WEB SERVICES USAGE MONITORING FOR FUTURE USAGE AND FAILURE PREDICTION

Kashif Ali[1], Naveed Iqbal Rao[2], Sarmad Sadik[3]

Department of Computer Software Engineering, National University of Sciences and Technology, Islamabad, Pakistan. .

syedkashif1990@gmail.com, sarmad.sadik@mcs.edu.pk, naveedi@mcs.edu.pk

Abstract. *Wider use of web services has dominated the software industry. Providing web services to its consumers, according to Service Level Agreement (SLA) is complex and difficult task. Failure to provide web services against agreed quality of service (QoS) parameters, i.e., unavailability of web services and slow response time will cause increase in penalties. This may lead to unsatisfied consumers that can be devastating for business goals and revenue of service providers. In order to ensure the satisfaction of consumers and avoid any violations of SLA, monitoring is required on the service provider side. However, monitoring against SLA is not enough - service providers must be able to analyse the past and current usage in order to predict future challenges. This research aims to provide a monitoring framework which empowers the service providers to monitor web services usage and failures. And analyse the monitoring data to predict future usage and failure patterns.*

Keywords: Service Level Agreement, SOA, Decision Making, Risk Management, Web Service Monitoring

1. INTRODUCTION

Service Oriented Architecture (SOA) is an emerging business centric approach for many business organizations. Many business organizations are shifting towards Software-as-a-Service model [1]. Different organizations are offering many types of web services on the internet. Some of these web services are very important or business critical for their consumers. Web service failures, unavailability or delayed response can cause a huge failure or economic loss to consumer's business. In above mentioned scenarios, the service provider has to compensate service consumer with penalty. These services failures when occurring iteratively will increase penalty costs and may lead to the loss of service consumers which is huge business loss for the service provider. Before a service provider start providing web services to a consumer, they must agree on a contract called Service Level Agreement (SLA). A SLA defines Quality of Service (QoS) attributes for a service, to be provided to its consumer. It also defines the conditions under the service will be provided to its consumers. Besides that SLA also defines the penalty cost which is paid or compensated by the service provider in case of SLA violation. A service provider has to minimize SLA violation to increase its profits and decrease penalty costs. In order to ensure the SLA enforcement, an efficient monitoring mechanism is required at the service provider's end. Different researchers have proposed many architectures and approaches for SLA monitoring. Most of them are used to validate SLA at runtime or find the reason of violation ex-post when the violation has occurred [1]. But only solving emerging service faults at deployment time or runtime is not enough [2]. One must have to analyse, identify and predict the risks which can cause the SLA violation. Many business organizations, for forecasting purposes perform analysis of their historical sales data. The forecasting data can be helpful for many management decisions i.e. Sales revenue forecasting, inventory planning, operation planning and marketing [3]. The domain of risk management has been used in different disciplines including software engineering. The goal of risk management in software engineering is to help to manage software projects in a specific time and budget boundaries but it is not limited to time and budget boundaries [4]. Risk management can be applied throughout the system development life cycle. To make good business and technical decisions risk management can provide the requisite data [5].

Maintenance issues like service failures or crashes, unavailability of services or slow response time can be coped with proper risk management. In context of risk management, the historical data of web services usage like hits per web service, failure or unavailability of a web service between a particular time span can provide information about highly used web services. This information can determine current and future patterns of a web service usage and failures i.e. increase or decrease in web service usage growth and web service failure growth. This research paper aims to provide a web service monitoring and analysing framework with the notion of future prediction for the service providers. The framework will help the service providers to predict the future increase or decrease in web service usage and failures. It will also help the service providers to take future business decisions and reduce risks and their impacts which can maximize their profits and minimize their penalty costs.

The rest of paper is organized as follows. In section 2; we present the literature review for SOA monitoring frameworks and their comparison with respect to risk management. We also provide a brief overview of usage analysis and future prediction in I.T and business organizations. Section 3 presents our proposed conceptual framework. Section 4 represents the implementation and results of prototype. In the end, section 5 concludes the paper with final remarks and highlights the conclusion & future work.

2. Literature Review

2.1 Web Service Monitoring

Service Oriented Architecture (SOA) is an emerging business centric approach for many business organizations. Many business organizations are shifting towards Software-as-a-Service model [1]. Different organizations are offering many types of web services on internet. Some of these web services are very important or business critical for their consumers. Web service failures, unavailability or delayed response can cause a huge failure or economic loss to consumer's business. In above mentioned scenarios, the service provider has to compensate service consumer with penalty. These services failures when occurring iteratively will increase penalty costs and may lead to the loss of service consumers which is huge business loss for the service provider. Before a service provider start providing web services to a consumer, they must agree on a contract called Service Level Agreement (SLA). A SLA defines Quality of Service (QoS) attributes for a service, to be provided to its consumer. It also defines the conditions under the service will be provided to its consumers. Besides that SLA also defines the penalty cost which is paid or compensated by the service provider in case of SLA violation. A service provider has to minimize SLA violation to increase its profits and decrease penalty costs. In order to ensure the SLA enforcement, an efficient monitoring mechanism is required at the service provider's end. Different researchers have proposed many architectures and approaches for SLA monitoring. Most of them are used to validate SLA at runtime or find the reason of violation ex-post when the violation has occurred [1]. But only solving emerging service faults at deployment time or runtime is not enough [2]. One must have to analyse, identify and predict the risks which can cause the SLA violation. Many business organizations, for forecasting purposes perform analysis of their historical sales data. The forecasting data can be helpful for many management decisions i.e. Sales revenue forecasting, inventory planning, operation planning and marketing [3]. The domain of risk management has been used in different disciplines including software engineering. The goal of risk management in software engineering is to help to manage software projects in a specific time and budget boundaries but it is not limited to time and budget boundaries [4]. Risk management can be applied throughout the system development life cycle. To make good business and technical decisions risk management can provide requisite data [5].

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2. Literature Review

Web Service Monitoring:

In order to ensure satisfaction of the SLAs monitoring is required at every service provider and at the service consumer end [6]. Basically, there are three main types of web service monitoring: Provider side monitoring (centralized or distributed), customer or end user side monitoring and third party monitoring. The drawback of provider-side and consumer-side monitoring is that in the case of problems neither side will trust the others [7]. The third party monitoring has bottleneck performance issues when the messaging between consumers and providers is increased.

Authors in [1] propose an event-based monitoring framework which predicts the SLA violation using machine learning techniques and runtime triggering of adaption actions for violation prevention.

A framework has been proposed [8] a framework for application level monitoring in cloud. The proposed architecture detects violation of SLA at application level and with the help of tools resource allocation and scheduling of tasks are done.

In another research [2] authors has proposed a risk driven service composition approach. With the help of this approach fault source can be identified and tracked when a fault occurs and risk components (web services) can be removed earlier.

Researchers in their work [7] provided an automated monitoring framework on the basis of a quality model to ensure the enforcement of SLA using agent technology. The quality model used in framework will point the related quality attributes of SLA and metrics from perspective of different stakeholders.

Authors of [9] analysed the limitation of web services monitoring at lower layer rather than at application level layer TCP/IP stack. They proposed a system model and indicator which analyses user's behaviour by browser information.

Researchers in [10] claimed that traditional HTTP web server logs can not be used for web service analysis as these web server logs are generally maintained for server debugging and they provide poor information. Some researchers has also proposed approaches [11,12] to monitor and analyze web services usage by using XML logs. However authors [13] claimed that obtaining information through such log formats require an overhead phase in which usage data is filtered and parsed into required format.

All of the mentioned monitoring frameworks provide a little or no risk management aspect and they provide no support for web service usage analysis. Table 1 provides the comparison of these frameworks with risk management perspective.

Table. 1. Comparison of Frameworks

	Monitoring Type	Monitoring Purpose	Risk Management	Usage Analysis Support
[1]	Provider Side - Centralized	Prediction and prevention of SLA violation	Run time action adaption	No support
[8]	Provider Side -Distributed	SLA violation Detection in Clouds	Resource allocation and scheduling	Partial support (Resource based)
[2]	Provider Side - Centralized	Fault tracking and risky component removing	Risky component removal	No support
[7]	Provider & Consumer Side - Agent based	Enforcement of SLA	NA	No Support
[9]	Consumer Side	Browser based user's behaviour information gathering	NA	Partial Support (User's Page Access)

2.2 Usage Analysis & Decision Making

With the rapid increase in internet users, it makes internet a perfect way for business organizations to interact with online consumers regardless of their geographical locations. In order to increase revenues more observations and importance must be given to online consumer's 4197nalyzin and their usage patterns. A study conducted [14] in Taiwan and Indonesia on online shopping shows that in Taiwan 70.1 precent of people are internet users and by 2014 the expected growth in the number of internet users in Indonesia will be 150 million. With this enormous growing trend Taiwan's government as a part of their future strategy is planning to achieve e-commerce revenue of US$33.333 billion by the end of 2015. Understanding the user's 4197nalyzin can play a vital role to predict the required changes and cope with upcoming challenges. Similarly according to the research two third of the population of the internet users participate and visits the social networking websites and blogs [15]. User's 4197nalyzin or usage analysis is also useful to understand the usage trends, improve advertisement placement polices, viral marketing and better workload management [16].

3. The Proposed Framework

From the literature review, it is analysed that there is a major drawback in existing monitoring frameworks from risk management point of view. Most of the frameworks do not or partially give the usage analysis and risk management support to providers. This is in fact very important for future decision making, prioritization of services from revenue aspect, allocation of resources for better availability and response time and adaption of new services and to track those services which are increasing penalty costs.

In order to overcome this drawback, a framework is proposed which will provide usage monitoring for analysis to service providers for decision making and risk management.

Figure 1 describes the conceptual architecture of our framework. The detailed description of components is given below.

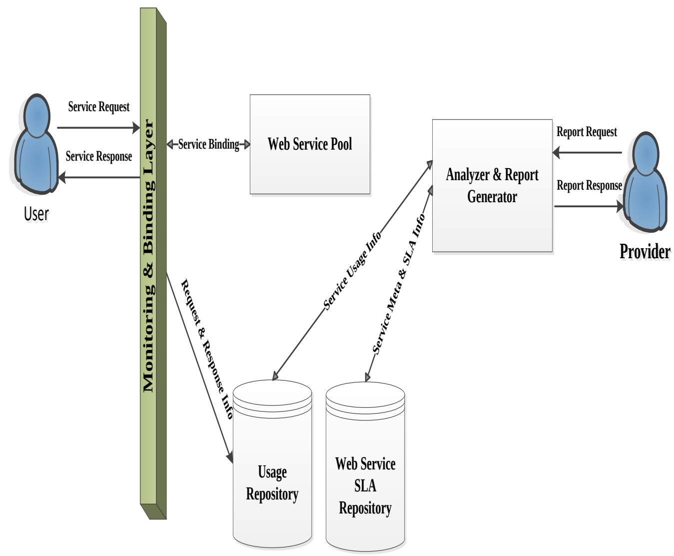

Figure 1. The Suggested Framework

Web Service Monitoring and Binding Layer: This component/layer first parse all the requests of users. It save the user's information and requested service information. Secondly it selects requested service from service repository and binds the requested service to user and saves the response information.

Web Service Pool: It contains actual services (software and Meta information) and registry and communication interfaces for users.

Usage Repository: All the information of web service usage .i.e. (request and response) and its user's information are saved in structured format in usage repository. All of the information is saved with parallel process.

Web Service SLA Repository: In this repository Meta information of web services is stored. This repository also holds the information of each SLA with every user. The information consists of quality of service parameters and the penalty costs in case of any type of SLA violation.

Analyzer & Report Generator: It compiles the information from all the repositories on the basis of statistical forecasting models for analysis and presents it in different types of graphs, simulations and in numerical data .i.e. Current & past usage trends, average usage, expected growth, penalty trends to service provider.

The framework is divided it into two parts. 1) Web Service Usage monitoring. 2) Usage Analysis for Risk Management. First part is responsible for logging user's request into usage repository and binding the requested service from service repository to the consumer. When a user requests for a particular web service, monitoring layer will save information of user and web service that is being requested in usage repository. After saving information monitoring layer shall select the web service from service pool and binds it the requested user and then save the response information i.e. time, status. Figure 2 illustrates the complete working sequence of first part of our framework.

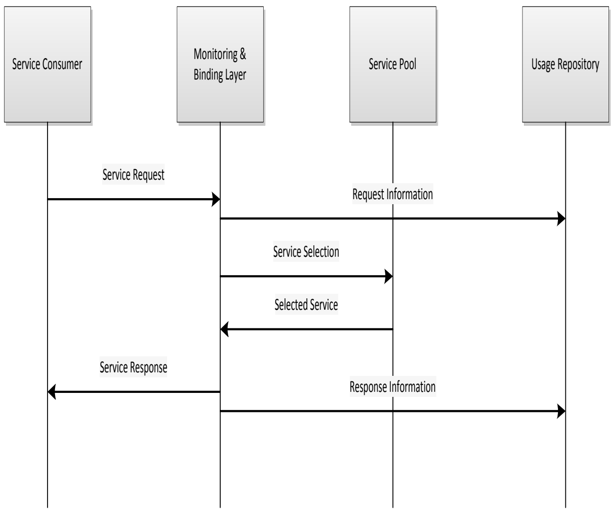

Figure 2. Web Service Usage Monitoring

The second part of our framework is back bone of our proposed framework which is responsible for analysing usage repository and SLA repository for report generation. It can use following quantitative models for forecasting.

- Weighted Moving Average
- Regression
- Exponential Smoothing

Service provider will provide report generation parameters i.e. specific time span to analyser and report generator. Analyser & report generator will use the usage repository and web service SLA repository to generate results such as usage graphs (past & current usage pattern, and forecast expected usage pattern). Similarly analyser & report generator will generate report for current SLA violations and penalties such as web service unavailability and forecast expected violations & penalties. Figure 3 describes the complete working sequence of second part of our framework.

The forecasting information generated by the proposed framework shall help the web service providers to point out those web services which are causing SLA violations and the root cause of these SLA violations can be identified and taken care off. Similarly the web services that usage is expected to grow will be identified and allocated with more resources in order to not compromising on their performance and avoiding any future anomalies.

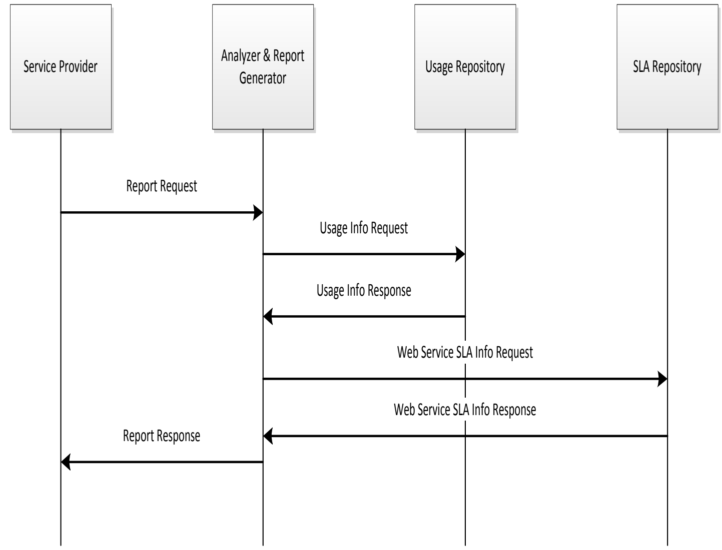

Figure 3. Usage Analysis for Risk Management

4. Implementation

In order to validate our proposed framework a prototype is developed and deployed in university's intra-network. The prototype is built in Microsoft Visual Studio for web and SQL Server 2008 both express editions and hosted in internet information server (IIS) 7.0. The prototype of Web Service Usage Monitoring & Analysis (WSUMA) is installed and deployed on a system with an Intel ® processor 2.6 GHZ and 8 GB RAM. System running windows 7 professional services pack 1 operating system. System is also running .Net framework 3.5.1 which supports all the previous additions of .Net framework and has an Ethernet and Wireless connection, connected to LAN.

Five dummy web services {WS1, WS2, WS3, WS4, WS5} were developed and a number of students were asked to use them. Their usage data; hits per web service and failure of each web service was monitored for a specific time and categorized in time spans {t1, t2, t3, t4, t5}. As described earlier analyzer and report generator is responsible for the analysis of monitored data and convert the data into statistical reports that will help the service provider to get the insight of current and future usage/failures of web services. For the proof of concept currently our analyzer is generating two types of reports; bar charts for current usage and failures and trend lines for expected futrue usage and failures.

At first part on the basis of monitored data simple bar charts of usage and failures are generated respected to time spans. Figure 4 and figure 5 shows the bar charts.

In second phase, on the basis of monitored data expected growth of web services usage and expected growth of web services failure has been calculated for future time spans {t6, t7}. For prototype purposes Weighted Moving Average.

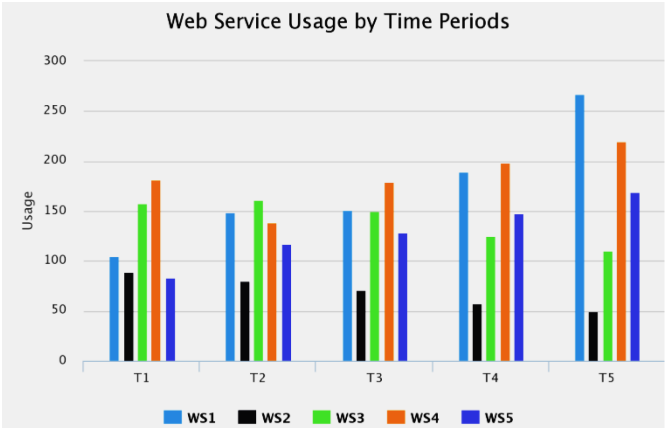

Figure 4: Web Services Usage Bar Chart

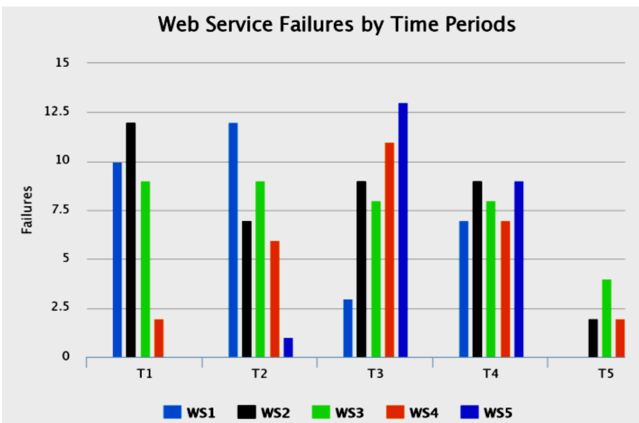

Figure 5: Web Services Failure Bar Chart

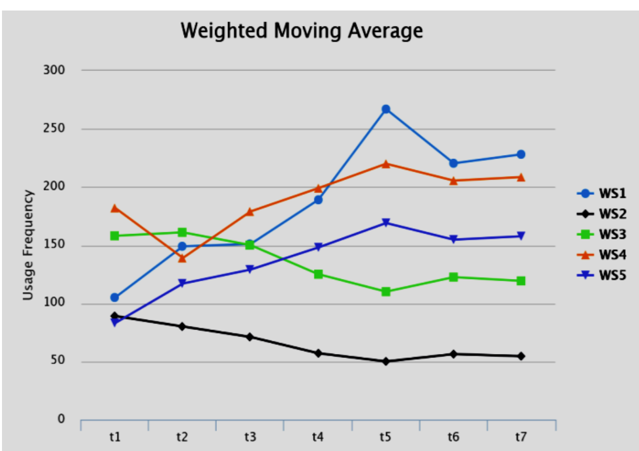

Figure 6: Web Services Usage Trend

has been used as forecasting method with weights assigned {0.2, 0.3, and 0.5} respectively. Figure 6 and Figure 7 depicts the trend lines for expected usage growth and failure growth respectively

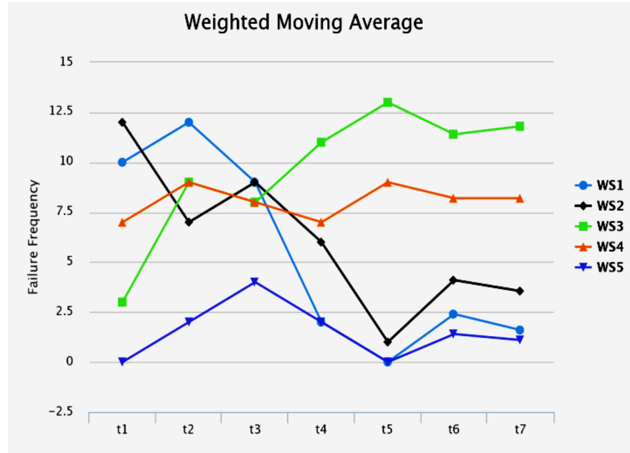

Figure 7: Web Services Failure Trend

5. CONCLUSION

Web service usage monitoring data can be very useful for the web service providers. This data can highlight revenue generating, highly used web services and those web services which are causing penalties. Furthermore, analysis of usage data can help web service providers to predict the growth in web services usage and failures. At present, prototype of proposed framework is implemented in control environment with limited scenarios. In future, we are looking forward to test our framework in real environment to get proven results. In addition the framework will be extended for multiple and distributed service provider level monitoring and furthermore proposed framework will be integrated with existing monitoring frameworks to enhance the capabilities.

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