Web Service Selection Based on Requester's Offering Constraints

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***Abstract*—Web service selection is a mechanism to select the most suitable Web service that satisfies requester's various non-functional requirements. In e-business environment, the business offers play a major role in attracting a numerous consumers. In order to find the most profitable service offering a valuable business offer, there is a need for the selection mechanism to rank the functionally similar Web services based on the provider's business offers and the requester's requirements on various business offers. In this paper, we propose an XML model to represent requester's complex requirements on multiple business offers. The paper explores the Web service selection mechanism which selects and ranks the functionally similar Web services based on the requester's requirements on business offers. The paper also presents the broker based architecture for business offer aware Web services publishing and selection. Finally, we present a scheme to represent the requester's alternative requirements on business offers and extend the selection mechanism to handle a set of alternative business offering requirements.**

I. INTRODUCTION

Web services technology promise to facilitate an efficient execution and coordination of B2B and B2C e-commerce by integrating various business applications over the Internet [16]. A Web service is an interface, which describes a collection of operations that are network accessible through standardized XML messaging [1]. The present Web service architecture is based on the interactions between three roles i.e. service provider, service registry and service requester. The interactions among them involve publish, find and bind operations [1]. Web service discovery is the mechanism, which facilitates the requester, to gain an access to Web service descriptions that satisfies his functional requirements. The Web service providers are growing enormously on the Web, offering services with similar or same functionality. This makes the requester to use tools and techniques, to select the Web services based on their non-functional requirements. The Web service selection is the process of choosing single Web service from the functionally similar Web services that satisfies requester's non-functional requirements. In literature, the Web service selection is made based on requester's non-functional requirements like personalization [3], requester's trust and connection policy [4] [5], requester's past experience (behavior) [6] and the Web service quality (QoS) [7] [8]. Many researchers have proposed varieties of architectures for the dynamic Web service selection. A broker based architecture for Web service selection involving non-functional properties like QoS is described in [7] [8] [9]. The UDDI information model is also extended to support non-functional properties like QoS for dynamic discovery and selection [10] [11] [12]. The authors in [13] [14], explains the role of an autonomic agent (agent proxy) in dynamic Web service selection. Thus, most of the selection mechanisms described in literature, deals with only generic QoS criteria of Web services to distinguish functionally similar Web services. A few researchers have used the business qualities like price, compensation rate etc. for the selection and ranking of functionally similar Web services [9] [15]. The business offers in e-business domain play a major role in selecting the business Web services having same functionality. There is a need to distinguish business Web services based on the service provider's various business offers and the requester's business offering requirements. In this paper, we present the Web service selection mechanism, which finds the most suitable Web service for the requester based on his business offering requirements.

A. Motivating Example

Consider the online reservation (booking) scenario of reserving air/train tickets and booking of hotel etc. In order to attract passengers (travelers) in good numbers, the business service providers (e.g. Yatra.com) offer many attractive gifts/offers. For example, the reservation service a may offer 10% reduction on every air ticket. Similarly, reservation service may offer a free gift hamper of worth $20 on five star hotel booking. On the other side, the tourists will have several requirements on business offers made by different booking services. For example, the tourist may prefer a discount on air ticket. The tourist may also prefer a gift hamper of worth $80 or a lucky coupon of worth $1000. If the requester has requirements on different business offers then, how to select the best (most profitable) Web service? It is requester's common tendency to enforce the strong requirements on business offers. For such business offer requirements, the

Web service selection may not find a match for the requester. In such a situation, the requester will have to submit slightly weaker requirements for the selection. This process is time consuming and also a burden for the server hosting the selection mechanism. If the requester has a set of alternative requirements with diminishing preferences on the business offers then, there is a need to find the representation scheme and the selection mechanism to find suitable Web service for the requester.

B. Contribution

To automate the business offer driven Web service publishing and selection, we need to address the following key issues.

(a) How to express the business offers of service providers?
(b) How to represent the business service provider's various business offers?
(c) How to express and represent the requester's requirements on different business offers?
(d) How to select the most profitable Web service for the requester based on his requirements on multiple offers?
(e) The architecture to publish and select business offer aware Web services?
(f) How to represent the requester's a set of alternative requirements on business offers and how to select the Web service for such business offer requirements?

In this paper, we find the solutions for the key issues and the contributions of this paper are:

1. An XML structure to represent requester's requirements on multiple business offers.
2. A selection mechanism to find the most suitable (profitable) business Web services based on requester's requirements on various business offers.
3. Business broker architecture for business offer driven Web service publishing and selection.
4. An extended tree model and an XML structure to represent requester's a set of alternative requirements on business offers.
5. A selection mechanism to handle requester's alternative business offer requirements.

The rest of the paper is organized as follows: In the next section, we introduce varieties of business offers and the information model for business offers. Section 3 describes the requester's various requirements on business offers and their representation schemes. Section 4 presents the business broker based architecture for business offer driven Web service publishing and selection. Section 5 explores the selection mechanism for functionally similar Web services based on their business offers. In section 6, we extend the tree structure to represent requester's alternative business offer requirements. Section 7 describes the implementation and experimentation details. Section 8 draws the conclusions.

II. A BUSINESS OFFER MODEL FOR WEB SERVICES

In e-business scenario, the business offers (offerings) play a major role in selection of business driven Web services. The service providers will advertise a lot of attractive business offers to attract customers in good numbers. We define business offer as a reduction in the price of commodity to be purchased or giving same/other commodity (or service) as a gift on purchase. We categorize business offers of providers as *Unconditional Business Offers*, *Conditional Business Offers*, *Probabilistic Business Offers, Seasonal Business Offers* and *Special Business Offers*.

A. Unconditional Business Offers

Unconditional business offers are delivered without any conditions on the business. This type of business offer is further classified as *Value based Business Offer* and *Commodity based Business Offer*.

1) Value based Business Offer: Value based business offers are normally consists of unconditional discounts or cash gifts on purchased item/service. We further classify value based business offers as *Cash based Business Offer* and *Discount based Business Offer*.

(i) Cash based Business Offer (UC): In cash based business offer, the providers will advertise a gift cheque or cash on every purchase.
(ii) Discount based Business Offer (UD): A discount based business offer involve a reduction in price (discount) on every purchase of goods/services.

2) Commodity based Business Offers: A commodity based business offers normally consists of gifts in the form of an item or service on purchase of specific commodity. We define the following two types of commodity based business offers.

(i) Article based Business Offer (UA): In article based offer, the seller gives the purchased article itself as a gift or any other article as a gift on purchase.
(ii) Service based Offer (US): A service based business offer normally delivers a service as a gift for the purchase.

B. Conditional Business Offers

The conditional business offers are either value based or commodity based business offers such that, the seller imposes a prior condition to enjoy the offer. The prior condition is a relational expression defined on the quantity or price involving relational operators like $>$ and $\geq$. We categorize conditional business offers as *Quantity based Business Offer* and *Sum based Business Offer*.

1) Quantity based Business Offers: In quantity based business offers, the condition is defined on the quantity (numbers) of business transaction. We identify four different types of quantity based business offers depending on the value and commodity involved in the business offer. They are: *Quantity-Cash based Business offer (QC)*, *Quantity-Discount based Business Offer (QD)*, *Quantity-Article based Business Offer (QA)* and *Quantity-Service based Business offer (QS).*

2) Sum based Business Offers: In the business offer, if the condition is defined on the transaction amount (sum) then, the offer is said to be sum based business offer. Depending on type of value or commodity involved in the sum based

business offer, we identify four types of sum based business offers. They are: *Sum-Cash based Business Offer (SC)*, *Sum-Discount based Business Offer (SD)*, *Sum-Article based Business Offer (SA)* and *Sum-Service based Business offer (SS)*.

C. Probabilistic Business Offers

Probabilistic business offers are either conditional or unconditional in nature. In these business offers, the delivery of an offer is probabilistic in nature and the offer is normally valid for some pre-defined period (days/months/years). We identify and define *four* types of probabilistic business offers.

1) Quantity based Lucky Coupon Offer (QL): This is a conditional business offer where, a lucky coupon offer is valid for the purchase of a specified quantity of commodity.

2) Sum based Lucky Coupon Offer (SL): It is conditional offer where, the lucky coupon offer is valid for a given period based on the transaction amount.

3) Unconditional Lucky Coupon Offer (UL): This is an unconditional offer where, the lucky coupon is given on every purchase of commodity.

4) Warranty Period Offer (WP): The warranty period business offers normally related to the delivery of technical service to the customer in the event of breakdown of the bought product/item. The warranty period a business offer which is expressed in terms of months or years that represent the duration for the free technical service.

D. Seasonal and Special Business Offers

Seasonal and special business offers are normally season dependent or special event dependent which is of fixed or varying period. The three business offer categories discussed earlier can be advertised as seasonal or special offers and the providers are responsible for the activation of the business offers during that season or event. For example, during rainy season, an air ticket reservation service may offer 20% discount on every booking. Similarly, at the event of 10^{th} anniversary of its existence, a reservation service may offer a gift hamper of worth $100 or a lucky coupon of worth $2000 on all kinds of bookings.

E. Information Model for Business Offers

The UDDI information model can be extended to represent various business offers by adding a new data structure (entity) under the business service *entity* called *Service Offer*. The service offer entity (data structure) holds the following information for all types of offers. *Offer Id* (Unique Identifier), *Offer Type* (string), *Item Name* (string), *Item value* (currency), *Offer Start Time* (date), and *Offer End Time* (date). Similarly, the service offer also holds the additional information which is dependent on offer type (Refer Table I). The business offer vocabulary defined in the data model has to be used by the Web service providers and requesters for the business offer-aware Web service publishing and selection. If the business offer is characterized with single offer dependent information parameter then such a business offer is called as *Atomic Business Offer* otherwise, it is termed as *Non-atomic Business Offer*. For example, value based business offer are atomic business offers whereas, conditional business offers are non atomic business offers.

TABLE I
BUSINESS OFFER SPECIFIC INFORMATION

Offer Type		Information
Value based Business Offers	UC	Cash value (Amount)
	UD	Discount (Percentage)
Commodity based Business Offers	UA	Gift value (Amount)
	US	Service value (Amount)
Quantity based Business Offers	QC	Cash value (Amount) & Quantity
	QD	Discount (Percentage) & Quantity
	QA	Gift value (Amount) & Quantity
	QS	Service value (Amount) & Quantity
Sum based Business Offers	SC	Cash value (Amount) & Sum
	SD	Discount (Percentage) & Sum
	SA	Gift value (Amount) & Sum
	SS	Service value (Amount) & Sum
Warranty based Business Offers	WP	Warranty period (in days/months)
Probabilistic Business Offers	UL	Coupon value (Amount)
	QL	Coupon value (Amount) & Quantity
	SL	Coupon value (Amount) & Sum

III. REQUESTER'S BUSINESS OFFER CONSTRAINTS AND MODELING

The Web service requester normally expects some requirements on business offers to be satisfied by the providers. We define a business offer constraint as the requester's requirement on service provider's business offerings. Formally, business offer constraint is a relational expression defined on business offers. Business offer constraints are normally different for individual requesters. Thus, Web service requesters can have different constraints on various business offers.

A. Requester's Business Offer Constraints

We categorize the requester's business offer constraints based on the constraint structure as *Simple Business Offer Constraint* and *Composite Business Offer Constraint*.

1) Simple Business Offer Constraint: A simple business offer constraint normally deals with one business offer. For example, the requester might say "I need a booking service which offers a free gift of worth $25". This is a simple business offer constraint which can be written as "UA ≥ 25". A simple business offer constraint takes the following format: O_i cp V_i where, O_i refers to atomic or non-atomic business offer, cp refers to comparison operator (> and ≥) and V_i refers to expected value(s) of O_i. A simple business offer constraint is further classified based on nature of business offer O_i. If the requested business offer is atomic in nature then the simple business offer constraint is called as *Atomic Business Offer Constraint*. The simple business offer constraint defined on non-atomic business offer is called as *Non-atomic Business*

Offer Constraint. For example, consider the requester's requirements "booking service which offers 10% discount for the booking amount above $100". This is non-atomic business offer constraint which is represented as "SD >10, 100".

2) Composite Business Offer Constraint: A composite business offer constraint is composed of multiple simple business offer constraints using constraint composition operators AND and OR. For example, the requester might say "I am interested in a reservation service that offers 10% plus discount and offers a lucky coupon of worth $300". This is composite business offer constraint which can be represented as "UD ≥ 10 AND UL ≥ 300". The Web service requesters can enforce either simple or composite business offer constraints during Web service selection to choose profitable service offering valuable business offer(s).

B. Requester's Business Offer Constraint Modeling

Consider the requester's business offer constraint which is to be satisfied on *M* business offers. We propose a tree structure called *Business Offer Constraint Tree* (*BOCT*) and its XML equivalent to represent requester's offer constraints on multiple business offers.

1) Business Offer Constraint Tree (BOCT): A business offer constraint tree [16] is a AND-OR tree whose leaf node contains three or four information items based on nature of requested business offer. The leaf node contains the following information items: business offer O_i, comparison operator cp and expected offer value(s) V_i. The internal node refers to constraint composition operator op i.e. AND/OR. The leaf node represents simple business offer constraint and any sub-tree rooted at internal node represents composite business offer constraint.

The requester's business offer constraint can be represented using BOCT. Consider online reservation scenario, with the traveler's business offer constraints as follows. The traveler prefers a service which offers 20% discount and offers a lucky coupon of worth above $500 or free gift of worth $60 or above. This constraint can be represented as "UD ≥ 20 AND UL ≥ 500 OR UA ≥ 60". The requester's business offer constraint can be represented as BOCT as shown in Fig 1.

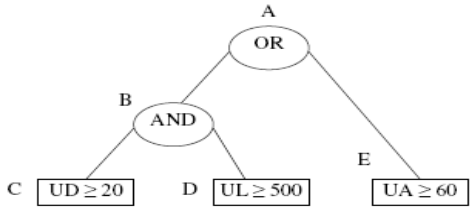

Fig 1. BOCT for Requester's Business Offer Constraints

2) XML Structure for Business Offer Constraint: Here we present the XML representation for requester's business offer constraints. If the requester is an agent program interacting with the selection mechanism then, the requester's business offer constraints have to be supplied for the selection by embedding the business offer constraints within the header of SOAP message. In XML representation, the BOCT is represented using a tag <BOCT> with sub-tags <INTERNAL> and <LEAF>. The internal node is represented with a tag <INTERNAL> and it takes two attributes namely type and level. For any internal node X, the type attribute refers to type of internal node (AND/OR) and the level attribute refers to level of the internal node. The leaf node is represented using tag <LEAF> that takes three attributes namely offer, operator and level. For any leaf node Y, the offer attribute refers to offer type Oi, operator attribute refers the comparison operator cp and the level attribute refers to level of the leaf node. The expected values of non-atomic business offer constraints are enclosed with tags <Value> and </Value>. Fig 2 shows the XML structure for business offer constraint tree of Fig 1.

```
<BOCT>
  <INTERNAL type = "OR" level = "2">
    <INTERNAL type = "AND" level = "1">
      <LEAF offer = "UD" operator = "≥" level = "0"> 20 </LEAF>
      <LEAF offer = "UL" operator = "≥" level = "0"> 500 </LEAF>
    </INTERNAL>
    <LEAF offer = "UA" operator = "≥" level = "0"> 60 </LEAF>
  </INTERNAL>
</BOCT>
```

Fig 2. XML Representation of BOCT

IV. BROKER BASED ARCHITECTURE FOR BUISNESS OFFER DRIVEN WEB SERVICE SELECTION

We propose the business broker based Web service architecture for dynamic Web service selection with an objective of selecting the most profitable Web service that satisfies requester's business offer constraints.

A. System Architecture

We define an additional role to the conceptual Web service architecture [1] named *business broker* and a new operation namely *select*. The broker is a middleware defined between service registry and the requester, which facilitates the requester to specify his business offer constraints. From an architectural perspective, business broker is a middleware which can be implemented as a Web service. The formats & rules for business offer driven Web service publishing and the selection is made available in the UDDI registry by publishing the business broker details into UDDI registry. The select operation is defined between the broker and a requester which facilitate the requester, to select profitable Web service based on business offer constraints. Fig 3 shows the roles and operations of business broker based Web service architecture.

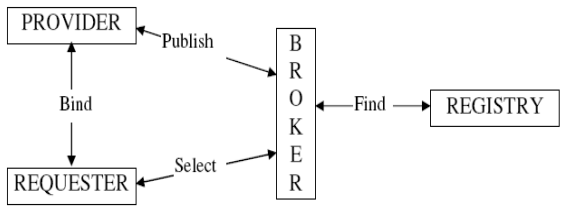

Fig 3. Broker Based Service Architecture

B. Business Broker Component Interactions

We propose broker with *four* components namely *Service Selector*, *Service Publisher* and *Business Offer Store*. The interaction among the various components (sequence diagram for service publishing and service query) is depicted in Fig 4. For each component, we define a set of functions to fulfill the requester's objective of selecting the most profitable Web service that satisfies his business offer constraints.

1) Service Selector: The main functionality of this component is to select and rank the functionally similar Web services based on requester's business offer constraints. The functions of this component include, receiving messages containing service functionality and business offer constraints from the requester, finding the functionally similar Web services (candidates) from the service registry though functionality matching [1] [2] and finally the ranking of candidate Web services based on requester's business offer constraints. The service requester can find the guidelines to form a search query through the UDDI registry entry of business broker. The sequence of activities among various components for a service selection request is shown in Fig 4 (a).

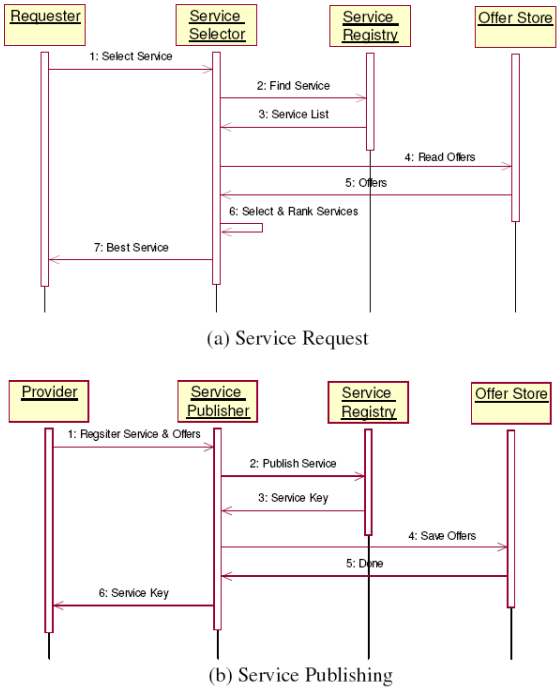

Fig 4. Sequence Diagram for Service Selection and Publishing

2) Service Publisher: This component facilitates the registration, updating and deletion of business and service specific information including business offerings. The architecture adopts the business offering vocabulary as defined in section 2. The Web service provider has to supply the necessary information related to business offers as defined by the business broker. The provider can obtain the format and rules for service publication from the UDDI registry, as the business broker itself is published in UDDI registry. The sequence of activities for service publishing is described in Fig 4 (b).

3) Business Offer Store: This component of the business broker is used to store the various business offers and their related information (business offer entity) for Web services. The business offer information is saved into business offer store by the service publisher component of the broker.

V. Business Offer Driven Web Service Selection

This section of the paper concentrates on the selection and ranking mechanism for business offer driven Web services based on requester's business offering constraints.

A. Evaluation of Business Offers

The Web service provider can advertise multiple business offers. This makes the selection mechanism to use common estimation criteria to evaluate different types of business offers. We define the estimation parameter called *Profit Index (PI)* which is computed as the ratio of profit amount to the payable amount. For discount offers, the profit value is expressed in terms of amount. The value of PI is computed based on the type of business offer. Table II shows the estimation of PI values for various business offers.

TABLE II.
Profit Index (PI) for Business Offers

Offer Type	Value of PI
Unconditional Business Offers	$PI = \frac{\text{Offer Value}}{\text{Item Value}}$
Quantity based Business Offers	$PI = \frac{\text{Offer Value}}{\text{Quantity x Item Value}}$
Sum based Business Offers	$PI = \frac{\text{Offer Value}}{\text{Amount}}$
Unconditional Lucky Coupon Offer	$PI = \frac{\text{Coupon Value}}{\text{Item Value x Offer Period}}$
Quantity based Lucky Coupon Offer	$PI = \frac{\text{Coupon Value}}{\text{Quantity x Item Value x Offer Period}}$
Sum based Lucky Coupon Offer	$PI = \frac{\text{Coupon Value}}{\text{Amount x Offer Period}}$
Warranty based offer	$PI = \frac{\text{Warranty Period}}{\text{Item Value}}$

B. Web Service Selection Mechanism

The service selector component of business broker is responsible for the business offer-aware Web service selection. The selection mechanism takes BOCT of height *H* and the candidate Web services i.e. Web services discovered from service registry (N) as an input and results in a list of Web services ranked based on prospective level of satisfaction of requester's business offering constraints. The algorithm traverses BOCT in level order fashion (level 0 to level H) and treats leaf and internal nodes in a different manner. At leaf nodes algorithm performs *two* actions: (1) *Filtering* and (2) *Ranking*. In filtering phase, the Web services satisfying business offer constraint defined at leaf node are selected and

attached to the leaf node. The ranking phase computes the profit index (PI) values for the attached Web services which represent the score (rank) for Web services at that leaf node.

At internal nodes, the algorithm performs *two* actions: (1) *Filtering* and (2) Ranking which are dependent on the type of node (*AND*/*OR*). In filtering phase, if the node is *AND* then, the Web service present in *all* its child nodes is selected. If the node is *OR* then, the *distinct* Web services in the descending order of their scores are selected from its child nodes. In ranking phase, if the node is *AND* then, the score of selected Web service is computed as the sum of scores of selected Web services at its child nodes. If the node is *OR* then, the score of selected Web service is made unchanged. After ranking the Web services at the root node, Web services are sorted in the descending order of their score. Finally, the algorithm returns first Web service to a requester as a most profitable (In terms of business offer) Web service. The detailed selection algorithm is presented below (Algorithm 1).

Algorithm 1.

Input: BOCT of height H, Candidate Web services returned from Web service registry
Output: Ranked list of Web services

1. For each BOCT node (X) at Level-0 (i.e., leaf node) of the form, O cp V perform the following sub-steps
   Filtering: Select Web services that satisfy offer constraint defined at leaf X and attach them to X
   Ranking: Compute the profit index (PI) values of business offer "O" for the selected Web services and attach the PI values to X
2. For Level-1 to Level-H of BOCT perform Step 3
3. For each internal node (X) perform the following
   Filtering:
   (i) If X is AND node then attach the Web services to X which are present in all child nodes of X
   (ii) If X is OR node then attach distinct Web services to X from its child nodes based on the descending order of their scores by eliminating the duplicates
   3.2 Ranking:
   Let Y_1, $Y_2 \ldots Y_C$ be C child nodes of X, S_{WS} be the new score for a Web service WS attached at X.
   (i) If X is AND node then for each attached Web service WS at X, new score S_{WS} is computed as: $S_{WS} = S_{WS}$ at $Y_1 + \ldots + S_{WS}$ at Y_C
   (ii) If X is OR node then for each attached Web service WS, the score is unchanged i.e. $S_{WS} = S_{WS}$ at Y_I where Y_I is the child node of X through which WS is selected
4. Let K be the number of Web services attached to the root node. Sort these Web services in the descending order of their scores. Now the first Web service becomes the best (most profitable) Web service for the requester.

The selection algorithm first filters the Web services based on requester's business offer constraints defined at the leaf nodes. The PI (profit index) values of the selected Web services represent a score where, the higher score indicates more profit deliverability of a Web service. At the internal node, the Web services are further filtered and the score is computed depending on the type of internal node (AND/OR). Thus at any node, the score of a Web service represents the rank at that node. After sorting the Web services at the root node, the first Web service becomes the profitable Web service for the requester satisfying his requirements on offers.

C. Illustration for the Selection Algorithm

Consider the ticket buying scenario (BOCT presented in Fig 1). Assume that, the service registry finds *five* ticket booking services with business offers as tabulated in Table III. We assume the ticket price at Web service providers BS_1 to BS_5 is \$120, \$250, \$300, \$150 and \$200.

TABLE III.
BUSINESS OFFERS OF RESERVATION SERVICES

Seller	Business Offers
BS_1	20% discount + \$700 worth lucky coupon for the period of 100 days
BS_2	Leather wallet of worth \$62 is free
BS_3	\$1200 worth lucky coupon (Gold coin) for the period of 50 days
BS_4	Buy 2 tickets and get one ticket free
BS_5	30% discount on purchase

The service selector reads the BOCT of height 2 representing requester's business offer constraints (Refer Fig 5) and then executes the Web service selection algorithm as follows. The algorithm first performs *Step* 1 for all leaf nodes. For example, consider the leaf node *C*, Web services BS_1 and BS_5 are attached with profit index (PI) values 0.2 (24/120) and 0.3 (60/200). Now the algorithm performs Step 3 for internal nodes. At node B (AND node), the Web service BS_1 is selected with the new score 0.25 (0.2 +0.05). Finally, at the root node A, the Web service BS_1 is selected and returned to the requester as a profitable ticket booking service.

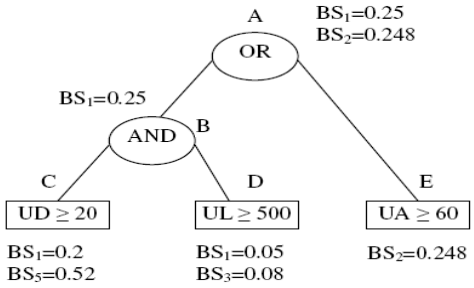

Fig 5. Trace of Selection Algorithm

VI. REQUESTER'S ALTERNATIVE CONSTRAINTS ON BUSINESS OFFERS AND THE SELECTION MECHANISM

Normally buyer (requester) looks for more profit from the business transaction. In such situations, business offer-aware Web service selection mechanism discussed in section 4 might return an empty Web service list to the buyer which makes him to refine his business offering constraints. This process is time consuming for the buyer and also a burden for the broker

hosting the selection mechanism. To avoid these problems, buyer can submit a set of alternative requirements on business offers in the order of diminishing preferences to the broker for selection.

We extend the BOCT structure to represent requester's set of alternative business offer constraints with diminishing preferences. We propose the concept of *extended business offer constraint tree* to represent requester's alternative business offer constraints. Consider S = {OC_1, OC_2… OC_R} be the set of R business offer constraints of the requester in the order of diminishing preferences. Let OC_1 be the highest preferred constraint and OC_2 to OC_R be the alternative business offer constraints in the order of diminishing preferences. Let $BOCT_1$, $BOCT_2$ … $BOCT_R$ be the BOC trees for R alternative business offer constraints OC_1, OC_2…OC_R. We create a new node called XOR and then attach these R, BOC trees to the XOR node. Now, the XOR node becomes the root for all BOC trees. The most preferred business offer constraint (strong constraint) is placed as the left most sub-tree and the other sub-trees are placed according to their preferences to the right of the rightmost sub-tree. As an example, consider the buyers alternative business offer constraints as follows: (1) Requester prefers booking service which offers 40% discount (2) Offers free gift of worth $60 and above (3) Offers 5% discount and a lucky coupon of worth $300 and above. The first constraint is requester's primary business offer constraint which is to be satisfied by the Web service. If no such web service is available; then the alternative constraints are used in sequence to search for the desired Web service. Fig 6 presents the extended BOCT for the ticket buyer's alternative business offer constraints. The left most business offer constraint i.e. UD ≥ 40 is a strong constraint and the constraint UA ≥ 60 is a first alternative followed by the weak constraint. The weak business offer constraint is composed of two simple business offer constraints.

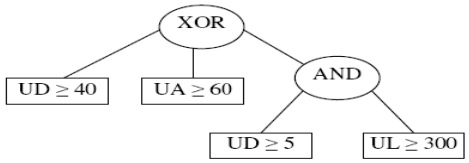

Fig 6: Extended BOCT for the Alternative Business Offer Constraints

The Web service selection mechanism takes the extended BOCT and the candidate Web services (functionally equivalent Web services returned from UDDI registry) as an input and results in a best Web service that satisfies requester's alternative business offer constraints having diminishing preferences. The service selector component of business broker first executes extended Web service selection algorithm (Algorithm 2) which in turn calls the *Algorithm 1* to select and rank the Web services based on the business offering constraints. At the root (*XOR* node), the algorithm takes the leftmost sub-tree and passes it to the selection algorithm (Algorithm 1) which finds the best Web service for a given business offer constraint. If no Web service is found, then second left most sub-tree is considered and this process is repeated until a desired Web service is found or the entire extended BOCT is considered for the selection. The formal algorithm to handle requester's set of alternative business offer constraints with diminishing preferences for the selection is presented below (Algorithm 2).

Algorithm 2.

Input: Extended BOCT, Candidate Web service List (*CWL*)
Output: Ranked List of Web services

Let S be the root (XOR) of extended BOCT.
1. Let Y_1,Y_2…Y_R be child nodes of S
2. For Y = Y_1 to Y_R do
   Let $BOCT_Y$ be the BOC tree rooted at Y
   WSL = Algorithm 1($BOCT_Y$, CWL)
   If WSL ≠ Nil then
      Select the first Web service from WSL and return it to the requester as a best Web service
      Break the loop (Step 2) and STOP

VII. IMPLEMENTATION AND EXPERIMENTS

The service selector component of the business broker is implemented on Windows XP platform using Microsoft Visual Studio .NET development environment and Microsoft visual C# as a programming language. To enable the interaction between .NET program and the UDDI-compliant server, we use Microsoft UDDI .NET 2.0 Beta 1 SDK. We use SAP UDDI V3 Test Public Business Registry [17] enquiry API to retrieve the functionally similar Web services from SAP UDDI test public registry. We use Microsoft SQL Server 2000 database to store the information related to various business offers of Web service providers. For this purpose, we maintain a single table with the following fields -Service Id, Offer Id, Offer Type, Item Name, Item Value, Offer Period, Offer value, Quantity and Amount. The business provider registers the service and the business offers through a user interface form consisting of service and business offer information fields. The broker publishes service specific information into service registry and copies the business offer specific information into business offer store.

To perform business offer aware search, the requester enters the service functionality and the business offer constraints are supplied (by taking *N*=4) to the broker as follows. The simple business offer constraints are fed in form as {Constraint number, Comparison Operator, business offer type, Value1, Value2} and the composite business offer constraints are fed in the form {Constraint number, Composition Operator, C_1, C_2, C_3, C_4} where, C_1, C_2, C_3 and C_4 are simple business offer constraints references. We have conducted several experiments to test the correctness and importance of business offers in e-business domain.

Here we present the simple experiment which is conducted to select best *reservation* Web service for the traveler with the following alternative business offer constraints in the order of diminishing preferences: (1) UD ≥ 5 AND UL ≥ 300 (2) UD ≥

20 AND QD ≥ 10, 4. The SAP test registry returns, *three* reservation Web services and the information related to business offerings of these Web services are given in the format {Web service, Item/Ticket value, UD (Percentage), UL (Amount), QD (Percentage), QD(Quantity) as follows. {BS_1, 100, 6, 400, -, -}, {BS_2, 150, -, 200, 25, 5} and {BS_3, 125, 3, -, 30, 3}. The requester's strong and weak (one alternative) business offer constraint is presented in Table IV and Table V.

TABLE IV.
STRONG BUSINESS OFFER CONSTRAINT

No	Operator	Offer	Value1	Value2
1	≥	UD	5	-
2	≥	UL	300	-
3	AND	1	2	-

TABLE V.
WEAK BUSINESS OFFER CONSTRAINT

No	Operator	Offer	Value1	Value2
1	≥	UD	20	-
2	≥	QD	10	4
3	AND	1	2	-

We can see that, the only Web service BS_1 satisfies the strong business offer constraint and the Web service BS_3 satisfies the weak business offer constraint. Thus, the business offer driven selection algorithm for the requester's alternative business offer constraints finds the Web service BS_1 as a best Web service which satisfies requester's strong business offer constraint.

VIII. CONCLUSION

The Web service selection is the mechanism to find the most suitable Web service based on requester's non-functional requirements. In this paper, we propose a mechanism to select the most profitable Web service that provides a valuable business offer to the requester. The selection mechanism also ranks the functionally similar Web services based on requester's constraints on multiple business offers. The paper explores an XML structure to represent requester's constraints on multiple business offers and proposes the business broker based architecture for business driven Web service selection. The paper also suggests the scheme to represent requester's alternative constraints on business offers and proposes the Web service selection mechanism to handle such constraints. We implemented the business broker and conducted several experiments and the experimentation shows that, the functionally similar Web services are effectively selected and ranked using requester's constraints on business offers. As a future work, we will identify more business offer types and the mechanism to handle business offers on multiple business items.

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