Best Web Service Selection Based on the Decision Making Between QoS Criteria of Service

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Abstract. Recently, extensive studies have been carried out on web service standards because of the necessity of developing large-scale applications in open environments. In particular, they enable services to be dynamically bound. However, current techniques fail to address the critical problem of selecting the right service instances. Service selection should be determined based on customer preferences and service level. We propose a best web service selection method which helps to find a service provider providing the optimal quality. Web service selection process was described with multi-criteria decision making approach(e.g. PROMETHEE) on the basis of evaluated values of qualities and the defined service level. The PROMETHEE method has advantages in comparison with the others(e.g. MAUT, AHP) as follows. First, the PROMETHEE method classifies alternatives which is difficult to be compared because of a trade-off relation of evaluation standards as non-comparable alternatives. Second, the PROMETHEE method is different from the AHP method in that there's no need to perform a pair-wise comparison again when comparative alternatives are added or deleted. Therefore, this method is a suitable approach in the web service selection problem. Because the problem has a lot of quality parameters which are measured and evaluated at the same time and frequently induces a drop of another quality parameter by the improvement of one quality attribute. Consequently, our approach enables applications to be dynamically configured at runtime in a manner that continually adapts to the preferences of the customers. We verify our approach through case study.

1 Introduction

Recently, there has been increasing interest in web service because of the following advantages: platform independent, interoperability and service availability. IDC estimated that the amount of sales of software related to web service is about 3 billion dollars in the year 2004 which are just 1.6% of 188 billion dollars,

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the whole software market. But it is expected to grow by 58% per year for next 5 years and will be 11 billion dollars in the year 2008[1].

Web service is a component-based distributed computing service independent of a platform and an implementation language in the wired/wireless web and consists of three operations, i.e. publish-find-bind. Each operation means a service provider which develops a web service and publishes in UDDI registry, the UDDI registry which helps service consumers to find the web service they need and a service consumer which binds to the web service and uses the function of the web service actually.

In a current web service model, the UDDI registry includes not an evaluation for the web service but an explanation and has defects that 48% of the UDDI registry have a link which contains information that are lost or broken or incorrect[2]. When a service consumer chooses one among a lot of similar web services, he generally gets to need information about the service quality(QoS) of the web service. Although UDDI was not designed to provide service quality information, UDDI registries tend to include this information to give convenience to service consumers.

This paper suggests the best web service selection method which helps to find a service provider providing the optimum quality that the consumer needs in a position of service consumer. In this paper, we considered the multi-criteria of QoS(Quality of Service) and CoS(Cost of Service) in the evaluation process to solve the problem of existing researches[3,4] related to the web service selection and used PROMETHEE as an evaluation method which is most suitable for the web service selection among MCDM approaches. The PROMETHEE method has advantages in comparison with the others(e.g. MAUT, AHP) as follows[5]. First, the PROMETHEE method classifies alternatives which is difficult to be compared because of a trade-off relation of evaluation standards as non-comparable alternatives. Second, the PROMETHEE method is different from the AHP method in that there's no need to perform a pair-wise comparison again when comparative alternatives are added or deleted. Therefore, this method is a suitable approach in the web service selection problem. Because the problem has a lot of quality parameters which are measured and evaluated at the same time and frequently induces a drop of another quality parameter by the improvement of one quality attribute[6].

This paper was organized as follows. We introduced the research trend about the web service selection and the theoretical background about the multi-criteria decision making approach in chapter 2 and suggested the quality evaluation criteria and the selection method used in the best web service selection process in chapter 3. In chapter 4, the selection method was verified through a case study and lastly conclusions and future works were described in chapter 5.

2 Related Work

In this chapter, we reviewed existing researches related to the web service selection and representative approaches about the multi-criteria decision making.

2.1 Research Trends of Web Service Selection

Patrick's[3] research proposed the combination that could increase the whole value between two issues(QoS and CoS) by trading more preferred issue for less preferred issue between two parties. In this model, QoS is related to the performance-oriented capability(distance and time), CoS is related to resources (ca-pital, hardware, software, network bandwidth) which are required to ensure QoS and a token-based approach was suggested to quantify the two-issue. In the proposed token-based approach, Resource is measured by the unit of QoS-token and Dollar is measured by the unit of CoS-token. If QoS and CoS are measured by token, the token trading between two parties is possible. As a result, the efficient allocation of resources can be caused. But, since this model considered just two issue groups except the other sub-issues included in QoS and CoS, there are defects that it can not handle a multi-issue and a multi-party.

Julian[4]'s research adopted a semantic model based on RDF and OWL to model the interaction between the client and the web service and proposed a reasoning engine constructed with JESS(Java Expert Systems Shell) to allow the client to reason what can provide the best web service among many web services that have the same sentences. This proposed research adopted the client-side augmentation approach to gain the experience information that is shared. The experience related to the generic QoS parameter is availability, reliability and execution time and is stored in the QoS forum that can be accessed in common. The QoS forum returns vectors of semantic models and the reasoning engine extracts the experience information from them. Through the evaluation equation that is the set of extracted experience information and weights, the service with the highest weighted sum is selected as the best one. But, in Julian's research, the web service selection problem was handled only as the past-experience standpoint and, since the cost was not considered, the negotiation strategies were not used.

2.2 Multi-criteria Decision Making Approach

MAUT(Multi-Attribute Utility Theory)[7] is a commonly used method to provide analytical support to the decision-making process. Utility theory allows decision makers to give formalized preference to a space defined by the alternatives and criteria. For example, in one method, each alternative/criteria pair is given a score reflecting how well the alternative meets the criteria. The scores for each alternative are combined with measures of each criterion's importance (i.e. weight) to give a total utility for the alternative. Utility is a measure of preference for one alternative relative to another.

AHP(Analytic Hierarchy Process)[8] proposed by Thomas Saaty is the approach on the basis of following three main principles: the principle of constructing hierarchies, the principle of establishing priorities, and the principle of logical consistency. The use of hierarchies helps to itemize the alternatives and attributes. Establishing priorities is based on pair-wise comparisons between the alternatives, one criterion at a time. Thus a problem with 5 alternatives and 4 criteria requires 40 comparisons. He then reduces this data using a weighted

Table 1. MCDM approaches[10]

	MAUT	AHP	PROMETHEE
Foundation	Classical MCDM Approach	Saaty's Eigenvector Approach	Outranking Approach
Basis	Utility Function additive model	Pair-wise Comparison matrix by means of 9 point scale	Pair-wise Comparison by means of Preference Function
Approaches to determine criteria weights	Trade-off Swing Direct-ratio Eigenvector approach	Saaty's Eigenvector approach	No
Result	Relative preference order	Relative preference order	Partial and complete ranking order

average to find the ranking of the alternatives. The method allows for checking consistency, the third principal.

PROMETHEE(Preference Ranking Organization METHod for Enrichment Evaluations)[9] have been proposed for the outranking analysis. PROMETHEE is based on the positive(out-) and negative(in-) preference flows for each alternative in the valued outranking relation to derive the ranking. The positive flow is expressing how much an alternative is dominating the other ones. And the negative flow how much it is dominated by the other ones. Based on the preference flows, PROMETHEE I provides a partial preorder. PROMETHEE II is also introduced to obtain a complete preorder by using a net flow, though, it loses much information of preference relations.

Table 1 gives an overview on the basic characteristics of the mentioned MCDM approaches[10].

3 Web Service Selection Method Using PROMETHEE Approach

3.1 Selection Process

Web service selection process consists of QoS Identification, QoS Selection, QoS Evaluation, Decision Making and Service Selection steps as illustrated in Figure 1[11]. QoS Identification step finds all quality characteristics related to the web service. QoS Selection step chooses the characteristics which can be measured among all quality characteristics that are found in previous step. In QoS Evaluation step, the service level[12] for selected quality characteristics should be defined by service provider or consumer and according to the measurement criteria, measured values are calculated. Decision Making step calculates the outranking relation of web services provided by service providers by applying PROMETHEE approach on the basis of measured result values. Finally, Service Selection step compares net flows of web service providers on the priority(partial

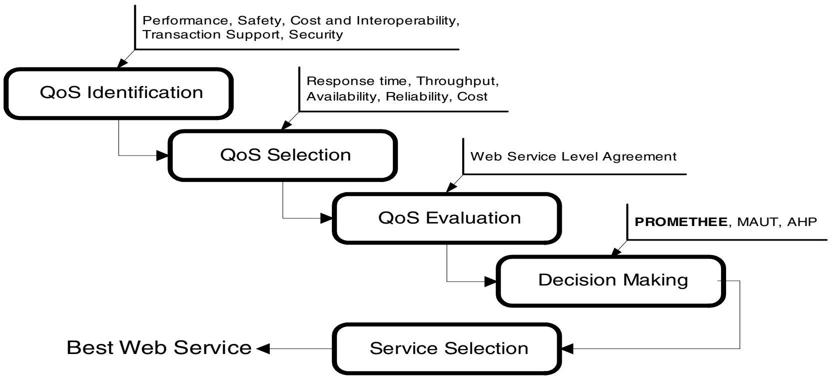

Fig. 1. Web Service Selection Process

ranking) and decides the web service having the largest net flow as the best web service.

3.2 Quality Evaluation Criteria

Since there is no the international web service quality standards model, in this paper, we classified qualities from five different views roughly[13,14]. Performance and safety quality mean that the provided web service is how performance is outstanding and provides services stably. Transaction support quality means the quality that can ensure the integrity when one web service transaction interacts with another web service transaction. Cost and Interoperability quality mean the service cost and the quality level that can be operated with several web services just like one system. Security quality means the web service quality that provides confidentiality and non-repudiation by providing authentication, message encryption and authorization of parties concerned in the web service.

From the web service characteristics, since the quality at the point of time when a customer use the web service acts as an important decision factor, we considered just performance and safety quality and cost in this paper. Table 3 shows the list of qualities except for unmeasurable cases among selected qualities and each quality is measured by given measurement method through web service stress tool periodically. At present, there are two type servers providing web services and these are divided into QoS server and legacy server according to supporting QoS or not[15].

In case of QoS server, service provider can provide the web service according to various service level like gold, silver and bronze and each service level are differentiated by each different quality parameter[12]. But at present most web service provider is a legacy server without the service quality level concept. Therefore, in this paper subjected to the legacy server, we considered the service level in Table 3 according to the level criteria of qualities requested by service consumers.

Table 2. Web Service QoS Criteria

Characteristic	Subcharacteristic	Definition
Performance	Response time	Time form sending Request to receiving response
	Throughput	Ratio of service request completed in unit time
Safety	Availability	Whether a service exists and is available instantly
	Reliability	Reliability degree for service
Cost and Interoperability	Cost	The cost involved in requesting the service
	Standardization	Service compliance with standard
	Compatibility	Compatibility with another web services
Transaction Support	Integrity	Guarantee of integrity when the web service transaction interacts with another web service transaction
Security	Authentication	Authentication of principals for the accessibility to service and data
	Authorization	Authorization allowance for only parties concerned to accessing the protected services
	Confidentiality	Only authorized principals can access data or treat data to modify
	Data encryption	Method that the service encrypt data
	Non-Repudiation	A principal cannot deny requesting a service or data after the fact

Table 3. Selected Web Service QoS Criteria to be measured

Characteristic	Unit	Measurement Method	Service Level		
			gold	silver	bronze
Response time	ms	The time taken to deliver services between service requestors and providers	≤0.3	≤0.7	≤0.9
Throughput	requests/s	Number of service invocation in a given period	200≥	150≥	100≥
Availability	probability	P(Number of Successful executions/Total number of invocations)	1≥	0.6≥	0.3≥
Reliability	probability	$1-P_{Availability}$	0≤	0.4≤	0.7≤
Cost	€	Cost(enactment)+Cost(licensing)	0.05	0.03	0.01

3.3 Web Service Selection Method

In order to select the best web service with result values calculated by 5 quality criteria, this paper adopted PROMETHEE approach and five steps are necessary[5]. The algorithm can be summarized as follows:

Step 1: Define criteria

PROMETHEE is built on the basic notation, with as set A of N alternatives that must be ranked, and K criteria that must be optimised:

$A := a_1, ..., a_N$: Set of discrete alternatives a_t(t=1...N)
$F := f_1, ..., a_K$: Set of criteria relevant for the decision f_k(k=1...K)

First step requires the definition of attributes concerning criteria. Relevant aspects of this input procedure are shown next.

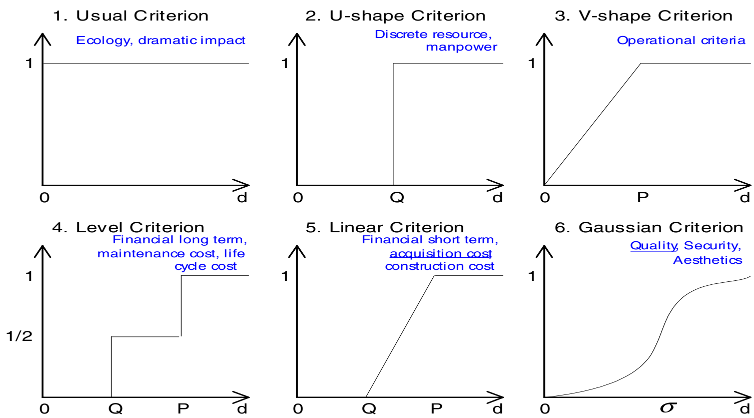

Fig. 2. The ranking obtained using the PROMETHEE method

In Min/Max, Max means an index which gives more positive influence to the relevant web service selection as the evaluation criteria value increases and Min means an opposite case. Weight is decided by experiences of the past and opinions of service consumers. Preference function is defined with 6 kinds as illustrated in Figure 2 and each function is selected by the type of criteria. Here, P and Q and σ mean preference, indifferent and Gaussian threshold that are needed to decide the concrete form of the preference function per evaluation criteria.

In this paper, we considered multi-party and multi-issue negotiation which contains service requester, several service providers and attributes, and focused on the method which finds the optimal compromise suggestion between both sides and decides the service provider offering the maximum gains.

Step 2: Define a vector containing the weigths

Define a vector containing the weights, which are a measure for the relative importance of each criterion, $w^N = [w_1, ..., w_K]$. If all the criteria are of the same importance in the opinion of the decision maker, all weights can be taken as being equal.

Step 3: Define for all the alternatives $\boldsymbol{WSP_i}, \boldsymbol{WSP_j} \in$ WSP the Outranking-Relation $\boldsymbol{\Pi}$:

First, the preference function value per quality criteria should be calculated and the preference function value $p_k(WSP_i, WSP_j)$ of the basis k means $p_k(f_k(WSP_i), f_k(WSP_j))$ which is the difference between WSP_i and WSP_j. The preference index $\Pi(WSP_i, WSP_j)$ is a measure for the intensity of the service consumer's preference for an alternative WSP_i in comparison with an alternative WSP_j for the simultaneous consideration of all quality criteria. It is basically a weighted average of the preference functions $p_k(WSP_i, WSP_j)$.

$$\Pi(WSP_i, WSPj) = \sum_{k=1}^{K} W_k \cdot p_k(WSP_i, WSP_j) \tag{1}$$

Step 4: As a measure for the strength(weakness) of the alternatives $\boldsymbol{WSP_i} \in$ WSP, the outranking flow is calculated:

The outranking relation of alternatives is calculated by figuring out leaving flow(ϕ^+), entering flow(ϕ^-) and net flow(ϕ) like equation 2 with preference index $\Pi(WSP_i, WSPj)$.

$$\begin{aligned} \phi^+(WSP_i) &= \frac{1}{N} \sum_{\substack{n=1 \\ n \neq i}}^{N} \Pi(WSP_i, WSP_n) \\ \phi^-(WSP_i) &= \frac{1}{N} \sum_{\substack{n=1 \\ n \neq i}}^{N} \Pi(WSP_i, WSP_n) \\ \phi^{net}(WSP_i) &= \phi^+(WSP_i) - \phi^-(WSP_i) \end{aligned} \tag{2}$$

Step 5: Graphical evaluation of the outranking relation:

The higher the leaving flow and the lower the entering flow, the better the alternative. In case a complete pre-order is requested, PROMETHEE II yields the so-called net flows. As the net flow $\phi^{net}(WSP)$ of preference is higher, the relevant WSP means the more superior alternative.

4 Case Study

In order to exemplify concretely the application process of PROMETHEE in this chapter, we evaluated web services provided by five different web service providers and selected the most suitable web service considering QoS among them.

4.1 Decision of Weight, Preference Function and Threshold by Evaluation Criteria

Table 5 gives the QoS parameters for the five criteria considered to have the same importance for the web service consumer, therefore all the weights are equal to 0.2. The Response time can become lower in case of failure than in case of accessing the reliable service. On this account, the default weight of the response time tends to be lower than that of the availability or the reliability[4]. But, for the convenience of analysis, we endowed the same weight as another criteria.

Table 5. Decision Table for the Criteria

	RESP	THRO	AVAI	RELI	COST
Min/Max	Min	Max	Max	Min	Min
Weight	0.2	0.2	0.2	0.2	0.2
Preference Function	Gaussi an	Gaussi an	Gaussi an	Gaussi an	Linear
Indifference Threshold	–	–	–	–	0.01
Preference Threshold	–	–	–	–	0.03
Gaussian Threshold	0.2	25	0.15	0.15	–
Unit	Ms	reques ts/s	proba bility	proba bility	€
WSP_1	0.2	100	0.9	0.1	0.04
WSP_2	0.8	160	0.4	0.6	0.02
WSP_3	0.6	130	0.8	0.2	0.05
WSP_4	0.5	180	0.5	0.5	0.04
WSP_5	0.1	140	0.7	0.3	0.03

As illustrated in Figure 2, the preference function of COST criterion was established as a linear type. The others were established as a Gaussian type. Web service consumer must endow a threshold to decide the concrete form of the preference function per evaluation criteria and for this we referred to service level of previous Table 3 in this paper. This paper supposed that the web service consumer require bronze level as COST criterion and more than silver level as other criteria. If the web service consumer is indifferent from 0.01 to 0.02(indifference threshold=0.01) and increases the preference from 0.02 to 0.04(preference threshold=0.03), the consumer definitely chooses the cheapest web service. Gaussian thresholds of other criteria were fixed at the middle value between the lowest limit of the gold level in which the preference increases and the lowest limit of the silver level which was set up as a default.

4.2 Calculation for Leaving Flow, Entering Flow and Net Flow of Preference

Table 6 shows the calculation result for the preference function value per the evaluation criteria. For example in Table 6, by the preference function between WSP_i and WSP_2 in case of the response time(RESP), each preference function value($p_j(WSP_1, WSP_2)$=0.9889, $p_j(WSP_2, WSP_1)$=0.0000) is calculated

Table 6. Preference Function Value per Evaluation Criteria

	RESP	THRO	AVAI	RELI	COST
$p_j(WSP1, WSP2)$	0.9889	0.0000	0.9961	0.9961	0.0000
$p_j(WSP1, WSP3)$	0.8647	0.0000	0.1993	0.1993	0.0000
$p_j(WSP1, WSP4)$	0.6753	0.0000	0.9714	0.9714	0.0000
$p_j(WSP1, WSP5)$	0.0000	0.0000	0.5889	0.5889	0.0000
$p_j(WSP2, WSP1)$	0.0000	0.9439	0.0000	0.0000	0.5000
$p_j(WSP2, WSP3)$	0.0000	0.5132	0.0000	0.0000	1.0000
$p_j(WSP2, WSP4)$	0.0000	0.0000	0.0000	0.0000	0.5000
$p_j(WSP2, WSP5)$	0.0000	0.2739	0.0000	0.0000	0.0000
$p_j(WSP3, WSP1)$	0.0000	0.5132	0.0000	0.0000	0.0000
$p_j(WSP3, WSP2)$	0.3935	0.0000	0.9714	0.9714	0.0000
$p_j(WSP3, WSP4)$	0.0000	0.0000	0.8647	0.8647	0.0000
$p_j(WSP3, WSP5)$	0.0000	0.0000	0.1993	0.1993	0.0000
$p_j(WSP4, WSP1)$	0.0000	0.9940	0.0000	0.0000	0.0000
$p_j(WSP4, WSP2)$	0.6753	0.2739	0.1993	0.1993	0.0000
$p_j(WSP4, WSP3)$	0.1175	0.8647	0.0000	0.0000	0.0000
$p_j(WSP4, WSP5)$	0.0000	0.7220	0.0000	0.0000	0.0000
$p_j(WSP5, WSP1)$	0.1175	0.7220	0.0000	0.0000	0.0000
$p_j(WSP5, WSP2)$	0.9978	0.0000	0.8647	0.8647	0.0000
$p_j(WSP5, WSP3)$	0.9561	0.0769	0.0000	0.0000	0.5000
$p_j(WSP5, WSP4)$	0.8647	0.0000	0.5889	0.5889	0.0000

Table 7. Preference index per evaluation criteria and leaving, entering and net flow

	WSP_1	WSP_2	WSP_3	WSP_4	WSP_5	ϕ^+	$\phi = \phi^+ - \phi^-$
WSP_1		0.5962	0.2527	0.5236	0.2356	0.4020	0.2125
WSP_2	0.2888		0.3026	0.1000	0.0548	0.1865	−0.2831
WSP_3	0.1026	0.4673		0.3459	0.0797	0.2489	−0.0157
WSP_4	0.1988	0.2696	0.1964		0.1444	0.2023	−0.1422
WSP_5	0.1679	0.5454	0.3066	0.4085		0.3571	0.2285
ϕ^-	0.1895	0.4696	0.2646	0.3445	0.1286		

like followings. Since RESP criterion has a more positive effect on the web service selection as it is smaller, in case that x, the difference of evaluation scores between two WSP, is negative, we calculated the selected preference function, Gaussian type func-tion, by substituting $(x = 0.8 - 0.2)$ for the difference of evaluation scores and $(\sigma = 0.2)$ for Gaussian threshold. Reversely, in case that x is positive, it was calculated at 0.0000 since it is not preferred. The preference index can be calculated by summing up preference function values per evaluation criteria and then by multiplying them by the weight. For example, the preference index between WSP_1 and WSP_2 can be calculated by summing up preference function values per evaluation criteria shown at each row of Table 6 and then by multiplying them by weight(0.2) like equation (3).

$$\Pi(WSP_1, WSP_2) = \frac{1}{5}(0.9889 + 0 + 0.9961 + 0.9961 + 0) = 0.5962 \quad (3)$$
$$\Pi(WSP_2, WSP_1) = \frac{1}{5}(0 + 0.9439 + 0 + 0 + 0.5) = 0.2888$$

Table 7 represents calculation results for the preference index per evaluation criteria, the leaving flow, the entering flow and net flow by applying above calculation procedures to all pairs of (WSP_i, WSP_j). The leaving flow and the entering flow of each WSP_i are the average values for the summation of all preference indexes in each ith row and column in table 7 and the net flow is the difference between them.

4.3 Graphical Evaluation of the Outranking Relation

Figure 3 presents the graphical ranking of the investigated alternatives for best web service selection resulting from the outranking method PROMETHEE. According to this evaluation, the web service provided by 5th Web Service Provider (WSP5) is the best choice, followed by the 1st Web Service Provider(WSP1), while the use of 2nd Web Service Provider(WSP2) comes offer as the worst alternative. Since no incomparibilities occur, both PROMETHEE I and the complete ranking in PROMETHEE II give the same order of investigated alternatives.

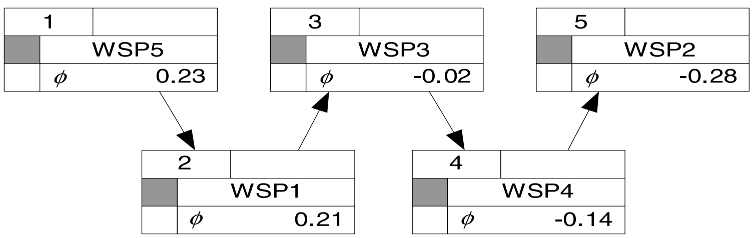

Fig. 3. The ranking obtained using the PROMETHEE II method

5 Conclusion

In this paper, we have presented the web service selection method that can help service consumers to find the service provider who provides the most optimal quality. Our approach allows the dynamic selection of Web services depending on various QoS values and defined service level. The results show that the proposed approach effectively selects high quality web service (i.e., web service which have higher overall QoS). From what has been discussed above, we can conclude that the proposed web service selection approach can be used as a solution for the complexity and reliability problem.

In future work, we will include the support for exception handling during service binding. For example, after a best web service has been decided and while it is being bounden, an exception may occur (e.g., unavailability of a web service). Another interesting issue is to extend our framework with support for mobile clients.

References

1. Sandra Rogers, "Web Services Software 2004-2008 Forecast", IDC, April, (2004)
2. Mike Clark, "UDDI weather report", Nov, (2001), Available online: http://www.webservicesarchitect.com/content/articles/clark04.asp

3. Hung, P.C.K, "Web Services Discovery Based on the Trade-off between Quality and Cost of Service: A Token-based Approach", in the ACM SIGecom Exchanges, Vol. 4.2, Sept, (2003), 20-26
4. Julian Day, Ralph Deters, "Selecting the Best Web Service", In Proceedings of the 14th Annual IBM Centers for Advanced Studies Conference (CASCON), Oct, (2004), 293-307
5. Jae Hyung Min, Young Min Song, "A Comparison of MAUT, AHP and PROMETHEE for Multicriteria Decisions", Proceedings of the Korean Operations and Management Science Society Conference, (2003), 229-232
6. K.H.Bennett, and others, "A Broker Architecture for Integrating Data Using a Web Services Environment", ICSOC, Vol.2910, (2003) 409-422
7. David G. Ullman, "The Ideal Engineering Decision Support System", Technical paper, Robust Decisions Inc., (2004)
8. Thomas Saaty, "Decision Making for Leaders", RWS Publications, (1995)
9. Brans, J. and P. Vincke, "A Preference Ranking Organization method(The PROMETHEE Method for Multiple Criteria Decision-Making)", Management Science, Vol. 31, No. 6, (1985), 647-656
10. Jutta Geldermann, Otto Rentz, "Multi-criteria analysis for the assessment of environmen-tally relevant installations", Journal of Industrial Ecology, (2004)
11. Torsten Bissel, Manfred Bogen, Christian Bonkowski, Volker Hadamschek, "Service Level Management with Agent Technology", Proceedings of the TARENA Networking Confer-ence, (2000), 831-841
12. Asit Dan, Heiko Ludwig, Giovanni Pacifici, "Web Services Differentiation with Service Level Agreements", White Paper, IBM Corporation, May, (2003)
13. Shuping Ran, "A Model for Web Services Discovery With QoS", ACM SIGecom Ex-changes, Vol.4, Issue.1, (2003), 1-10
14. NCA, "A Study on Technical Trends and Deployment Strategies of Web Service Quality Management", National Computerization Agency Research Report, Dec, (2003), Available online: http://www.nca.or.kr/eindex.htm
15. Yu, T., Lin, K.-J., "The Design of QoS Broker Algorithms for QoS-Capable Web Services", Proceedings of the e-Technology, e-Commerce and e-Service Conference, (2004), 17-24