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A NEW REUSABILITY METRICS TO ESTIMATE COMPLEXITY AND PERFORMANCE OF COMPONENT-BASED SOFTWARE

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Abstract: In the era of cloud computing and Big Data, a number of web services are being developed and deployed over intranet and web. The reusability helps in selection of most suitable web service by accessing Quality-of-Service (QOS) from a pool of similar web services. This paper proposes a new reusability metric for web service with four identified QOS factors for reusability estimation. The paper finds Coupling, Interface Complexity, Response Time and Reliability as potential factors for reusability estimation. The paper also discusses estimation of complexity and performance of web service component using proposed reusability metric.

Key Words: Reusability metric, quality-of-service, web service, coupling, interface complexity, response time, reliability theory;

1. INTRODUCTION

With the popularity of Service-Oriented Architecture (SOA), a wide variety of web services have been developed and deployed over web. Web services are modular, self describing and self contained components. Web services are published on web by developers, which are later located and invoked by consumer [1]. The reusability of these web service components can help in recommendation by accessing Quality-of-Service (QOS) [2] as reusability is one of the factors of software quality. Web services exploit SOA architecture and are publish its services with XML based Web Services Description Language (WSDL). These web services are accessible across platforms. Simple Object Access Protocol (SOAP) is the basic messaging system through which web applications interact with web services. These features make web service component superior in reusability among other component types like class, component etc. [3]. The reusability estimation for web service components is still a research topic of concern among software engineering research community.

The expected reuse potential shown by a component is treated as its reusability. Component reusability is one of the quality attributes that not only improves productivity of software development but also has a positive impact on the quality and maintainability of an application [4]. In respect to web services the reusability refers to the extent to which an existing web service can

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be reused. All the benefits of reusability like reduced cost and time of a new web application will be intact in web service context also.

This paper proposes reusability metric for web service components. This reusability metric is based on four QOS factors for web services. The paper also estimates complexity and performance of web services with the reusability metric before and after interaction with other web service.

The remaining paper is structured as follows. Section 2 discusses the related work in the area of web service reusability estimation. In section 3 the factors for reusability estimation are identified. Section 4 presents the reusability metric. Section 5 performs reusability estimation for a case study using proposed reusability metric and discusses the complexity and performance estimation. Finally the paper concludes in section 6.

2. RELATED WORK

In reference to significant advantages of software reuse, the reusability estimation has been a topic of research in the context of Object-Oriented System (OOS) and Component-Based Software Development (CBSD). There is sufficient literature available for quality evaluation as well as specifically for reusability evaluation in the field of OOS and CBSD. The work in these fields is best reviewed and presented by [5-10]. The web services also follow reuse by participating in compositions other than for which they were developed. The new web applications reuse pre existing web services published by service provider companies. With this ability the reusability metric in respect to web service components has been the subject of research from last decade.

According to Laden [11] most of the research in web service context has been paying attention on developing, metrics for black-box or high level components, while others are focused on structural metrics. The QOS of web service is also gained significant attention [12] [13]. Ladan [11] suggested two categories of metrics: Quality Metrics and Structural Metrics.

Sneed [14] proposed a metric suite to measure web service interfaces. The proposed metric suite consists of size metrics like lines of code and number of statements, quality and complexity metrics for Web Services. The proposed metric suit is purely based on WSDL.

According to Choi and Kim [15] *reusability of service is the degree to which the service can be used in more than one business process or service applications without having much overhead to discover configure and invoke it*. They find reusability of service as a major factor for QOS evaluation. According to authors the OOS and CBSD based reusability models cannot used as it is to services in web service context. They have proposed a quality model using reusability metric with factors like business commonality, modularity, adaptability, standard conformance and discoverability.

The reusability metrics are being developed from decades but most of them are unsuitable for web services [16]. Hence there is a great need for suitable reusability metric in order to estimate the QOS of web services.

3. IDENTIFICATION OF FACTORS FOR REUSABILITY ESTIMATION

This paper is an extended work of Singh and Tomar [3]. The reusability metric in reference to web service component has different factors to cater the difference between general software component and web service component. In web service components the WSDL is used for defining interfaces with one or more operations having input and output.

For reusability measurement of a web service, the identified factors in [3] were Coupling, Interface Complexity, Security, Response time and Statelessness. Now this paper replaces security

with reliability and drops statelessness as a factor. The paper finds security and statelessness values mostly similar in web services. This study selected Coupling, Interface Complexity, Response Time and Reliability as potential factor for estimating reusability. These factors are selected for reusability estimation based on experience from literature survey and some of them were used as means to measure performance of web services [17] [18] [19].

3.1 Coupling

Similarly as in software components, coupling is the dependency on other services. So the composition of self-contained, independent and stateless web service in an application will lead to low coupling. The coupling of web services can be measured with degree of interactions among services [11]. Standardized web service components create common ground and increase interoperability. The interoperability is also directly proportional to loose coupling.

3.2 Interface Complexity

The web service component is accessed via published interfaces. The published interfaces work as input port and output port to get and return data. These interface methods have parameters to receive data dynamically from actual parameters [3]. The complexity of these interface methods can be measured by analyzing the method parameters and their types. Singh and Tomar [7] proposed a method to measure interface complexity for software components which is modified to measure interface complexity in web service context. The modification is required as the data types like Java programming language are not available in WSDL. The updated Interface Complexity (IC) metric for web service as (2) is estimated using Message Complexity (MC) (1):

$$MC_k = \sum_{i=1}^{n} p_i \tag{1}$$

Where p_i is the complexity of ith parameter of kth message. The value of p_i is 1 if i is xsd type otherwise p_i is the depth of tree correlating to its element type.

$$\mathrm{IC} = \frac{\sum_{k=1}^{m} MC_k}{m} \tag{2}$$

Where m is the number of messages defined in WSDL.

3.3 Response Time

In web service context the response time of a web service is the time duration between the request send by a client and response received. The response time of web service depends on the no pending requests at web server, shared resources and input parameter values [20]. The response time estimation may also estimated sometime using a specialized observer agent services/software. This service/software is specialized to log response time efficiently and give a near prediction by gathering statistics after applying load from different servers located globally.

3.4 Reliability

The reliability is the capability of a system or a component to perform its necessary functions under stated environment for a specified period of time [21]. In web service context the reliability is the capability of sustaining the service consistently with desired quality over a long period of time like per month or year. In web service context, availability is also similar to reliability [19]. So this study will treat availability factor as indicator of reliability of web service in this context.

4. PROPOSED REUSABILITY METRIC FOR SOFTWARE COMPONENT

To improve quality and development productivity the developers relies on various reusable web services. The reusability measurement for web service components cannot be done directly by using identified factors because each factor has a relative significance for reusability measurement. The reusability measurement is thus performed using proportional weight of each factor. These weights can be influenced by domain constraints and may have different relative importance in different environment.

To measure web service reusability, all identified factors have to be quantified before aggregation to measure reusability of web service component. Web Service Reusability (WSR) for web service can be obtained by denoting different weights for different factor value as (3):

$$\mathrm{WSR} = \mathrm{w}_1 * (1 - \mathrm{CP}) + \mathrm{w}_2 * (1 - \mathrm{IC}) + \mathrm{w}_3 * (1 - \mathrm{RT}) + \mathrm{w}_4 * \mathrm{R} \quad (3)$$

Where Wi (i=1… 4) denotes weights for four factors, *CP* is Coupling, *IC* is interface Complexity, *RT* is Response Time and *R* is reliability. The equation uses (1-IC), (1-CP) and (1-RT) as the interface complexity, coupling and response time should have lower value for higher reusability. To facilitate the comparison of different web service reusability all factor and weight values should be normalized to a specific range [0...1]. The weights are used for the relative importance of factors for measurement of reusability and can be decided empirically. Due to the normalization, the sum of weights has to be 1.

5. REUSABILITY EVALUATION

In this section the proposed reusability metric is applied to evaluate web service reusability based on data collected from some freely available E-Mail verification, country code and currency conversion web services. The data is gathered by analyzing WSDL document of eight web services in accordance with Suchithra and Ramakrishnan [22]. Total eight web services are chosen six of them are providing similar service of E-Mail verification, rest two are for providing currency code for countries and for currency conversion rate. All four identified factors for reusability metric are tested against these web services. Table 1 shows the calculated values of identified factors for selected web services.

Table 1.
Reusability Metrics for Web Service Components

S. No.	*Service Name*	*Complexity*		*Performance*		*Reusability*
		CP	*IC*	*RT*	*R*	
1	XML Logic Validate Email	0.22	0.2	0.48	0.8	0.712
2	XWebservices EmailValidation	0.01	0.167	0.72	0.81	0.6939
3	StrikeIron Email Verification	0.01	0.33	0.47	0.96	0.75
4	CDYNE Email Verifier	0.07	0.20	0.60	0.90	0.726
5	Webservicex Validate Email	0.02	0.25	0.82	0.85	0.645
6	ServiceObjects Email Validation	0.1	0.72	0.26	0.99	0.684
7	Webservicex country	0.22	0.20	0.34	0.80	0.754
8	WebserviceX Currency Converter	0.22	0.33	1	0.54	0.465

All the values estimated for identified factors are normalized to be between 0 and 1.

To implement these values for reusability measurement through reusability metrics (3), the relative weight value is required for each factor. The weight values are decided for relative importance of identified attributes, in this case study the weight values are adjusted in consultation with practitioners working on web projects and researchers of this area. The decided weight values are: w1=0.2, w2=0.3, w3=0.3 and w4=0.2. The reusability estimation with this set of weights is given in table 1. This way the reusability of web service component can be estimated using proposed reusability metrics. The weight values for selected factors may be adjusted depending on the importance criteria.

This reusability metric can also be used to estimate complexity and performance of web service components. According to Cardoso [23], Web process complexity is the degree to which a process is difficult to analyze, understand or explain. The two factors coupling and interface complexity of proposed reusability metric are good indicator of web service complexity. In the same way web service performance can be measured using response time [19]. The other two factors, response time and reliability are good indicator of web service performance as shown in table 1. In order to identify the effect on complexity and performance before and after the integration of web service in an application, a small web application is developed which access the service of WebserviceX country code and WebserviceX currency converter web services separately and one web page having integration of both web services. By analyzing code in visual studio 2015, it is evident that the complexity increases with improvement in performance after integrating two web services.

CONCLUSION

Software reuse has been eagerly pursued in software development. The concept of reuse is extended in SOA as it contributes to runtime reuse. In this paper a new reusability metric is proposed for web service reusability estimation. This approach is based on four identified QOS factors coupling, interface complexity, response time and reliability. The paper suggests quantification criteria for all four selected factors. A new Interface Complexity metric is also proposed for web service component. All these factors are consolidated to metric formula for reusability estimation. The paper also discussed about estimation of complexity and performance of web services using proposed reusability metric. To validate, this reusability metric is implemented for estimating reusability of eight freely available web services.

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