COTS Component Quality Evaluation Using AHP

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Abstract: Because of rapid development of software technology, a number of software professionals have been concerned with component-based development methodologies. Up to date, the evaluation of component quality has been focused on object-oriented metric based methodology. But this paper presents the selection process and evaluation criteria based on an MCDM(Multiple Criteria Decision Making) technique for the selection of optimal COTS component from consumers' viewpoints. We considered functionality, efficiency and usability based on ISO/IEC 9126 for quality measurement and conducted practical analysis into commercial EJB component in internet. This paper shows that the proposed selection technique is applicable for the selection of the optimal COTS component.

Keywords: AHP, MCDM, Software Metric, Evaluation Criteria

1. INTRODUCTION

Component technology, which is recently getting much attention in software industries, is one of the fastest-growing technologies in Korea as well as in many advanced countries. This is mainly because it has a lot of advantages, including its re-usuability in the software development, convenient interface for programs and the productivity of software products. The world's component industry is expected to grow by an average of 49 percent. This is much higher than an average 14.5 percent growth rate for the software industry during the corresponding period[11]. Component technology is a technology that is to develop a system through acquisition and assembly. What is the most important during the acquisition process is to choose a high-quality component that would fit the system the most. It is because a component-based system is largely dependent on the quality of each component that comprises the system. Many research institutions have been studying methodologies for the component development and made great progress in standardizing the platforms. But from the consumers' viewpoints, there are little achievements in researches into the comparison and evaluation of COTS. Currently, two kinds of approaches, that is to say, process-oriented and product-oriented approaches, are used for evaluating the quality of component-based software in an objective manner. Internationally standardized ISO/IEC 9126 and ISO/IEC 14598, both product-oriented, have already come up with a series of metrics and processes designed to evaluate the quality and characteristics of relevant softwares. However, they only specified the basic evaluation process without clarifying any specific testing methods or evaluation criteria.

To select the optimal COTS component in accordance with the internationally standardized ISO/IEC 9126 and ISO/IEC 14598 for the sake of consumers, this paper will feature the four-step selection process that employs MCDM(Multiple Criteria Decision Making) method, while presenting specific testing methods and evaluation criteria. This research has been focused on the functionality, efficiency and usability of the COTS out of six characteristics stipulated by the internationally standardized ISO/IEC 9126. By conducting a series of practical analysis into commercial EJB components that are on sale through Internet, this paper will prove that its proposed selection methods can be applied for the selection of the optimal COTS component. The second chapter will deal with the theoretic background of the quality evaluation needed for the selection of COTS, while the third chapter will present the selection process, testing methods and selection criteria for the selection of COTS. The fourth chapter will verify the selection process and criteria through a series of case studies before we reach a conclusion at the fifth chapter.

2. RELATED WORKS

Component is a module that performs an independent operation or function in a software system. It can be defined as a part that can be replaced for the maintenance and repair of a system. The word, commercial component, in this paper can be defined as "commercialized component that can be supplied independently through distribution channels such as Component Bank." It requires a knowledge of the quality characteristics to assess the quality of the component[2][7]. The quality characteristics should be based on such quality models as the internationally standardized ISO/IEC 9126 and usually divided into three categories; operation, revision and composition. They are also summarized in detail in Table 1 as follows;

Table 1. Component Quality Factor

Classification	Characteristics	Meaning
Component Operation	Functionality	Does it meet the requirement and objectives
	Reliability	Does it cope with the defects Exceptional situations
	Efficiency	Is it efficient in using time and resources
	Usability	Is it easy for a user to make use of it
Component Revision	Extensibility	Can it be extended for further purposes
	Portability	Can it be ported into different environments
	Maintainability	Is it easy for maintenance and Repair
Component Composition	Compatibility	Is it compatible with other system networks
	Plugability	Can it be plugged into other Components
	Interface	Is its service is clearly defined

As the quality characteristics of the COTS should be assessed from consumers' viewpoints, our research has been focused on the component operation among other two classifications mentioned in Table 1. It also took into account the functionality, efficiency and usability of the COTS, which are all stipulated by the internationally standardized ISO/IEC 9126 and included in the quality characteristics of component operations. Meanwhile, the other characteristics in component operation are excluded from this paper due to time constraints. This is because these characteristics can be measured only after the completion of the component composition. The evaluation criteria are a series of specific methods that can be used for the evaluation of component quality. This paper has presented three kinds of evaluation criteria as well as the best selection method for the optimal COTS component with the MCDM (Multiple Criteria Decision Making) applicable to the evaluation values. MCDM is a method under which a number of selection criteria are extensively analyzed to the best and final criterion. More detailed information on the criteria for such quality characteristics as functionality, efficiency and usability as well as the MCDM method will be presented in the third chapter.

3. COMPONENT SELECTION PROCESS

The selection process consists of four steps totaling 10 activities. The first step is to define the quality characteristics to be evaluated and then specify the quality and the second step is to present the evaluation criteria for the quality characteristics. The third step is to evaluate the quality characteristics and the fourth step is to analyze the result by using the correlation before applying the MCDM method into the consequence value to select the optimal COTS component.

3.1 Testing Methods and Evaluation Criteria for Functionality

Tests for component's functionality in this paper employed the equivalent area testing method to minimize the number of test cases and maximize efficiency. As the functionality of a component is expressed through its methods, we will divide method-input domains into equivalent areas and boundary values and extract a combination of each domain input data as a test case. The equivalent test is a black box testing method to minimize the number of test cases and can be divided into two steps[9].

[First Step] :

It can be divided into an effective equivalent area and an ineffective equivalent area in accordance with the input conditions. The input conditions are as follows;

① In case the input condition indicates its extent

It can be defined with at least one effective equivalent area and two ineffective equivalent areas.

② In case the input condition indicates a specific value

It can be defined with at least one effective equivalent area and two ineffective equivalent areas.

③ In case the input condition is a set

It can be defined with at least one effective equivalent area and one invalid equivalent area.

④ In case the input condition is Boolean value

It can be defined with at least one equivalent area and one ineffective equivalent area.

[Second Step] :

Test case will be decided in accordance with the following criteria.

① Label a serial number on the defined equivalent areas.

② Make a test case cover as many equivalent areas as possible.

More specific criteria for the selection of test cases should be decided in accordance with the following.

① Coverage: Every possible input should be covered by one of equivalent areas.

② Disjointness: The same input should not belong to the same equivalent area.

③ Representation: When an error occurs during the execution after a member of specific equivalent areas is used as an input, the same error will occur even though a member of the same equivalent area is used as an input.

The methods comprising components and the quality of the entire components are classified into qualified or disqualified. Hypothesis and antithesis are established before the verification of the ratio with its significant level set at $\alpha = 0.05$.

. Hypothesis H0: The satisfaction rate of the population is over 90 percent.

. Antithesis H1 : The satisfaction rate of the population is under 90 percent.

For the verification, we have statistically analyzed and conducted a series of tests with the significant level set at $\alpha=0.05$ and then obtained a P0 value or the probability of producing a different value from the expected value as a result of the input of component (i.e., the probability of errors). The P0 value will decide whether it is qualified or disqualified as follows;

$P0>\alpha$: H0 should not be rejected. In other word, H0 can be declared as qualified.

$P0<=\alpha$: H0 should be rejected. In other word, H0 can be declared as disqualified.

3.2 Testing Methods and Evaluation Criteria for Efficiency

This is to evaluate the efficiency based on the performance tests of components and comprises five testing classifications. Idle processing answering time is the duration needed for a client to request the execution of methods and receive the results, while transaction processing answering time is the duration needed for processing data from database. The used memory rate means the capacity of heap memory needed for component processing, while the used CPU rate means the capacity of CUP used during the execution of methods. As more clients are connected, there will be higher possibility of generating the exceptions[4][8].

3.3 Testing Methods and Evaluation Criteria for Usability

This is to evaluate the usability based on the document tests of components and comprises nine testing classifications. The usability of a component can be evaluated through installation guidebook, user manual, marketing document, tutorial, warranty period, label, driver, stuff and existence or nonexistence of error messages[5][6].

3.4 Analysis of Correlation between Quality Characteristics

This is a process of analyzing correlation between quality characteristics by using the consequent value measured in accordance with evaluation criteria. The followings are the meaning of correlation coefficient values between two quality characteristics.

. Correlation coefficient (α), $0<\alpha<1$:

Two quality characteristics are mutually proportional and closely related.

. Correlation coefficient (α), $-1<\alpha<0$:

Two quality characteristics are inversely proportional and closely related.

. Correlation coefficient (α), $\alpha=0$:

Two quality characteristics have no mutual relation.

3.5 Selection Methods of COTS Components

To select the optimal COTS component by using the consequent value in accordance with three kinds of quality criteria, this paper employed an AHP (Analytic Hierarchy Process) method among MCDM (Multiple Criteria Decision Making). Table 2 represents an AHP evaluation analysis. The weight used here is a consequent value gained by pairwise comparison with the AHP method. The finally selected COTS component will be a component whose final preference result has the largest sum.

Table 2. AHP Evaluation Analysis Table

j	Weight	Measurement Result		
		Component 1	-----	Component n
Functionality	W1	R1	-----	R1
Efficiency	W2	R2	-----	R2
Usability	W3	R3	-----	R3
Sum(S)		S1	-----	Sn

j: Quality Criteria, *n*: Number of Quality Criteria,
Wj: Weight of Quality Criteria j
Rj: Preference Value of j,
S : Measurement Resullt Sum of component

$$S = \sum_{j=1}^{n} W_j R_j$$

The final alternative is that when the consistency rate is calculated for the verification and the result is more than 0 and less than 0.1, the evaluator's logical consistency can be seen as meaningful.

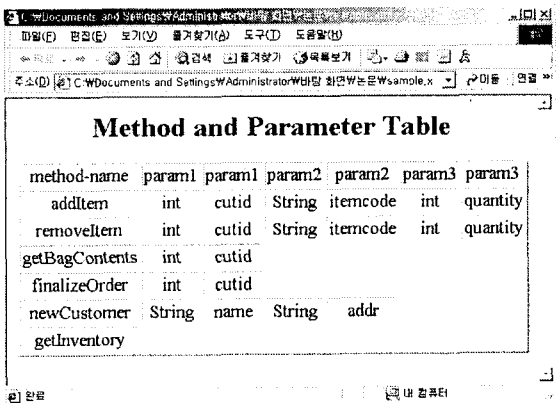
4. CASE STUDY

As a part of case study in this paper, we will purchase *"EJB Components"* in online shopping malls. The *EJB Components* should feature methods such as addItem(), newCustomer(), finalizeOrder(), getBagContents(), removeItem() or getInven-tory(). We will introduce the selection process for the optimal

component among 10 commercial components that a component shop recommended us. The selection will be made in terms of functionality, efficiency and usability. This case study will feature the evaluation and selection process in terms of the three quality characteristics, while skipping the processes needed for quality specification and evaluation category selection.

4.1 Quality Measurement

We have chosen a test case based on equivalent area and boundary value after applying XSL into methods and parameters among component batch deployment descriptors and summarizing the result in HTML. Those written in normal fonts refer to data that are included in effective equivalent area and those written in Italic fonts refer to date in ineffective equivalent area. Fig 1 represents the consequences of ratio testing concerning addItem() Method.



Method and Parameter Table

method-name	param1	param1	param2	param2	param3	param3
addItem	int	cutid	String	itemcode	int	quantity
removeItem	int	cutid	String	itemcode	int	quantity
getBagContents	int	cutid				
finalizeOrder	int	cutid				
newCustomer	String	name	String	addr		
getInventory						

Fig. 1. : XML Metadata Table

4.2 Analysis of Correlation between Quality

Table 3 is a result of grouping the final tabulation into two sections and analyzing them statistically. As we can see in Table 3, the correlation coefficient between functionality and efficiency is 0.682, a statistically meaningful figure. The correlation coefficient between functionality and efficiency is minus 0.310 that is of significance, while that between functionality and usability is 0.1 that is of little significance

Table 3. Correlation between three quality

		Efficiency	Usability	Functionality
Efficiency	Pearson Correlation Sig·(2-tailed) N	1.000 . 5	.682 .205 5	-.310 .612 5
Usability	Pearson Correlation Sig·(2-tailed) N	.682 .205 5	1.000 . 5	.100 .873 5
Functionality	Pearson Correlation Sig·(2-tailed) N	-.310 .612 5	.100 .873 5	1.000 . 5

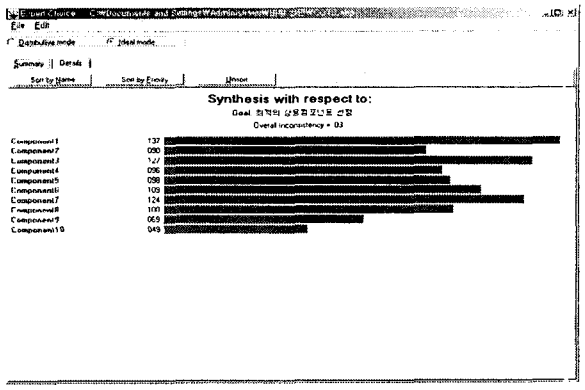


Fig. 2. Final Result using AHP

4.3 The Final Selection of COTS Component

For the selection of an optimal COTS component, we chose a group of 10 experts on components and employed Expert Choice Tool for more objective AHP technique. Then we selected COTS components and also conducted consistency tests. Fig. 2 is a final calculation using AHP technique, showing that "Component 1" was chosen with a sum of total significance rate at 0.137. The total consistency rate is 0.03, proving an evaluator's logical consistency

4.4 Evaluation of the COTS Component Selection

As we successfully proved an evaluator's logical consistency during the final selection of COTS component, we now move on to the next-step acceptance testing in which we confirm whether we could assemble the finally selected COTS components to build a system that will meet buyers' requirements. The acceptance testing in this paper has been based on the beta testing and designed to confirm whether the computer system that was built on stress-testing techniques satisfies the buyers' requirements. Fig. 4 features a comparison between Samsung Mall website using the finally selected "Component 1" and Hyundai Mall website using unselected "Component 7." According to our tests, the Samsung Mall website that was built with the finally selected COTS components showed better performance than other shopping malls that were built with other components.

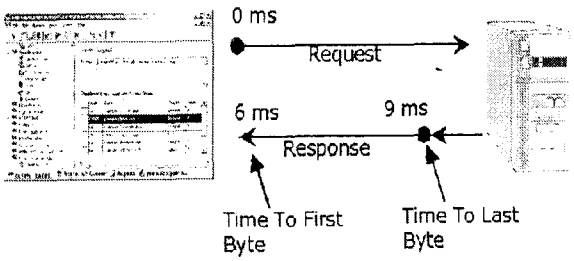


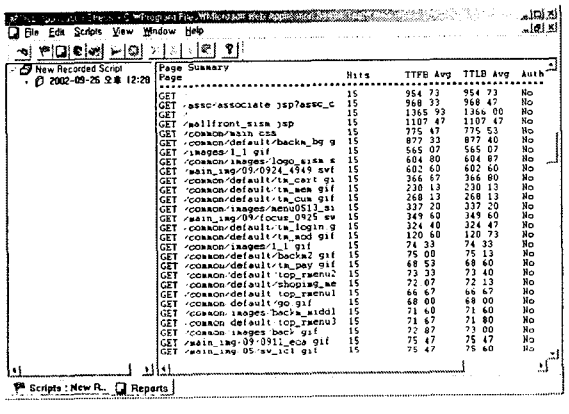
Fig. 3. WAS Operation Activity

The stress testing device used for this paper is a WAS(Web Application Stress) tool of Microsoft and widely accepted by web testing experts. Its testing methods are presented in Fig. 3. WAS conducts the performance evaluation by averaging byte time from the start of server service to the finish of server service consumed to respond to the client's request[1][3].

5. CONCLUSION

This paper has presented the selection process and criteria needed to select high-quality COTS components and researched ways of comparing and evaluating component quality from consumers' viewpoints. We focused our research on the functionality, efficiency and usability among six major quality characteristics stipulated by the international standard ISO/IEC 9126. We also conducted practical analysis into commercial EJB components currently on sale on Internet to successfully confirm the accuracy and reliability of the selection methods presented in this paper. To verify the selection process and criteria presented in this paper, we picked ten COTS components and analyzed the correlation between their quality characteristics before getting to select the optimal COTS component through the MCDM method.

Our future research will be focused on presenting the evaluation criteria for the remaining quality characteristics stipulated by the international standard ISO/IEC 9126 to provide more specific process and evaluation module to be used in systematically comparing and evaluating COTS components.



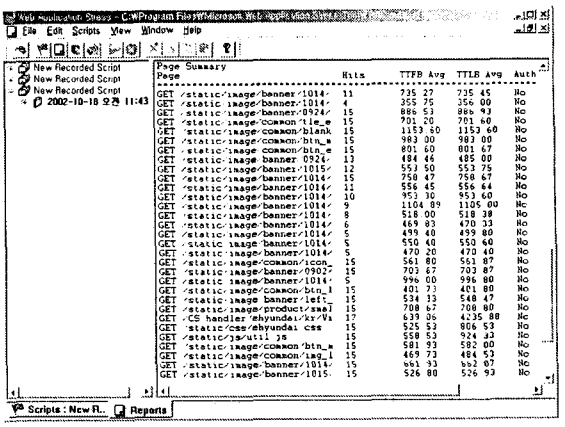


Fig. 4. Comparison Result between Samsung and Hyundai Site

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