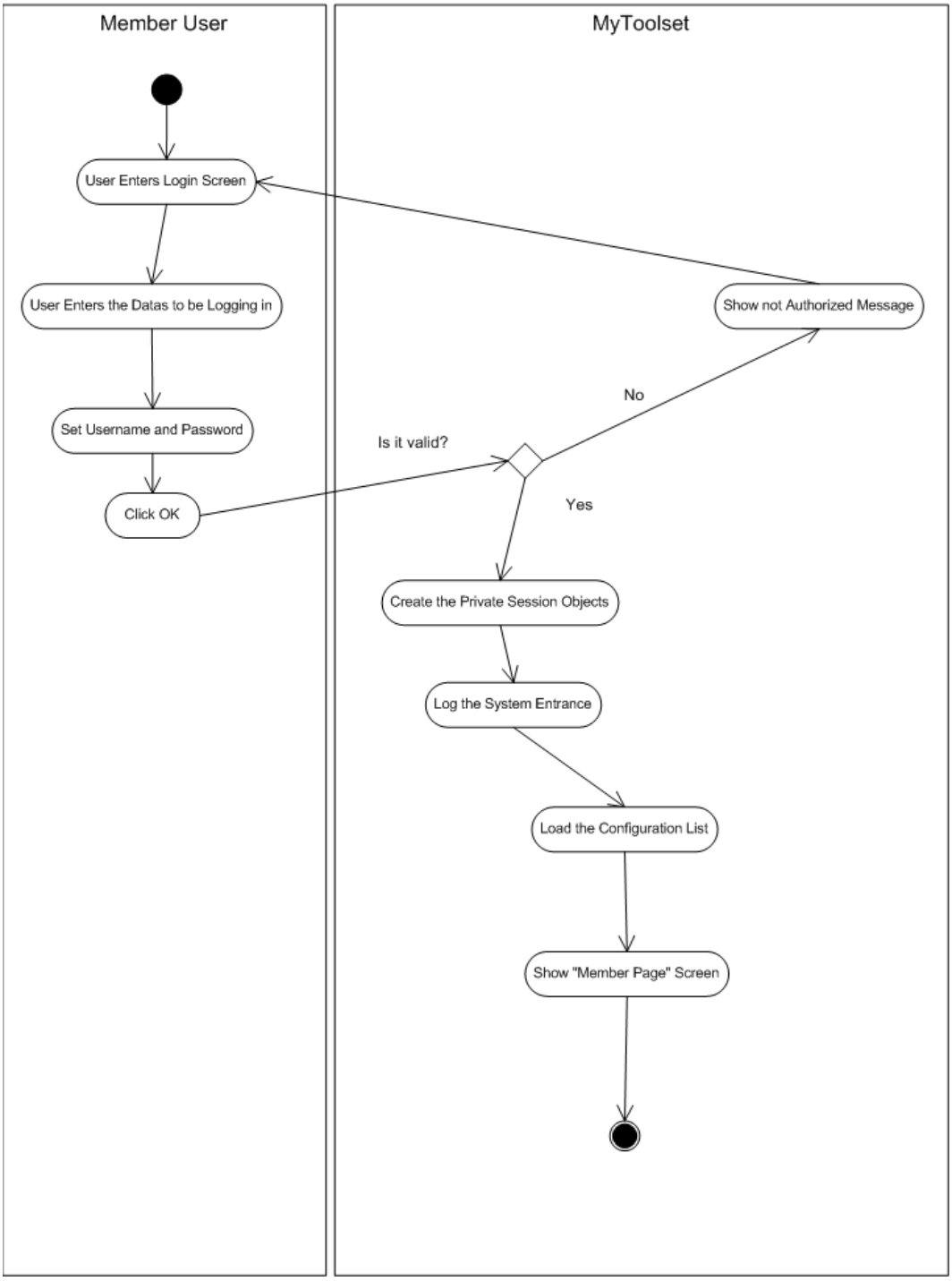

Figure 56 Activity Diagram of "Login as Member"

“Create Configuration” activity diagram shows the creating a new configuration (see Figure 57).

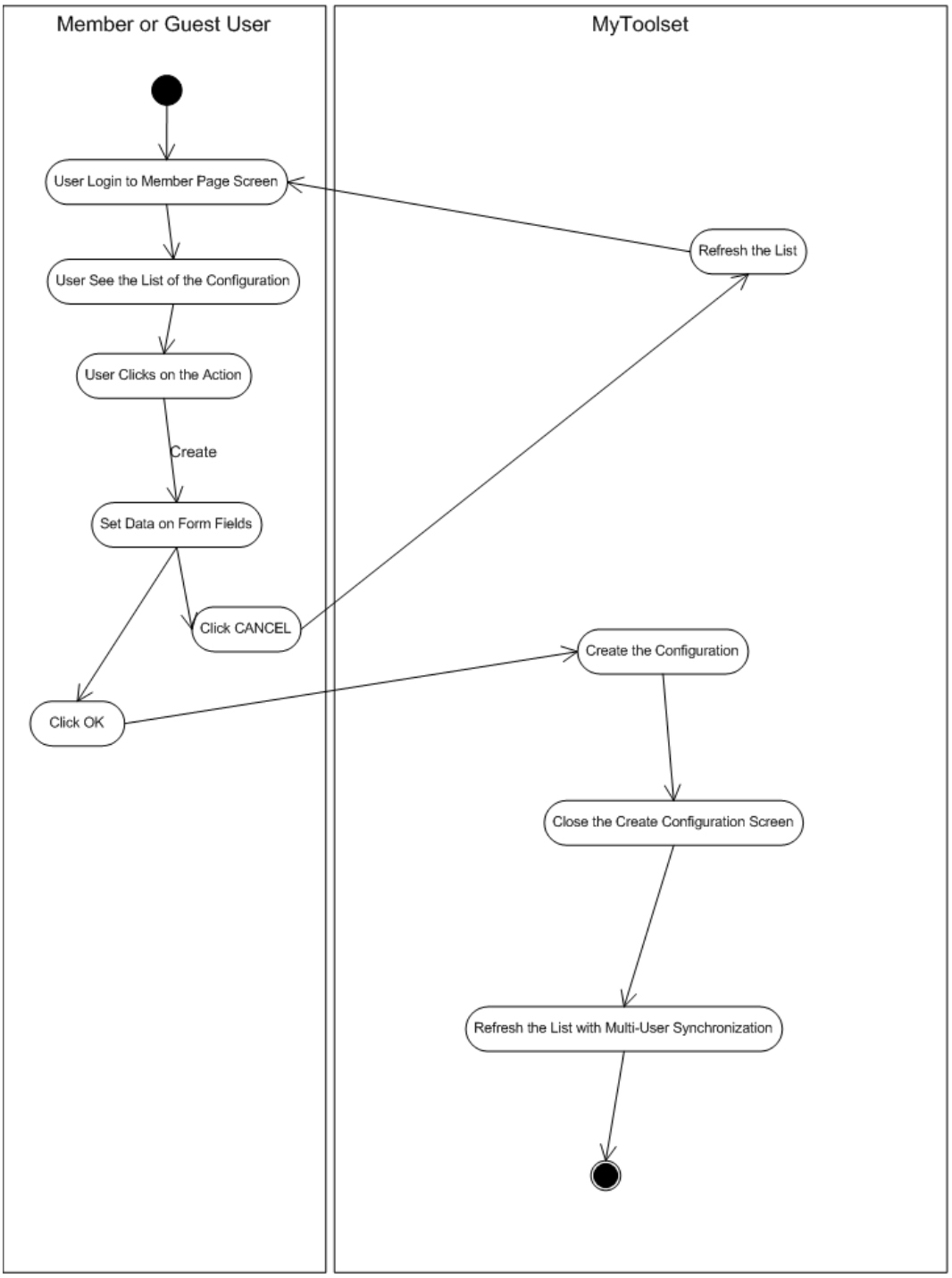

Figure 57 Activity Diagram of "Create Configuration"

“Edit Configuration” activity diagram shows the updating one of the chosen configurations (see Figure 58).

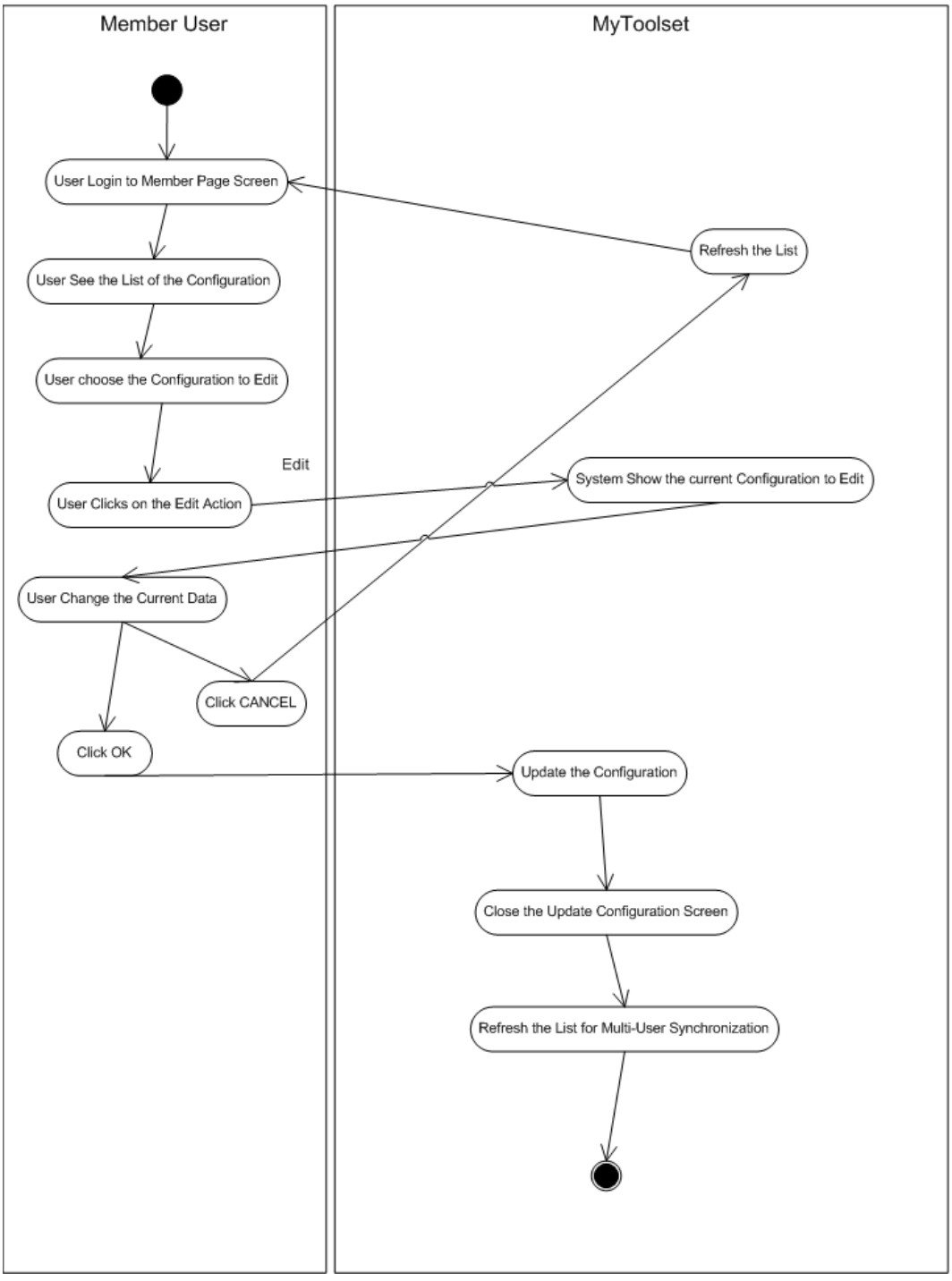

Figure 58 Activity Diagram of "Edit Configuration"

“Delete Configuration” activity diagram shows the deleting any of the chosen configurations and also deleting all of the Alert Rules and Alerts belongs to it (see Figure 59).

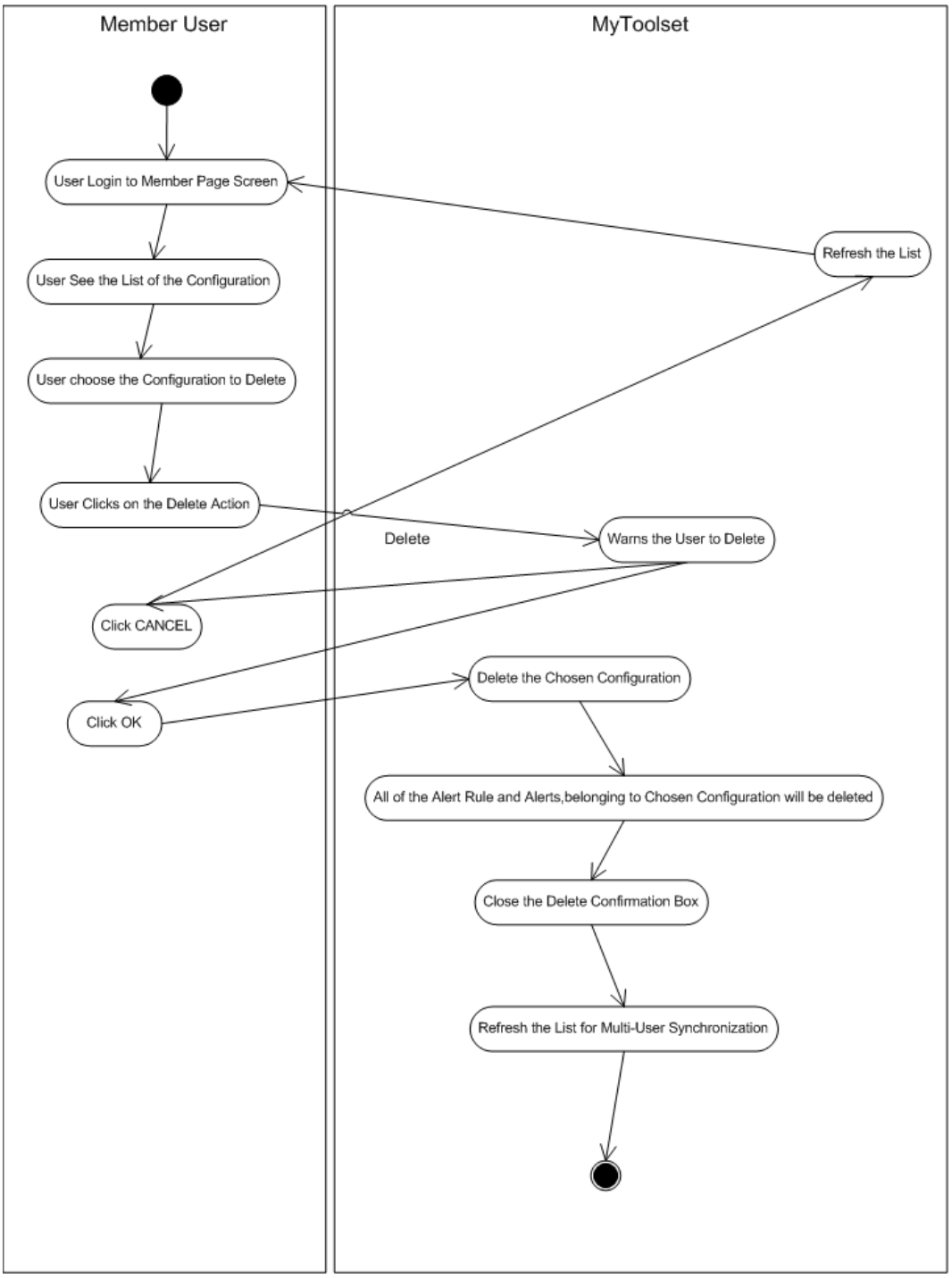

Figure 59 Activity Diagram of "Delete Configuration"

“List Configuration” activity diagram shows the gathering the list of all configurations and clear the list of the Alert Rule and Alert List on the screen (see Figure 60).

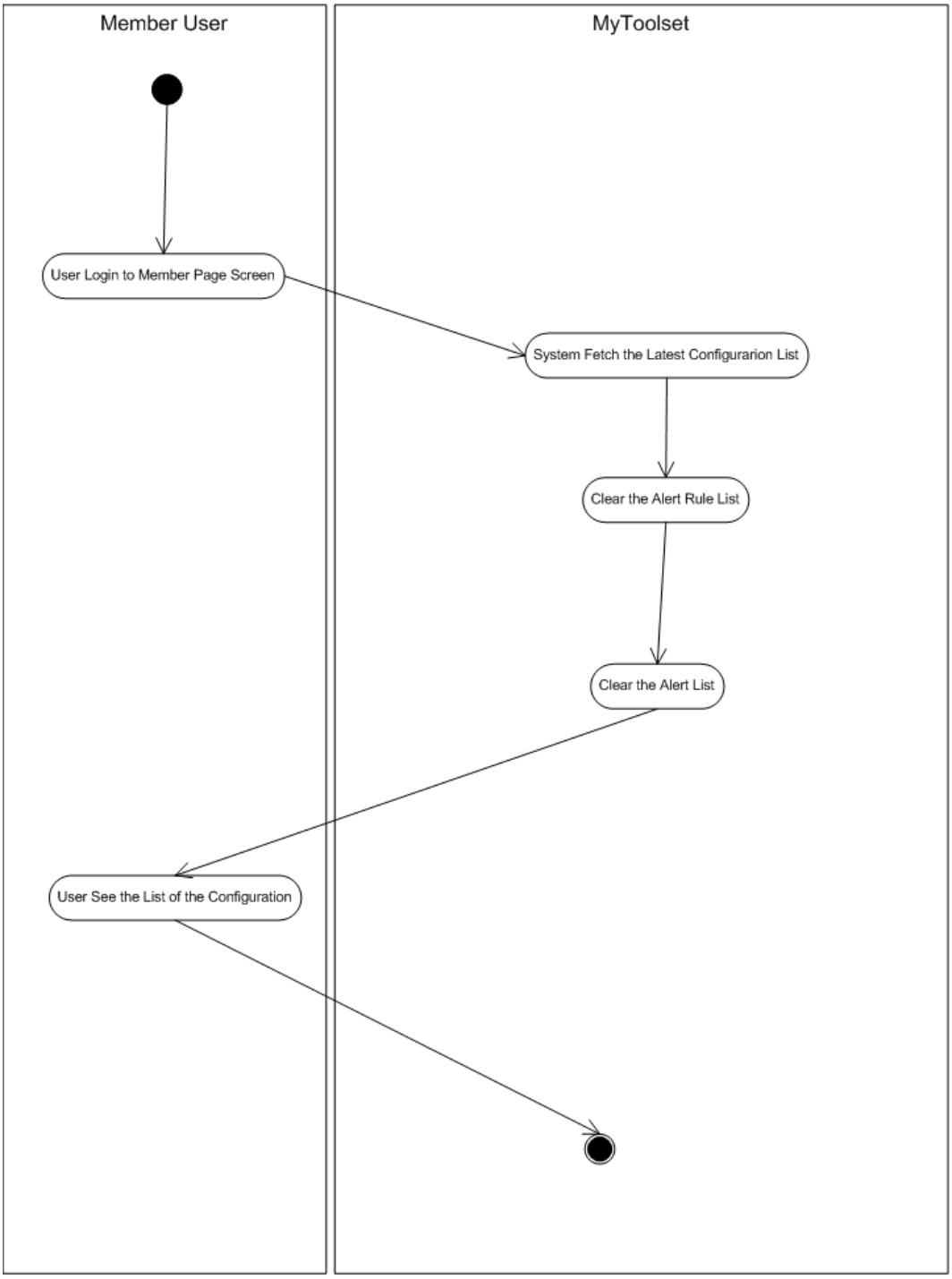

Figure 60 Activity Diagram of "List Configuration"

“Create and Schedule Alert Rule” activity diagram shows the creating the Alert Rule, copy the Macro Data, that was gathered on IMR and Scheduling the Alert Rule. The Alert Rule list was refreshed on the Alert Rule List (see Figure 61).

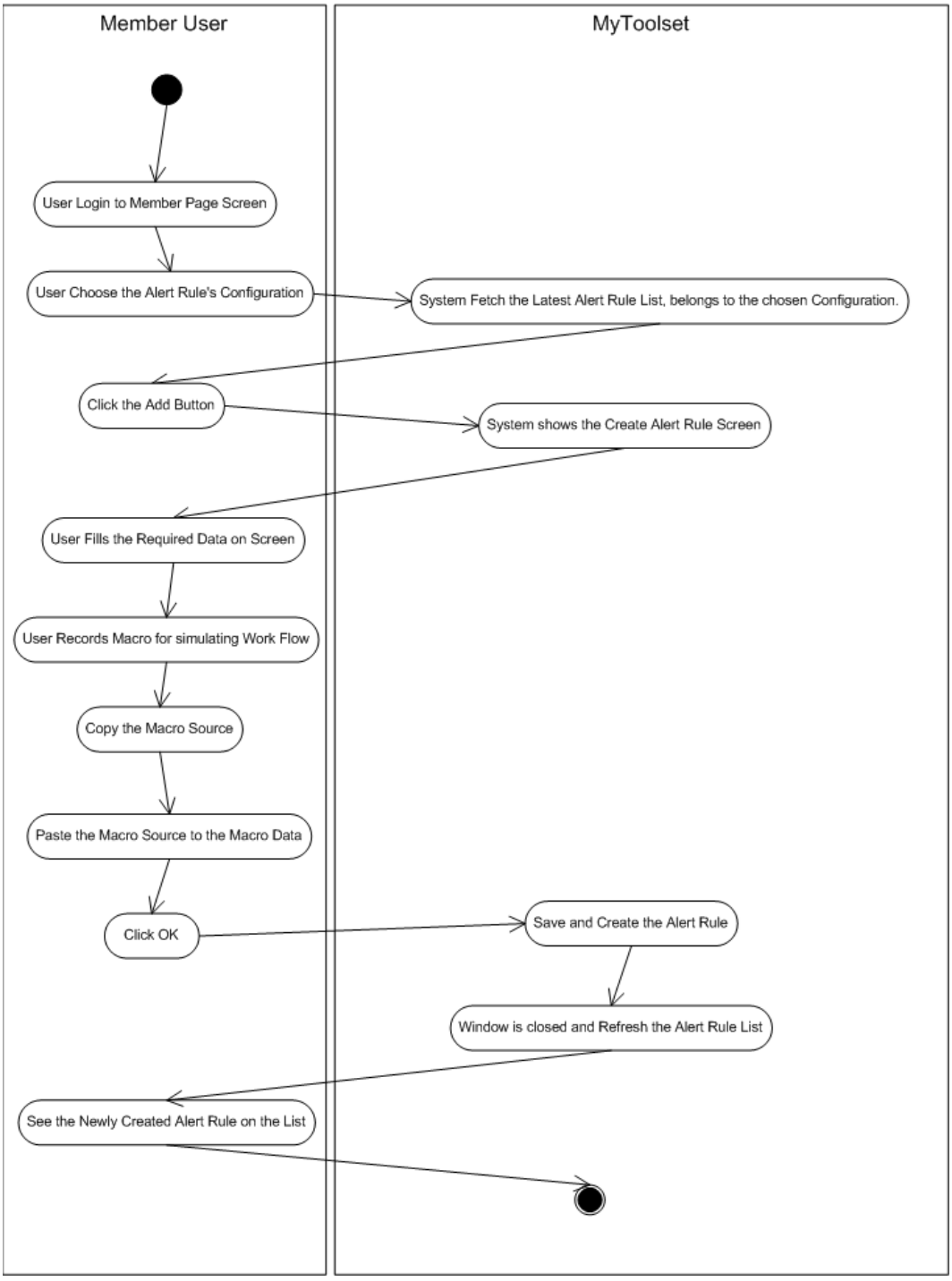

Figure 61 Activity Diagram of "Create and Schedule Alert Rule"

“Create and Schedule Alert Rule” activity diagram shows the recording the IMacros Macro. “Create and Schedule Alert Rule” use case is used to record Macro Data as Alert Rule Macro Data (see Figure 62).

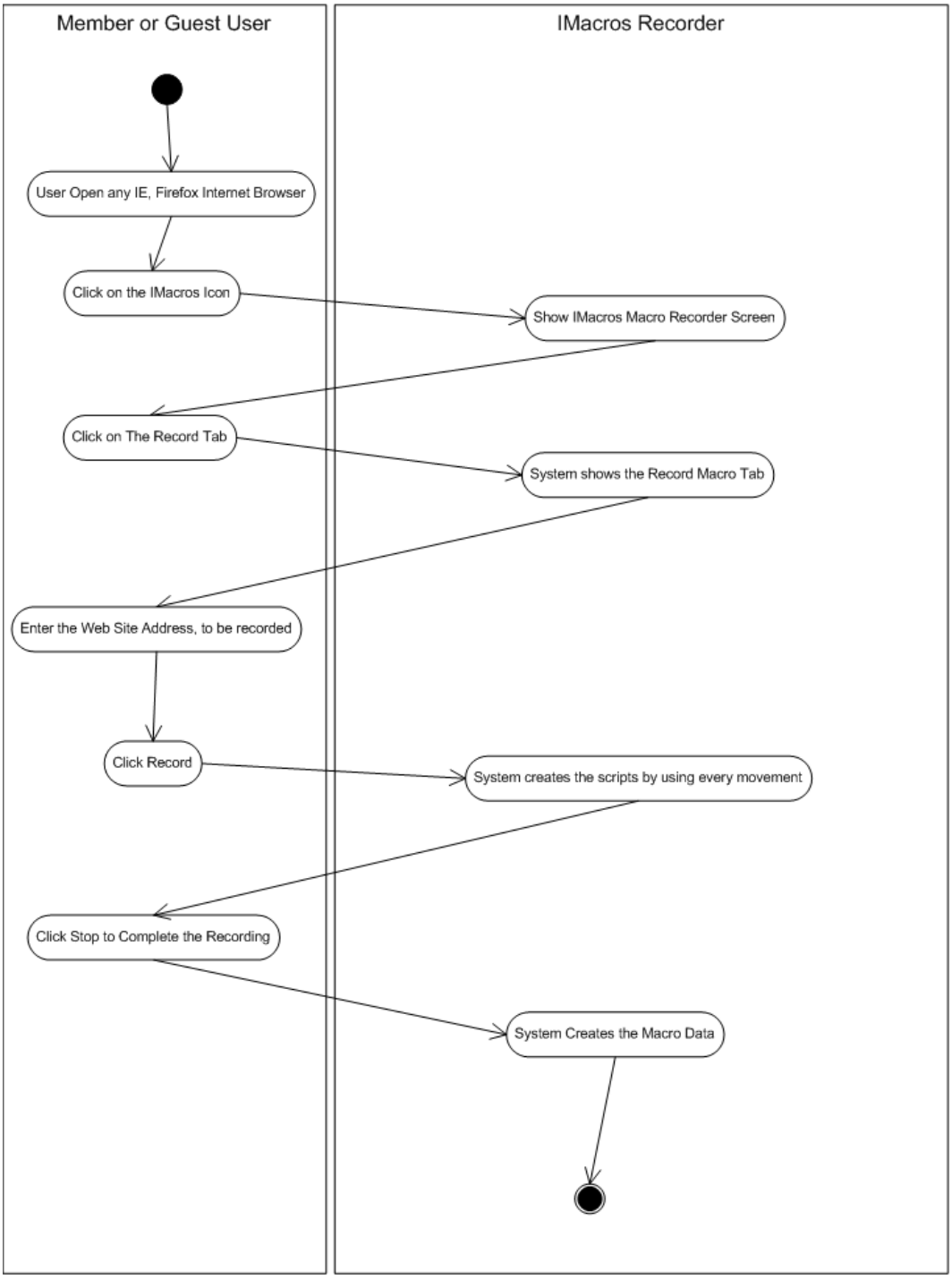

Figure 62 Activity Diagram of "Record Macro"

“List Alert Rule” activity diagram shows the gathering the list of all alert rules belonging to the chosen configuration (see Figure 63).

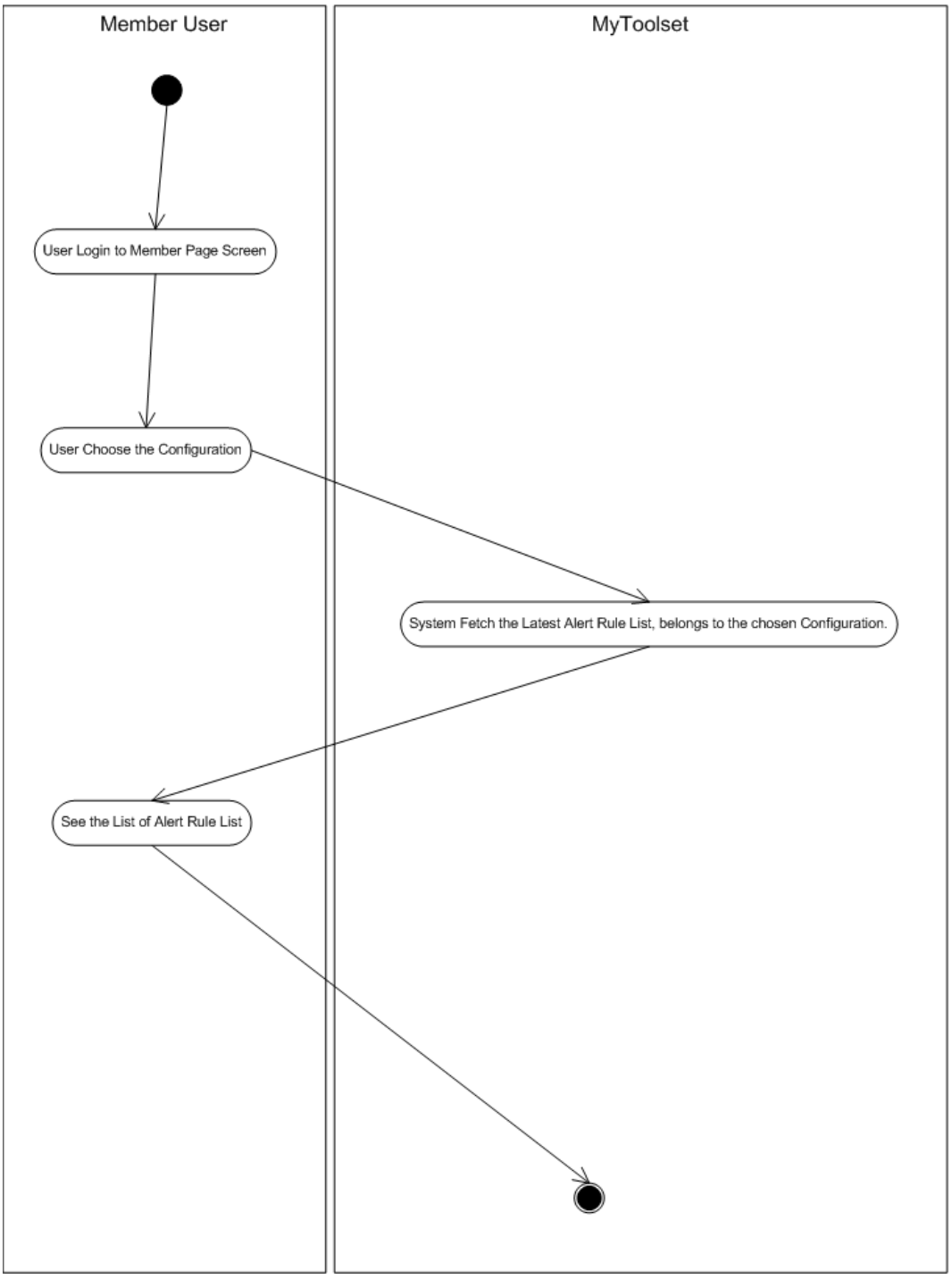

Figure 63 Activity Diagram of "List Alert Rule"

“Edit Alert Rule” activity diagram shows the editing of the Alert Rule. It stops to run current Alert Rule, changes the state of the Alert Rule “Not Tested” and deletes the all of the Alert Data belonging to this Alert Rule (see Figure 64).

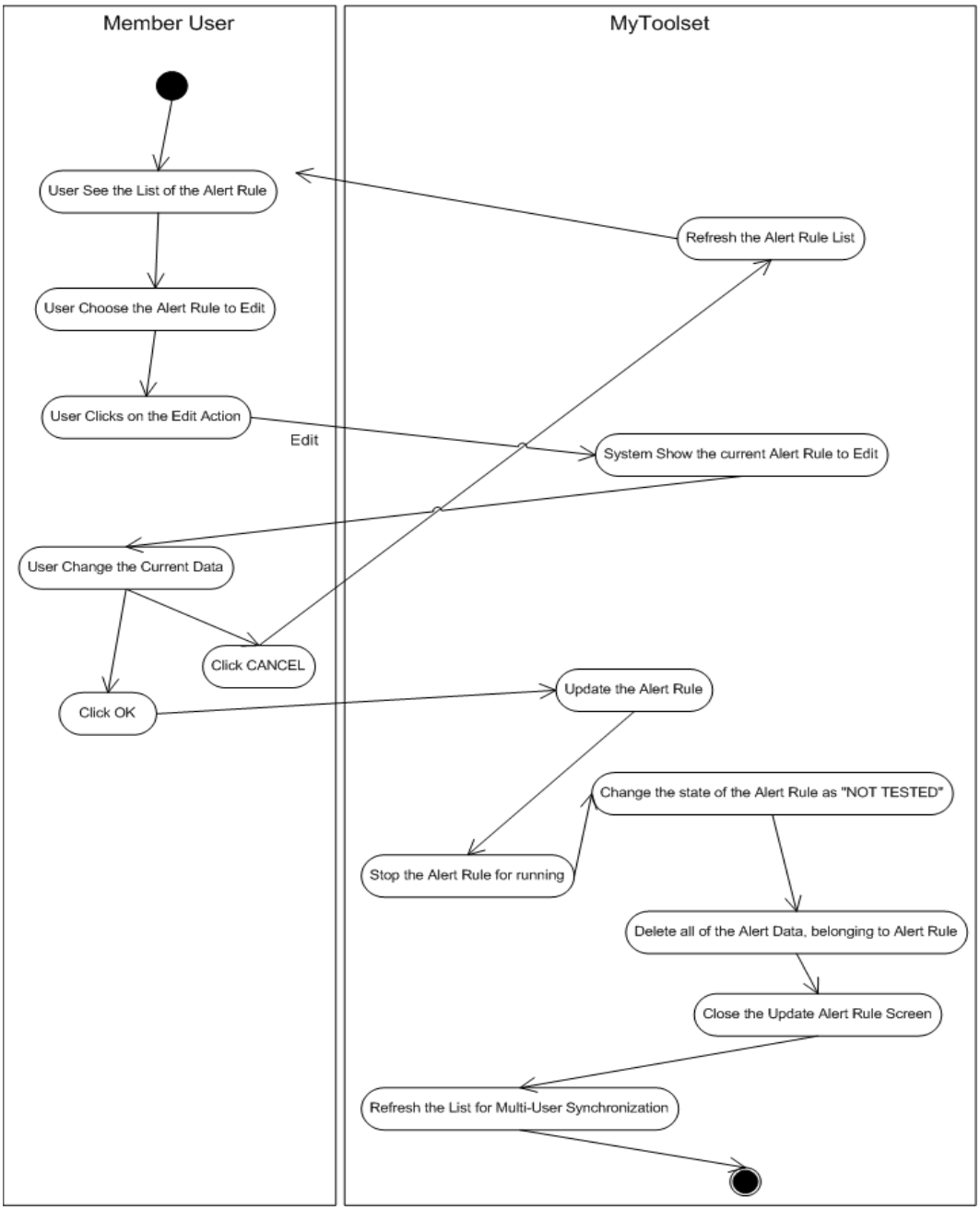

Figure 64 Activity Diagram of "Edit Alert Rule"

“Gather Chart Report 24x7” activity diagram shows the gathering the chart of the response time values during the macro data script execution. It is simulating the Virtual User Browser and its response time values. These values are displayed on Line Chart at 4 minutes period on each day at current week (see Figure 65).

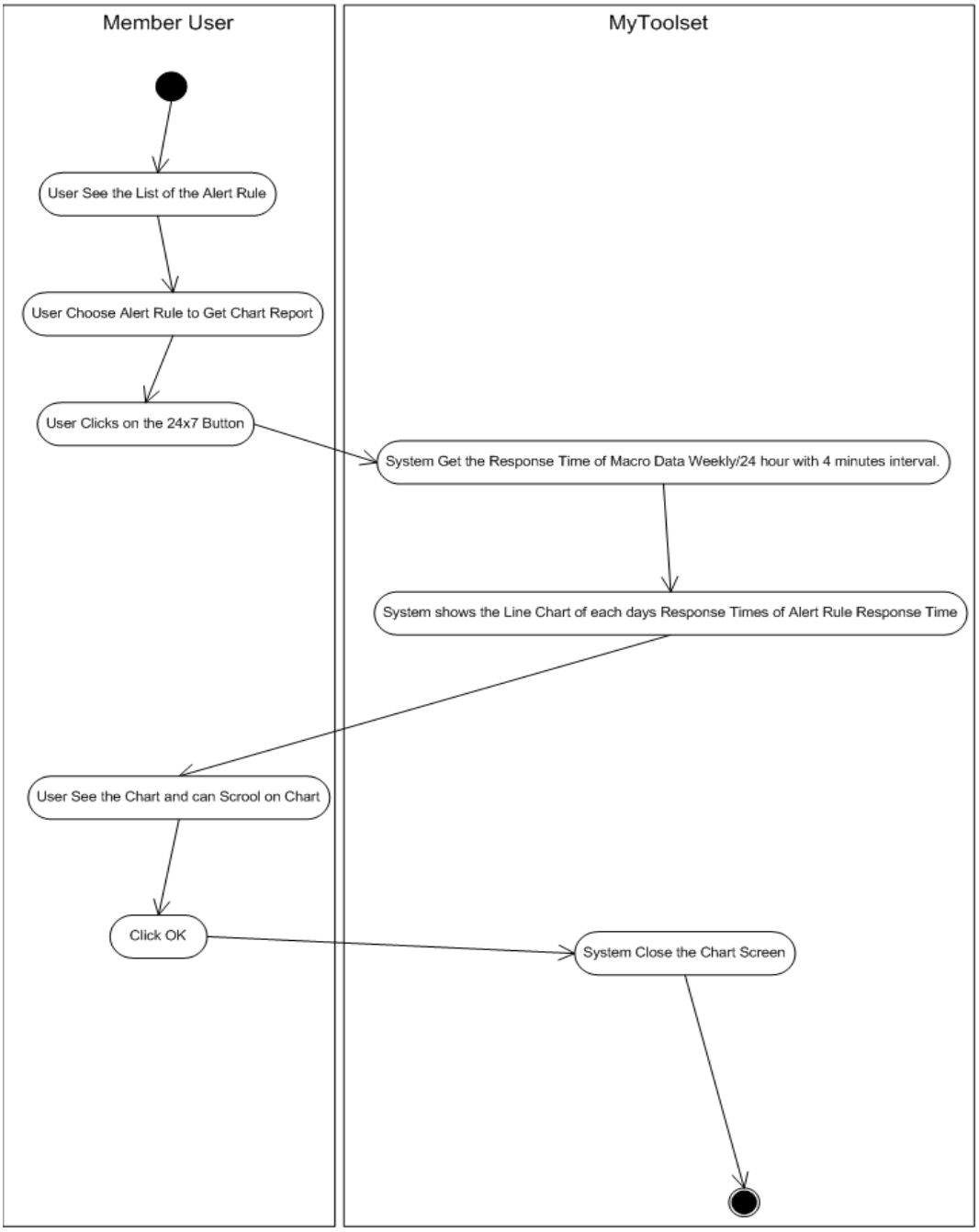

Figure 65 Activity Diagram of "Gather Chart Report 7x24"

"Delete Alert Rule" activity diagram shows the deleting any of the chosen Alert Rule and also deleting all of the Alerts Data belongs to it (see Figure 66).

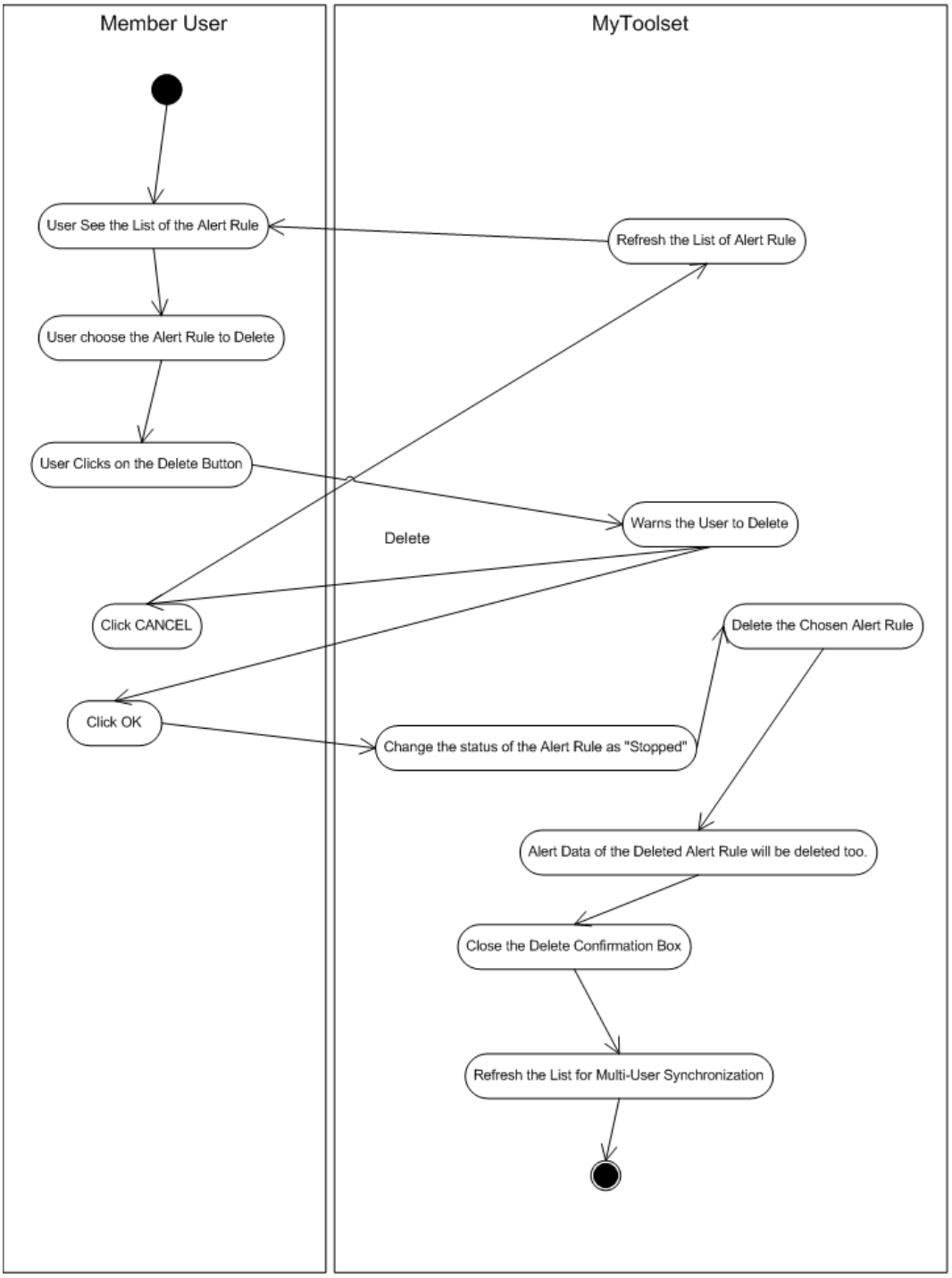

Figure 66 Activity Diagram of "Delete Alert Rule"

“Change Status” activity diagram shows the changing status of the Alert Rule as “Run” or “Stopped”. If the Alert Rule is at Stopped status, it will not continue to collect the Response Time of the Macro Data (Virtual User Simulation) (see Figure 67).

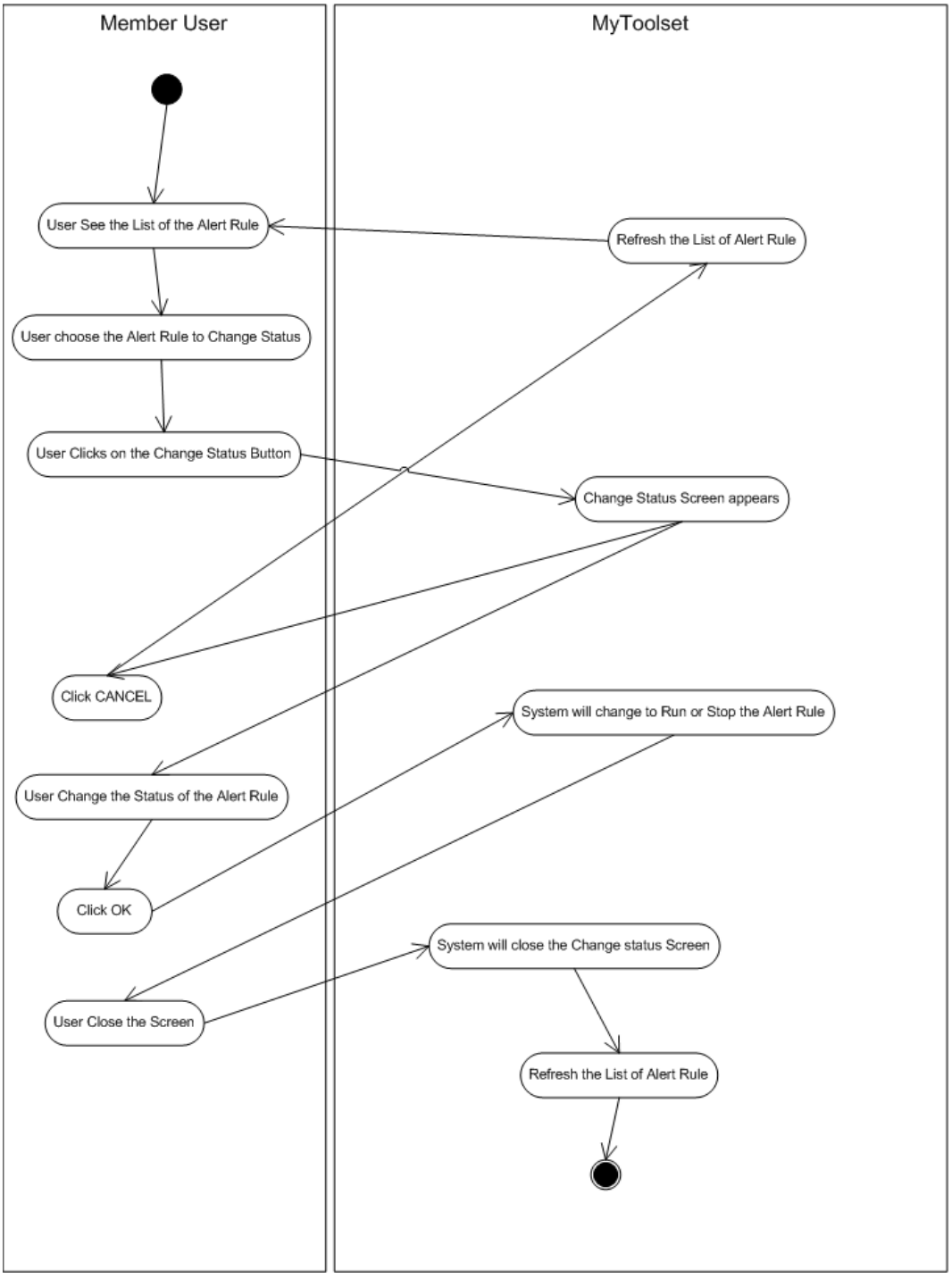

Figure 67 Activity Diagram of "Change Status"

“Test and Save” activity diagram (see Figure 68) shows “Edit and Test the Macro Data” before scheduling and running it. It has the syntax checker for the Macro Data Script. If there are any errors on the Macro Data, then it is not saving and

running this Macro Data Script at all. If the Macro Data was not tested, then Alert Rule will be still at “NOT TESTED” state. So, the Alert Rule cannot be run and collect the Virtual User Simulating Macro Data Response Times at all. If Macro Data Script has no syntax error and not empty during testing, then its state can be changed to “TESTED” state.

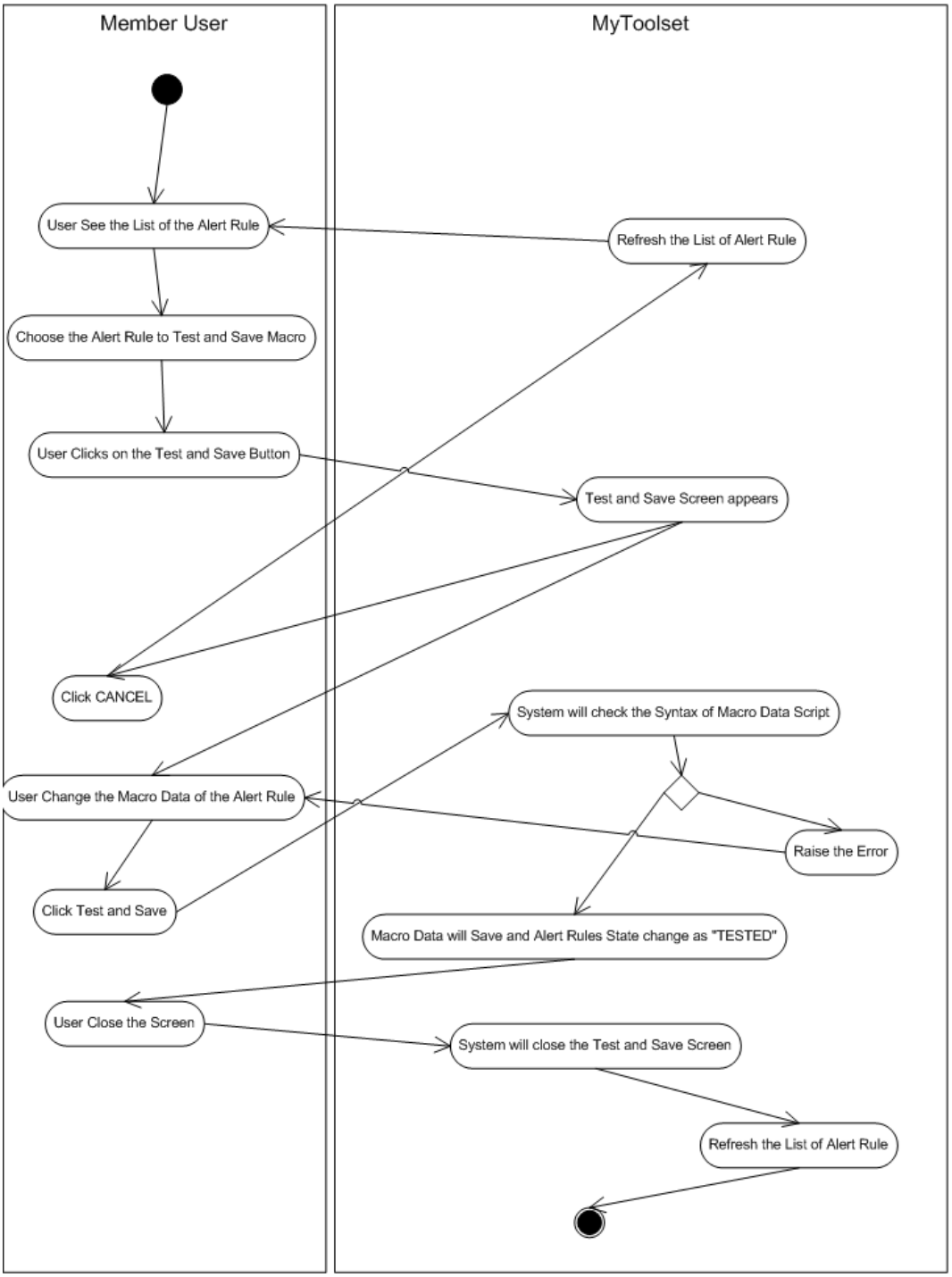

Figure 68 Activity Diagram of "Test and Save"

“List Alert” activity diagram shows the gathering the list of all alerts belonging to the chosen Alert Rule (see Figure 69).

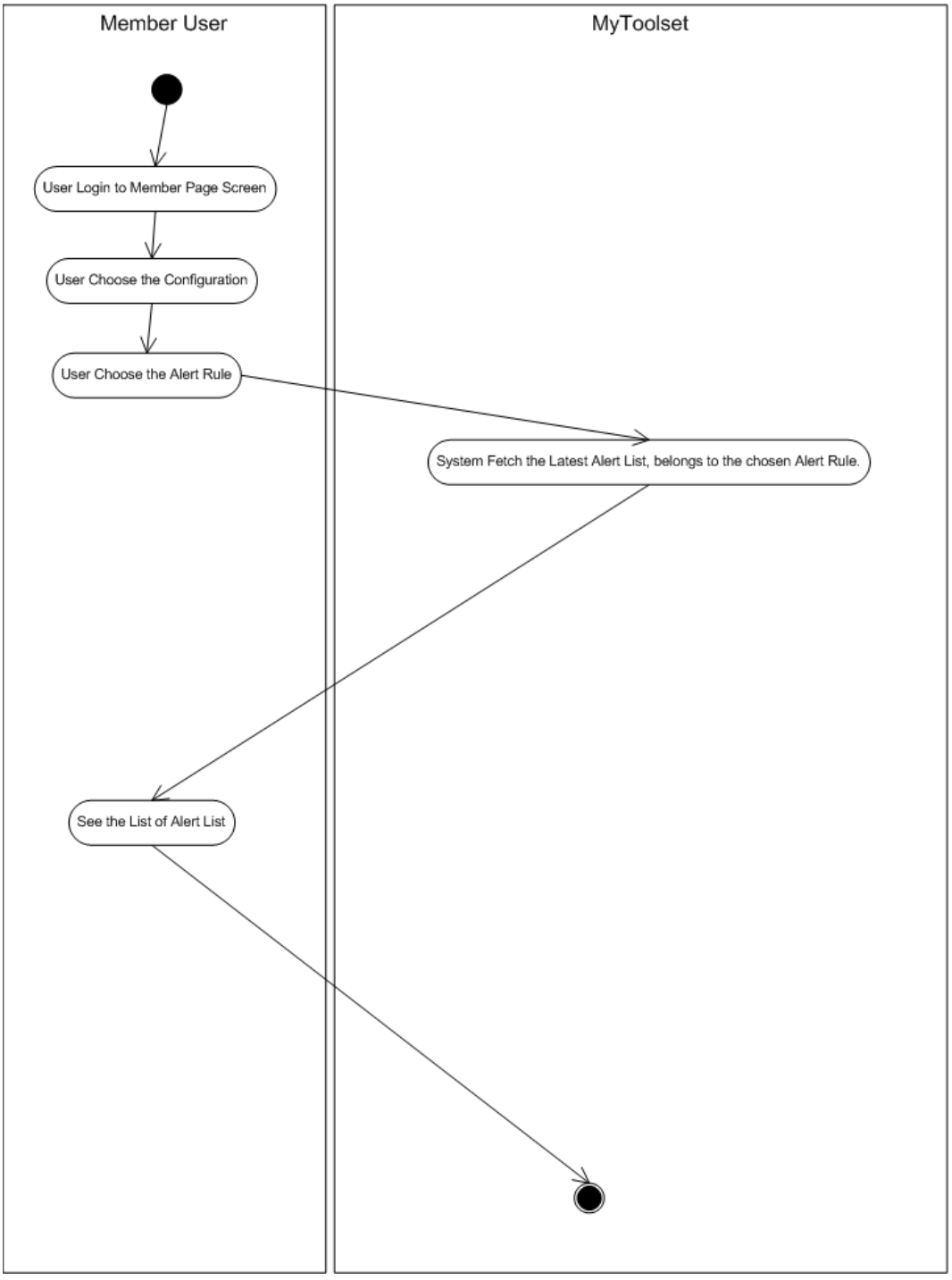

Figure 69 Activity Diagram of "List Alert"

“Edit Why Data Alert” activity diagram shows the editing Why Data. It changes why data of the Alert Event Log entry. This data will keep track of the why this performance degradation or failure on Web-Based Application Macro Work Flow (see Figure 70).

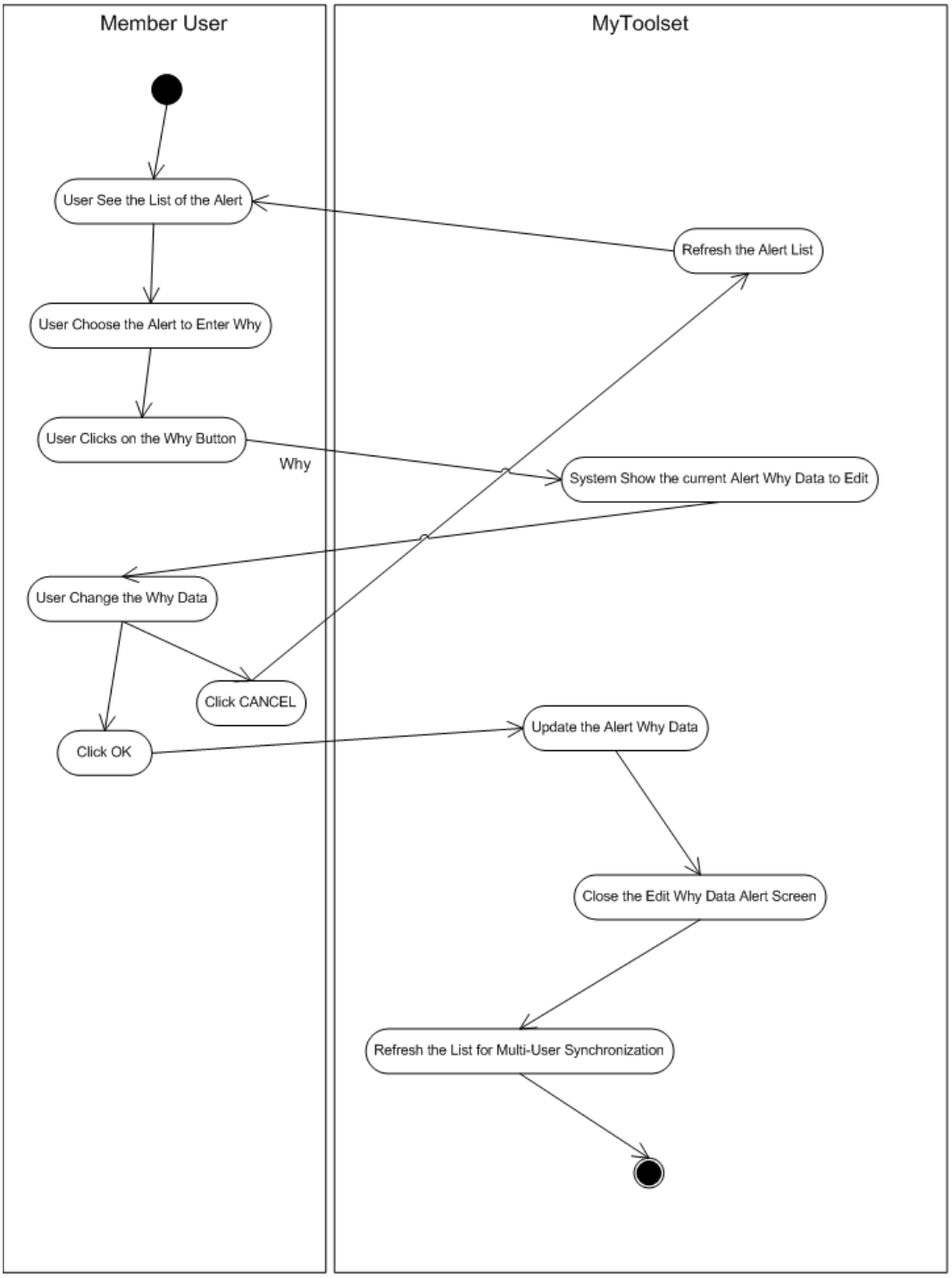

Figure 70 Activity Diagram of "Edit Why Data Alert"

“Get Evidence Alert” activity diagram shows the evidence screenshot of the performance degradation or the failure of the Web-Based Application Macro Work Flow (see Figure 71).

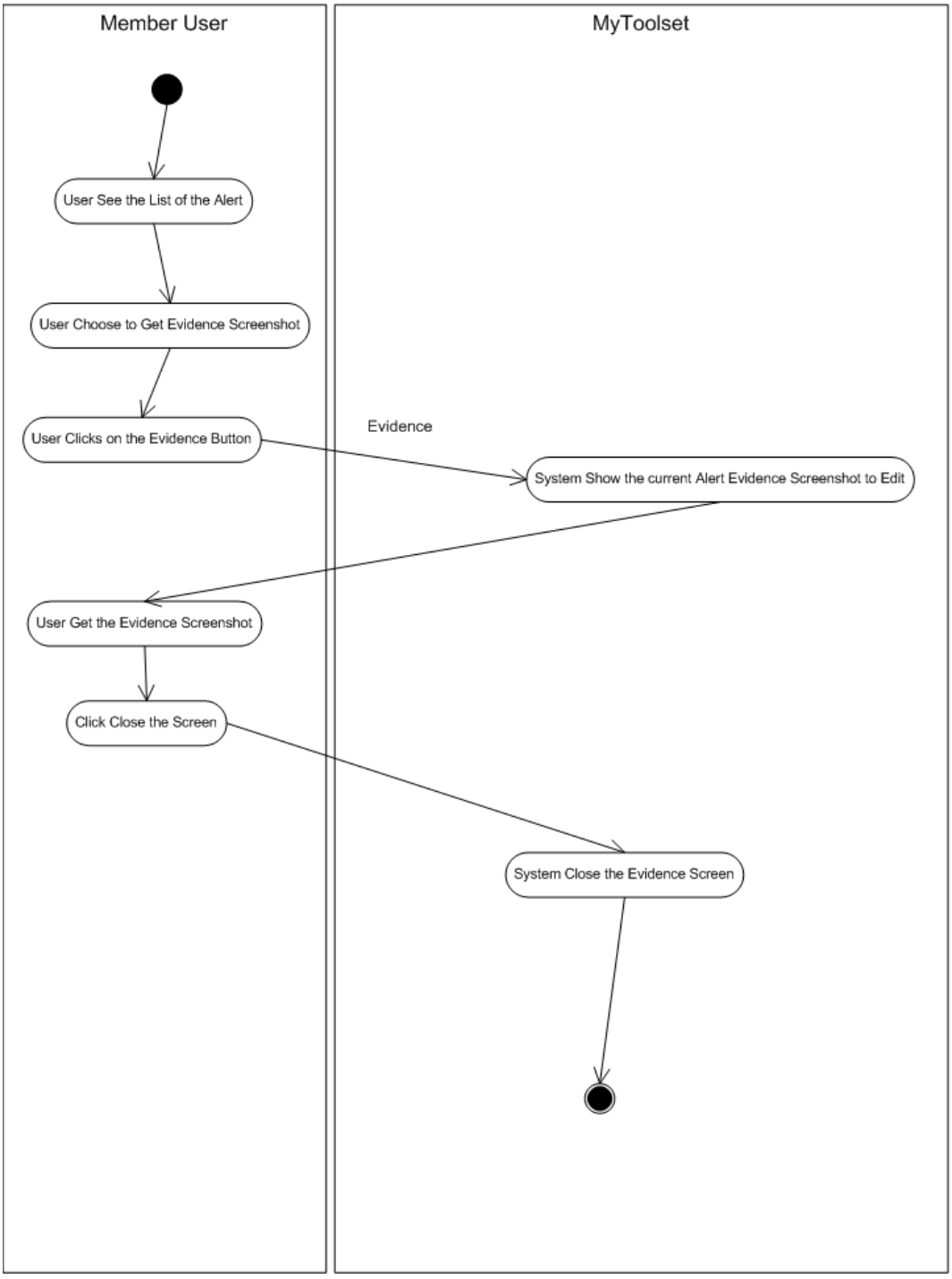

Figure 71 Activity Diagram of "Get Evidence Alert"

APPENDIX B – THE PERMISSION LETTER

18.09.2013

ÇANKAYA ÜNİVERSİTESİ, BİLGİSAYAR MÜHENDİSLİĞİ ANA BİLİM DALI BAŞKANLIĞI'NA

ANKARA

201171220 öğrenci no'lu Alper ASLAN 'ın "Sanal Kullanıcı Simulatörü Yardımıyla Web Tabanlı Uygulamaların Performans Stabilite Skoru" başlıklı yüksek lisans tezi dahilinde Savunma Teknolojileri Mühendislik ve Ticaret A.Ş. kurumsal internet websitesini son kullanıcı yetkileri dahilinde araştırmalarına konu olacak şekilde kullanmasında sakınca bulunmamaktadır.

Bilgilerinize arz ederim.

Yazılım Müdürü

Aydın KARA

CURRICULUM VITAE

Personal Information

Surname, Name: Alper ASLAN

Nationality: Turkish (TC)

Date and Place of Birth: 24 April 1974, Ankara

Marital Status: Married, with 2 children

Phone: 0530 656 28 14

Email: alper@mytoolset.org

Education

Degree	Institution	Year of Graduation
MS	Çankaya Üniversitesi Computer Engineering	2014
BS	O.D.T.Ü. Mathematics	2002
High School	Ankara Lisesi	1991

Work Experience

Year	Place	Enrollment
2012 - …	Savunma Teknolojileri Mühendislik A.Ş.	Senior Software Developer, Team Lead and DBMS Consultant
2006 – 2012	Ordu Yardımlaşma Kurumu Genel Müdürlüğü	Mentor and Lead Software Developer
2002 – 2006	OYTEK A.Ş.	Director
2000 - 2002	Meteksan Sistem A.Ş.	Software Group Leader
1999 - 2000	Datasel A.S.	R&D Developer
1997 - 1999	MMA Ltd.	Part time Software Developer

Foreign Languages

Advanced English, Turkish (Native)

Hobbies

Trekking, swimming and aquarium care.