Service Selection using WS-Agreement

by

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Declaration

This is to certify that

i) The thesis comprises my original work towards the degree of Master of Technology in Information and Communication Technology at DA-IICT and has not been submitted elsewhere for a degree

ii) Due acknowledgement has been made in the text to all other material used.

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This is to certify that the thesis work entitled 'Service Selection using WS-Agreement' has been carried out by Nrupen Chudasma(200511011) for the degree of Master of Technology in Information and Communication Technology at this Institute under my supervision.

Thesis Supervisor

Abstract

The business requirements are dynamic in nature and identification of suitable business partners "on demand", who can satisfy a set of guarantees is a critical process. Selection of business partners is influenced by several parameters including maximizing profit, minimizing cost, reliability, credit history, etc. A business process can be decomposed into several tasks, possibly expressed as Web services implementing desired business functionalities. Each service offers a set of guarantees, each defining a Service Level Objective(SLO). Many service providers may provide the similar business functionality in the form of service with different SLOs. Thus it is necessary to select the service offered by service partner such that overall performance of the process is improved.

The thesis proposes an architecture for solving selection of the best service provided by available service partners. To put across our approach, the thesis has taken examples from the Agro-Produce marketing System. By specifying requirements of the service in the form of multiple service level objectives (SLOs), selection of a service provider can be achieved based on the best or optimal matching of SLOs of service consumer and providers. A set of services, SLOs, and participating actors constitute a Service Level Agreement (SLA). In this work, WS-Agreement specification is used to specify the SLA. For flexible selection, role of semantic web concepts such as ontology and semantic rule language is discussed. The service partner must comply with the multiple criteria and preferences of a requester, Multi Criteria Decision Making (MCDM) methods is required in the service selection process.

Two scenarios for service selection from Agro-Produce market system are taken. One is single service selection where selection of sellers selling mangos are selected based on the best seller offer. Second one is related to service composition where more than two services need to be selected, such that overall process performance is improved. The scenario is from rice production process where selection of farmer, rice-miller, storage provider and transporter contribute to overall cost, quantity and quality of rice.

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Chapter 1

Introduction

Using service oriented architecture (SOA), organizations can organize, utilize and control their distributed capabilities [2]. A web service, which is a software system designed to support interoperable machine-to-machine interaction over network [1], utilizes the standards such as WSDL [3] to describe service interfaces by service provider, SOAP [4] for machine-to-machine interoperability of message exchange and UDDI [5] to publish services and later discovered by the service consumers. With web services, loosely coupled and interoperable distributed applications can be visualized.

To achieve applications utilizing web services, a service passes through many phases, importantly (i) service creation, (ii) service discovery, (iii) service selection, (iv) service composition, (v) service execution and monitoring and (vi) service termination. Service creation phase can have many sub phases such as service interface identification, building software components implementing the interfaces, deploying the web service and publishing the web service using UDDI.

Searching for required service and service provider from registry (e.g. UDDI) is an important phase which aides choosing best possible service. The service selection is the process of choosing the service achieving the business demands. When required services are chosen, generating a work-flow constituting a business process is the next phase. The process is composed of a set of services acting as a building block. The providers create services publish it to service registries. Service composition engine discovers and selects the desired services dynamically and composes the process. Monitoring the service execution refers to checking the fulfillments of the

business requirements and taking taking the desired the steps.

With web services, the loose coupling of software components realizes the applications the dynamic selection of suitable partners on Internet and applications ranging from E-commerce, Supply Chain Management (SCM), Enterprise Applications, Grid Applications and many more can be instantiated on demand by business parties with proper composition of web services. The question is, with the technologies mentioned above is it sufficient to achieve all the goals of applications constructed using Service Oriented Architecture (SOA) [2]?

The services parameters in general are functional and non-functional. The functional aspects of a service has to do with, "what a service does". Where as non-functional attributes of service constitute the guarantees associated with the service. These guarantees can be of Quality of Services (QoS), e.g. response time, availability, reliability, performance, throughput, cost etc. In brief, the non-functional aspect of a service is associated with, "how well a service does". The demand of guarantees might be different according to different classes of users. For each user/class of user, a guarantee defines the service level he/she is opting for. Each guarantee is associated with Service Level Objectives (SLOs). Set of services, set of parties, set of SLOs, and their relationships defines the Service Level Agreement (SLA).

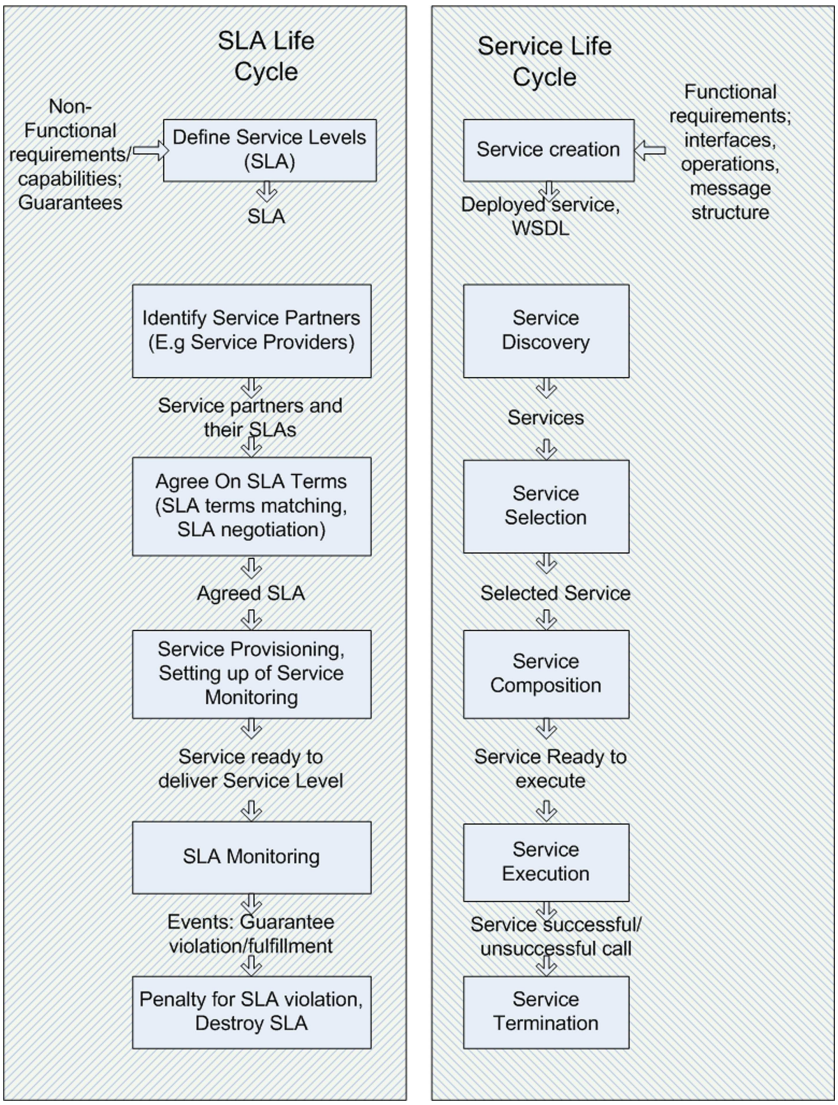

Figure 1.1: Service and SLA life cycle

Figure 1.1 shows the important phases in the life cycle of service as discussed previously and accordingly the life cycle of SLA. As far as SLA is concerned, when creating a service, one needs to specify the service levels for different service consumers. For consumer as well, appropriate SLA defines his/her requirements. In service discovery identifying a set of candidate services based on service level is important. Service selection is choosing the best partner based on service levels specified, and that is choosing best SLA possible. In service provisioning, estimating the service capabilities according to the required SLOs mentioned in SLA is desirable. Service

execution and monitoring requires verifying the fulfillments of agreement guarantees and taking appropriate actions. Apart from this, while negotiating for services, the service partners must define the SLA for which they are negotiating and should craft negotiation strategies based on the SLO requirements.

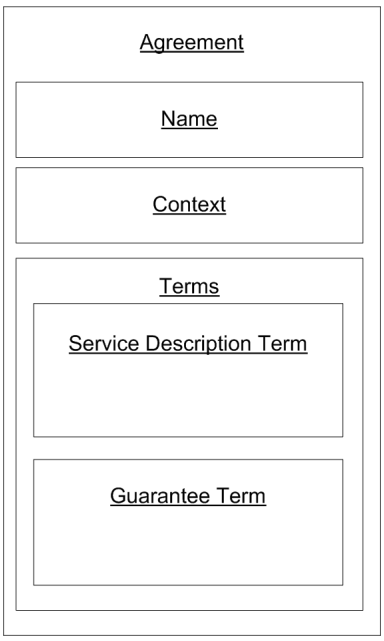

Figure 1.2: Structure of WS-Agreement[6]

WS-Agreement [6] specification is developed by the participants of the GRAAP Working Group (Grid Resource Allocation and Agreement Protocol WG) of the compute area of the OGF (Open Grid Forum). WS-Agreement defines the schema for specifying a service level agreement (SLA). It also defines an agreement template and a set of port types and operations for managing agreement life-cycle, including creation, expiration and monitoring of agreement states [6]. Apart from this, WSLA [7] specification is developed by IBM which is similar to WS-Agreement.

The structure of WS-Agreement as shown in Fugure 1.2 consists of (i) Context, describing the concerned parties and their role in agreement (ii) Service Description Term (SDT) and (iii) Guarantee Terms. WS-Agreement provides a protocol for achieving the agreement by exchanging the agreement offers and accepting/rejecting the offers.

After a brief introduction about web service and SLA, let's take a real world problem of dynamic service consumption where one business process is identified according to the business requirements and it is specified with the help of work-flow technology. The process can be decomposed into a number of web services provided by possibly many parties. Each service is assigned business requirements, which affects the overall process requirements.

To get the best performance while running the process, one needs to find the best partner who meets the business requirements; minimize the cost and maximize the benefits while running the underlying transactions. Selecting the proper service, i.e. finding the service provider, who satisfies the best possible service criteria is crucial.

The thesis work is motivated by the Grid Business Process [36] discussing the scenarios from Agro-Produce Market System, an effort of integrating distributed agriculture markets for trading the agriculture commodities. The thesis evaluates requirements for selection of different stake holders such as sellers, buyers, transporters and such related to Agro-Produce industry based on the service levels they offer.

The thesis proceeds by defining the service selection problem formally in chapter 2. In chapter 3 the architecture for web service selection using SLAs is proposed. An example scenario for web service selection is discussed in chapter 4. Dynamic service selection in service composition with an example scenario is discussed in chapter 5. The conclusions and future work are in chapter 6.1 and chapter 6.2 respectively.

Chapter 2

Service Selection

As mentioned before, the service selection process selects the best possible service provider who would satisfy all the criteria of a service consumer.

SLA provides a mechanism to specify service criteria in terms of service level objectives(SLOs). With this service selection is reduced to find an SLA of a service provider, which satisfies the best SLOs and preferences over SLOs.

The consumer specifies the service selection criteria in possibly multiple SLOs which constitutes an SLA. Each alternative provider may be providing the service at different service level. Suppose we have a service consumer c and set of service providers p_1, p_2 ... p_n where $n \geq 1$. The SLA_c contains the service requirements of consumer c and SLA_{p1} ... SLA_{pn} specifies the support of service levels by each service provider. Our objective is to find out the provider p_x, $1 \leq x \leq n$ such that SLA_{px} meets the best requirements of SLA_c.

While matching the SLAs, it is not guaranteed to get the best match for each SLO. One provider might be satisfying one SLO the best while the other criteria satisfaction might be average or even poor. The same may apply to the other providers. It is also possible that the SLO requirements are such that two SLOs conflict, e.g. cost and benefits of the service. One would like to maximize the benefits and minimize the cost. In general while reducing the cost the benefits cannot be maximized. Reversing the situation, maximizing the benefits, the cost of a service increases.

To summarize, SLA matching problem is selection based on multiple criteria problem. One can use Multi Criteria Decision Making (MCDM) [24] techniques to fulfill

this requirement.

2.1 Related Work

Sheth A. et al [13] utilized WS-Agreement for selecting the partner with an approach of using semantic web concepts for matching SLO. The proposed solution discusses the use of Ontology constructed in OWL [8] to annotate the SLA described with WS-Agreement. The rule language such as SWRL [9] is utilized to define rules for matching two SLOs. The solution automates the matching process. The approach is flexible as describing the rules in descriptive logic is easy and they don't have to be hard coded in a program. The solutions tries to match one SLO at a time and list out the best match according to the specific SLO requirement. On the other hand, as discussed previously SLA matching is based on overall SLA match. Optimization methods are required to decide which SLA is best offered by the provider.

Hai Jin and Hao Wu [14] proposed an OWL ontology to express QoS guarantees in Web Service Agreement and SWRL rules for matching SLO and contract negotiation.

Maximilien and Singh [15] addressed the issue of dynamic service selection using agent framework and QoS ontology. They have used WS-Policy [16] specification for specifying QoS. In similar approach Verma et al [17] proposed semantic matching of WS-Policy to find out the partners satisfying required QoS.

WS-QoS [21], QoSOnt [19] and DAML-QoS [20] are the efforts to define the QoS Ontology for dynamic discovery and selection of services. Xia Wang et. al [18] proposed an approach for selecting service based on QoS ontology and a matching algorithm which matches QoS profiles.

Chapter 3

Proposed Architecture for Service Selection

A brief architecture for service selection is explained in Figure 3.1, where service provider provide service level assurances in a given SLA. Service consumer specifies service level requirements in terms of service selection criteria and preferences. The matchmaker searches SLAs of the providers and decides the the best match and returns the results to the consumer.

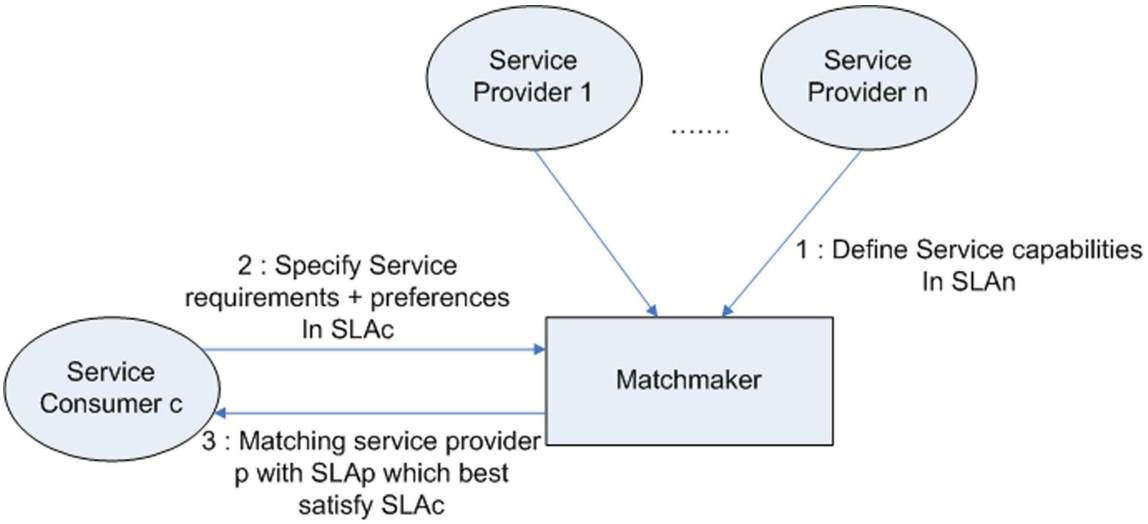

Figure 3.1: Abstract Architecture for Service Selection

3.1 Specifying SLAs

Service selection process starts by specifying service capabilities/requirements. Both the parties must decide the non-functional parameters and metrics of the parameters. For example QoS parameter like availability, response time, throughput, cost etc and the metrics for all the QoS attributes must be decided prior to the service selection. The unspecified parameters during service selection process are assumed to be of no importance as far as the service agreement is concerned.

Selection process compares the supported service levels, i.e. parameter/value pairs of a service provider with service the requirements of consumer. Both the parties have to share the same semantics of service parameters. If not then syntactic comparison of parameters becomes inefficient. Syntactic comparison is inflexible as meanings of parameters are not utilized fully. For example "averageResponseTime" of a service is defined as mean over "responseTime" parameter. The syntactic comparator has to do more rigorous task to work out such complexity and it has to be programmed exhaustively for each case. Designing an Ontology would help to overcome this difficulties. Ontology is "an explicit specification of conceptualization" [12]. Building ontology for non-functional attributes of the service is the first step towards specifying the service selection criteria. One needs to identify the service parameters of interests, define the simple parameters and their metrics and then define the composite parameters. The service parameters, their metric, valid value restrictions, and the relationship between parameters defines the ontology for the service selection process. Two types of ontology needs to be constructed. Domain independent ontology such as "Time", "QoS", "Currency" ontology which define the generic attributes of interest. As service criteria must be composed of domain dependent service parameters, domain dependant ontology construction is also important. With ontology and Horn Clauses (the semantic rule language) the comparison of SLOs at later stage becomes efficient which aids the decision making process for service selection.

After identifying the service parameters, the parties needs to define the service levels (Service Level Objectives) of interest. SLO describes the restrictions for the values over parameters, e.g. "responseTime $\leq$ 5 seconds".

For a service consumer, an SLO is a criteria function that has to be optimized.

For a service provider, an SLO specifies the assurance over the service level described by the parameter values.

Specifying restriction over values is not an easy task. It affects the final outcome of the selection process. Often the provider might not be able to specify the exact value for each parameter. Service levels can also be specified in non-quantitative way. Many providers can describe service level as GOLD, SILVER, BRONZE etc, with it's meaning defined. A consumer may specify SLO as "Availability = HIGH", where HIGH is defined as for example "$\leq$ 99%" and LOW is "$\leq$ 80%". Specifying service levels this way leads to flexibility and simplicity of choosing the desired parameter values.

The service consumer, after defining the SLO, decides the weight for each criteria. Describing weights in non-increasing order, defines the sort of priority among the SLOs and the importance of criteria. The selection process would try to fulfill the most weighted objectives first.

The qualifying condition sub-section of WS-Agreement can be utilized to describe necessary pre-requisite of SLO to hold, where as BusinessValueList sub-section in WS-Agreement provides a way to define the importance of SLO for the service. The weight of the selection criteria and the priority for given SLO can be specified in BusinessValueList. Penalties/Rewards can be handled as service selection criteria, which needs to be compared in every providers's SLA and based on that appropriate actions should be taken at time of decision making.

3.2 Matchmaking Process

A service consumer arrives to find the service of his interest, submits the SLOs, preferences and importance over SLOs to the Matchmaker. The Matchmaker is an entity which decides the best possible provider providing the service described in related SLAs.

The matchmaking process, based on consumer's service selection criteria, searches the available annotated SLAs alternatives. Queries need to constructed according to the SLOs of the consumer, searching for desired SLA. Utilizing ontological constructs

in queries help better searching and reasoning in knowledge base. A query from selection criteria (SLOs) of consumer using the Ontology and a rules language such as SWRL [9], is applied to the reasoning engine of the knowledge base, which compares consumer SLO to SLOs of the providers and classifies the service providers according to the given query. The list of providers ordered according to the given selection criteria is generated.

Making a decision with respect to multiple criteria is not an easy task. Multi criteria Decision Aid/Making methods such as AHP (Saaty, 1980) [22], TOPSIS (Hwang and Yoon, 1981) [24], ELECTRE (Bernard Roy, 1991) [26], Goal Programming (Charnes, Cooper and Ferguson 1955) [25] etc. can be used in decision making process in appropriate scenarios [27]. The final outcome of the decision process, that is selected service level agreement is of importance to the consumer. The trade-offs between the alternative SLAs and how far the other SLAs were to the selected one during selection process is of importance to the consumer guiding him for the appropriate actions.

For matchmaker, efficiency of the selection process is important. Questions like, which one of the service providers who has submitted his SLAs is good for a wide range of given service selection criteria?, i.e. the dominant SLA for large range of criteria, are interesting. One might also be interested in sensitivity analysis, i.e. for which criteria, a slight variation leads to fluctuations in the final outcome? This strengthens the ability of matchmaker to better reason about the outcome.

3.3 Detailed Architecture for Service Selection

Figure 3.2 represents the proposed detailed architecture of the service selection problem. In figure 3.2 proper modules and the steps that are executed in chronology are described. The actors, the service providers and consumers provide their service levels to the syntactic SLA validation module. Each party's service levels are transformed to SLA using WS-Agreement schema. Already provided SLA according to WS-Agreement schema needs to be verified using this module. The annotation module relates the agreement concepts to the ontological concepts that are already

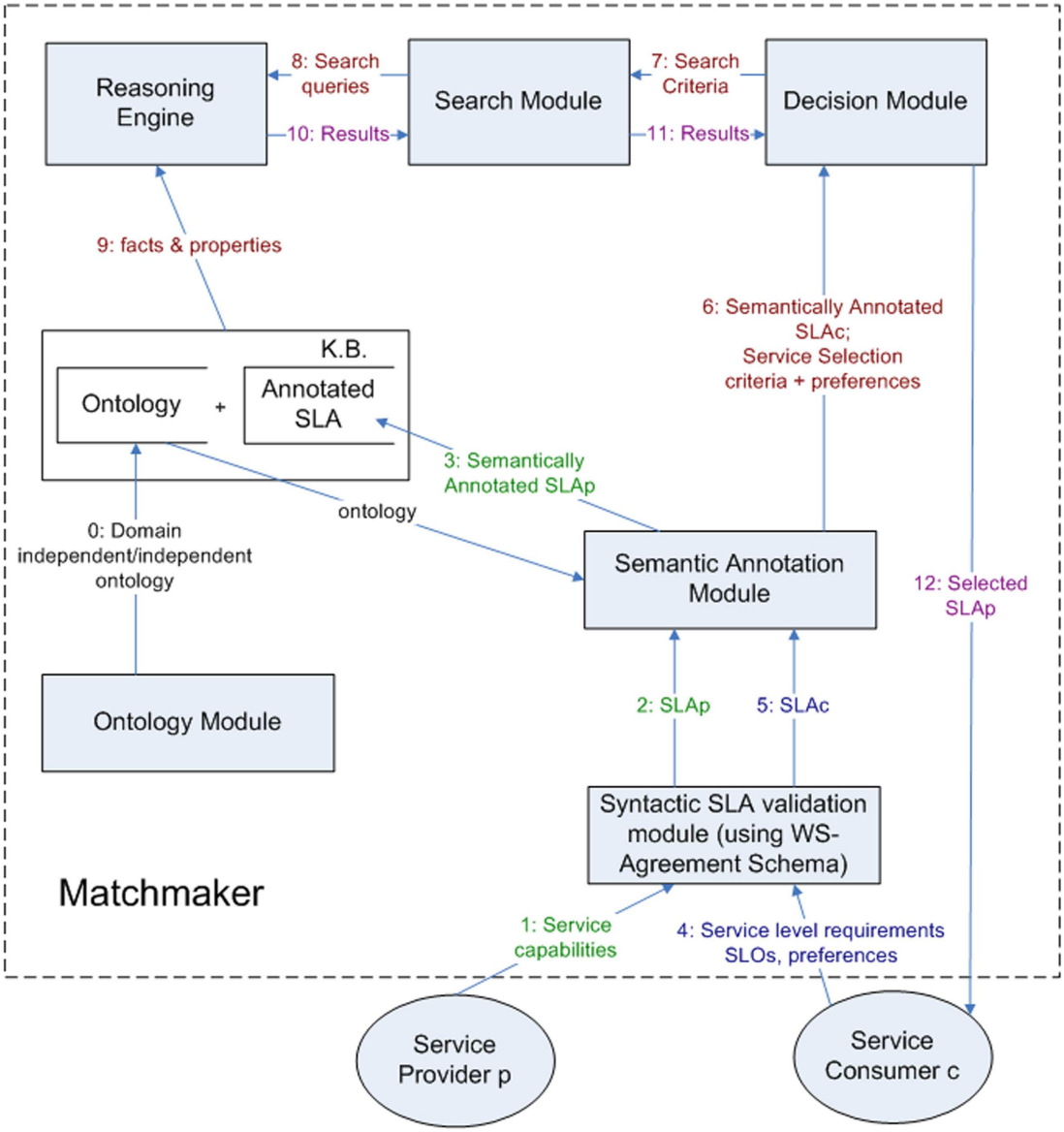

Figure 3.2: Proposed Architecture for Service Selection

constructed. Relating the service parameters to the ontological concepts makes the semantic search possible, improving the flexibility in match making. The consumer's SLA and preferences are passed to the decision making module. The selection criteria are extracted and passed to the search module. The search module constructs the search queries given specific reasoning engine. The reasoning module containing the reasoning engine and the knowledge base executes the applied queries. The knowledge base contains ontology and semantically annotated SLAs. The results from knowledge base is passed to decision module, which chooses the matching SLA applying appropriate decision techniques based on multiple criteria and preferences of the consumer.

In the architecture, the modules are separated according to the desired functionality to the selection process. For example, decision making module uses the functionality of search module, which handles the queries and the results, aiding the decision process. It is possible to implement different optimization methods extending the functionality of decision module. Similarly, search module constructs the queries according to the reasoning engine implementation. Transferring to different ontology implementations such as RDF, OWL etc, and rule language such as SWRL, SPARQL, affects only the implementation of search module and not the decision making module.

Chapter 4

Research Experiments

We have considered the scenario of Agro-Produce Market System, where the buyers and sellers are trading the agriculture produces in markets. We are focusing on developing a broker who tries to find the seller, based on the buyers' criteria. The reverse situation can also be handled with appropriate adjustments. In line of that, the application of a matchmaker, deciding the best possible offer becomes inevitable. While implementing the system it is divided into two parts according to the functionality, submission of offers by providers and the selection of service according to the consumer's intensions.

4.1 Submission of Offers by Providers

Let's assume that a buyer is interested in the sellers, selling agriculture produce mango. The criteria that the buyer might be interested in can be variety of mango (e.g Kesar, Alphonso etc), quality of mango (e.g. dimension, maturity), price, quantity, seller's location (market) etc. The dimension is assumed to be size i.e. the length of a piece of the mango. The maturity of the mango assumed to have two values, "Not Matured" and "Matured". A buyer manufacturing the food products based on mango would like "Matured" (i.e. ripe) fruit for near future, whereas international buyer would like the "Not Matured" status of the fruit.

Assume that four sellers would like to sell mango as shown in table I.

Offers	Seller	Location	Variety	Price	Quantity		Dimension		Maturity
					Min	Max	Min	Max	
Offer1	S1	Ahmedabad	Alphonso	100	30	50	9	11	Not Matured
Offer2	S2	Ahmedabad	Alphonso	95	35	45	10	12	Not Matured
Offer3	S3	Ahmedabad	Kesar	70	40	60	9	11	Not Matured
Offer4	S4	Valsad	Alphonso	85	10	50	10	13	Not Matured

Quantity is assumed to be in number of boxes, each containing 10 pieces of Mangoes.
Price is in Rs per each Box

Table I: Sellers' offers for mangoes

The quantity is specified as minimum and maximum possible. It is possible that a seller would like to sell more agro-produce with low price and decides not to sell small quantity at given price. The buyer is obliged to fulfill the minimum support levels of the quantity for buying at a given price. Similarly the buyer would like the guarantee on the dimension of the fruit, i.e. minimum size. Bigger the dimension, the price may increase.

To specify the seller's service offer containing set of guarantees, WS-Agreement schema is used. The AgreementOffer snippet describes an offer specified using WS-Agreement.

AgreementOffer 1 Representation of Agreement Offer using WS-Agreement.

```
<wsag:AgreementOffer wsag:AgreementId= "Offer1" xmlns:wsag="..."
... <wsag:Terms>
  <wsag:ServiceDescriptionTerm wsag:Name="SDT1"
    wsag:ServiceName="SellerService">
    </wsag:ServiceDescriptionTerm>
      <wsag: ServiceReference>
        <wsa:EndpointReference >
        <wsa:Address> http://foo.com/SellerService
        </wsa:Address>
        <wsa:PortType> http://foo.com/SellerService
            #submitOffer</wsa:PortType>
      </wsa:EndpointReference>
    </wsag:ServiceReference>
...
  <wsag:GuaranteeTerm wsag:Name="GT_Price"
    Obligated="ServiceProvider">
    <wsag:ServiceLevelObjective>
      <Expression>
        <Predicate type="Equals">
          <Parameter>Price</Parameter>
          <Value>100<Value><Unit>Rupees<Unit>
          </Predicate>
      </Expression>
    </wsag:ServiceLevelObjective>
  </wsag:GuaranteeTerm>
  <wsag:GuaranteeTerm wsag:Name="GT_CropVeriety"
    Obligated="ServiceProvider">
    <wsag:ServiceLevelObjective>
      <Expression>
        <Predicate type="Equals">
          <Parameter>CropVeriety</Parameter>
          <Value>Alphonso<Value></Predicate>
          </Expression>
    </wsag:ServiceLevelObjective>
  </wsag:GuaranteeTerm>
... </wsag:AgreementOffer>
```

As discussed before, for better search and inference while matchmaking, the use of

semantic annotation of agreement offer is utilized here. The agriculture business domain ontology "AgricultureConcept" is constructed containing concepts such as Agriculture_Produce, Crop, Fruit, Mango etc. For agreement vocabulary, "AgreementConcept" ontology is developed which defines the concepts such as AgreementOffer, Context, Actor, SLO, Expression, Parameter, Predicate. It contains the properties such as hasContext, hasActor, hasSLO, hasExpression, hasPredicate, hasPrameter, hasValue etc relating to relevant concepts. Protg [10] is used to develop the ontology.

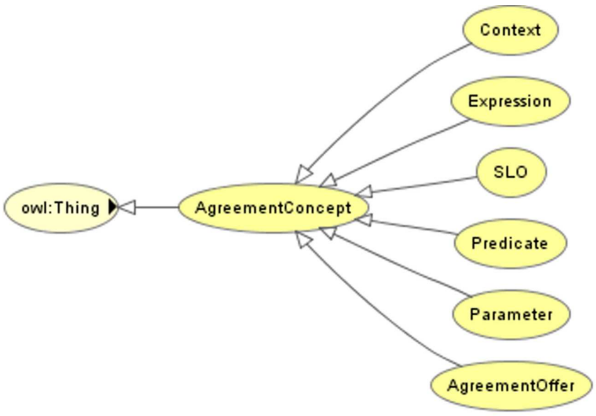

Figure 4.1: Ontology defining agreement concepts

The agreement offer, after the process of annotation with above AgreementConcept ontology combined with the AgricultureConcept ontology, transforms into AnnotatedAgreement. Small snippet of it is shown in next page for readability.

AnnotatedAgreement 1 Representation of Agreement Offer using Ontology.

```
<da:Seller rdf:ID="Seller_1"/> <da:Alphonso
rdf:ID="Alphonso_1"/>...<AgreementOffer
 rdf:ID="Offer1"><hasContext>
    <Context rdf:ID="Context_1">
      <hasActor>
        <da:Seller rdf:ID="Seller_1"/> </hasActor>
    </Context>
  <hasContext>
...
  <hasSLO>
     <SLO rdf:ID="SLO_11">
       <hasExpression>
         <Expression rdf:ID="Expression_11">
            <hasValueInt
            rdf:datatype="http://www.w3.org/2001/
            XMLSchema#int">
            100</hasValueInt>
            <hasParameter rdf:resource="#Price"/>
            <hasPredicate rdf:resource="#Equals"/>
         </Expression>
      </hasExpression>
    </SLO>
...
  </hasSLO>
    <SLO rdf:ID="SLO_12">
      <hasExpression>
        <Expression rdf:ID="Expression_12">
          <hasValueObject rdf:resource="#Alphonso_1"/>
          <hasParameter rdf:resource="#CropVeriety"/>
          <hasPredicate rdf:resource="#Equals"/>
        </Expression>
      </hasExpression>
    </SLO>
... </AgreementOffer> ...
```

4.2 The Service Selection Process

Now let's assume a scenario where the buyer arrives with requirements specified as in table II.

Location	Ahmedabad
Variety	Alphonso
Price	100 Rs
Quantity	70
Quality (Dimension minimum)	9 cm
Maturity	Not Matured

Table II: Buyers' selection criteria for mangoes

The above-mentioned SLOs are specified as an SLA_c in WS-Agreement. Once the SLA is handed to the DecisionAider, the selection parameters/value pairs are extracted and passed to the search module. In that, the QueryHandler generates the SWRL query using the selection criteria and passes it to the QueryExecutor.

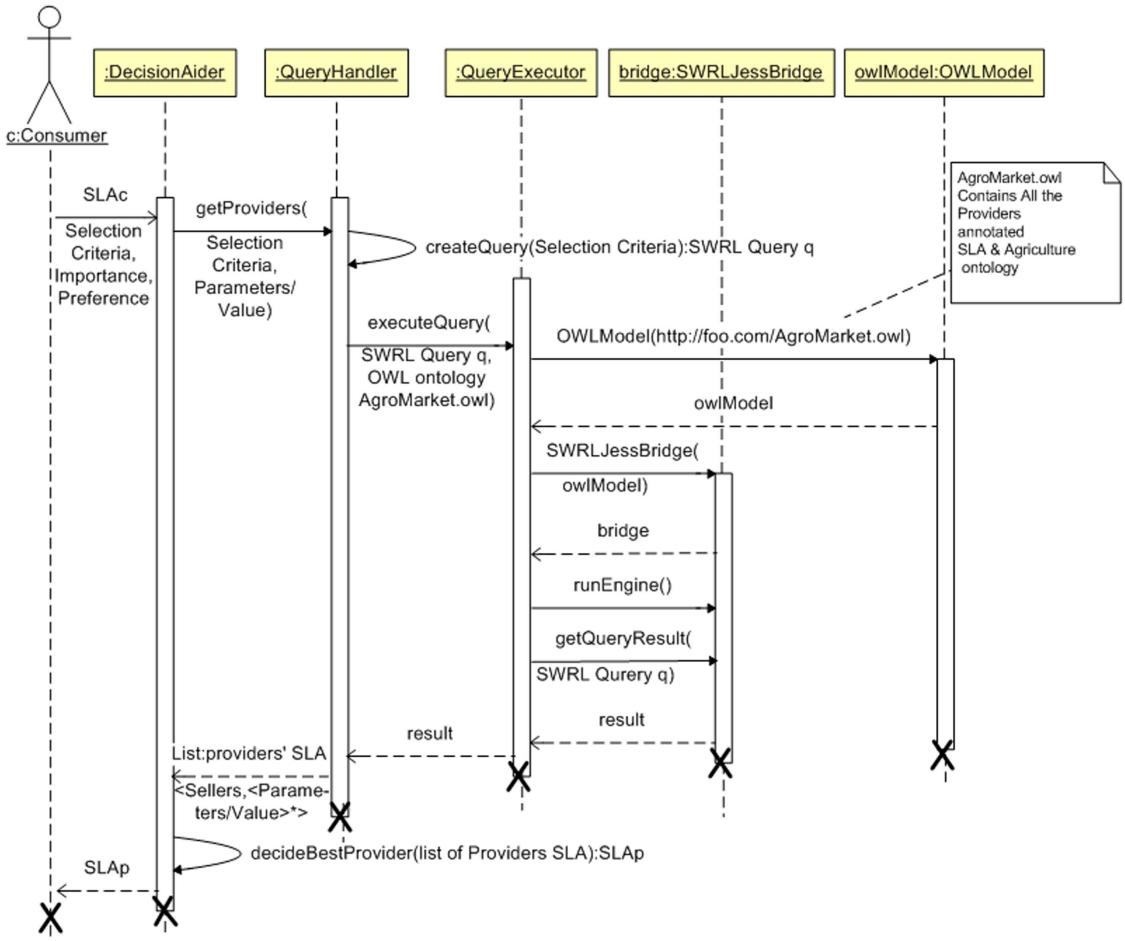

Figure 4.2: Sequence diagram: Consumer's interaction with selection process

The QueryExecutor uses the Protg-OWL API [29] and the SWRL API [30] to execute the query. SWRLJessBridge [31] [32] is used to convert the OWL ontology and SWRL query into facts, properties and query for Jess [11] engine. The result of execution of the query in Jess engine is passed to the QueryHandler which extracts the list of sellers with desired criteria. The list is passed to the DecisionAider. Below are few queries related to the example.

Query-1:

$$AgreementOffer(?a) \wedge hasSLO(?a, ?s) \wedge hasExpression(?s, ?e) \wedge$$

$$hasPredicate(?e, Equals) \wedge hasParameter(?e, Price) \wedge hasValueInt(?e, ?p) \wedge$$

$$swrlb : lessThanOrEqual(?p, 100) \rightarrow query : select(?a, ?p) \wedge query : orderBy(?p)$$

For buyer's price criteria (price should not exceed 100) the appropriate offers are scrutinized and result is generated in non increasing order of price attribute as under:

Agreement Offer	Price
Offer3	70
Offer4	85
Offer2	95
Offer1	100

Table III: Mango offers ordered by price

Likewise for other criteria, similar query can be constructed to aid the decision making.

Clearly for given scenario, no seller is suitable satisfying every selection criteria as guarantee for desired quantity is not achievable. If the buyer is flexible for desired quantity and the other criteria are satisfied profitably he may continue. Assuming that the buyer has strict requirement for variety "Alphonso" and Maturity "Not Matured", the desired query can be constructed as:

Query-2:

$$AgreementOffer(?a) \wedge hasSLO(?a, ?s1) \wedge hasExpression(?s1, ?e1) \wedge$$

$$hasPredicate(?e1, Equals) \wedge hasParameter(?e1, CropVariety) \wedge$$

$$hasValueObject(?e1, Alphonso) \wedge hasSLO(?a, ?s2) \wedge hasExpression(?s2, ?e2)$$

$$\wedge hasPredicate(?e2, Equals) \wedge hasParameter(?e2, Maturity) \wedge$$

$$hasValueString(?e2, "NotMatured") \rightarrow query : select(?a)$$

By applying the criteria of variety and maturity, seller S3 is discarded. We are left with three sellers.

The question, which alternative offer is suitable for give buyer's utility, still remains. Decision has to be made satisfying the best among multiple criteria. As discussed before, MCDM methods can aid making a decision for choosing one SLA offer.

The paper implements the Analytical Hierarchy Process (AHP, Saaty 1980) [22] method for finding suitable providers assuming the preferences over criteria can be provided by the consumer. Based on preferences the method compares two providers. The effectiveness of the result is dependant on the preferences that the consumer specifies which is subjective in nature. The consumer specifies the preference over criteria as well as rating of each offers for a given criteria with the help of the AHP measurement scale [28].

The comparison between criteria by consumer to find out the preference over criteria are provided to DecisionAider as shown in table IV. For implementation purpose these comparisons are represented using XML as discussed in Appendix A.1.

Criteria	Location	Price	Quantity	Quality
Location	1	1/3	3	2
Price	3	1	5	4
Quantity	1/3	1/5	1	1
Quality	1/4	1/2	1	1

Table IV: Comparison of criteria to find preference for mango sellers

Note the price is weakly more important (that is why column has value 3) than location, strongly important (value 5) then quantity and likewise. Value 1 in a column states indifference over comparison.

According to AHP, after normalizing the above matrix (that is for each entry, divide by sum of column it appears in), and taking the average of row, the weight of

each criteria is determine stated in table V.

Criteria	Weight
Location	0.24
Price	0.54
Quantity	0.10
Quality	0.12

Table V: Weight of each criteria in selection of mango sellers

One can see that price criteria is assigned much more weight and quantity and quality criteria are neglected too some extend.

Pair wise comparison of alternating seller with respect to each criteria by the consumer.

1. Location: Desired location is Ahmedabad.

Location	S1	S2	S4
S1	1	1	3
S2	1	1	3
S4	1/3	1/3	1

Table VI: Location preference among mango sellers

2. Price: Desired rice=100

Price	S1	S2	S4
S1	1	1/3	/17
S2	3	1	1/5
S4	7	5	1

Table VII: Price preference among mango sellers

3. Quantity (Maximum possible): Desired quantity=70

Quantity	S1	S2	S4
S1	1	3	1
S2	1/3	1	1/3
S4	1	3	1

Table VIII: Quantity preference among mango sellers

4. Quality (Dimension of mango that is required minimum size): Desired value=9

Quality	S1	S2	S4
S1	1	1/3	1/3
S2	3	1	1
S4	3	1	1

Table IX: Quality preference among mango sellers

After normalizing each matrix of alternative seller criteria comparison and finding the weights for each seller for given criteria, the final matrix for criteria/seller is as shown as below.

	Location	Price	Quantity	Quality
S1	0.43	0.08	0.43	0.14
S2	0.43	0.19	0.14	0.43
S4	0.14	0.72	0.43	0.43

Table X: Mango sellers-criteria rating

Dot product of of each row vector in table X with weight vector of table V gives the value for a given seller.

Sellers	Value of Offer
S1	0.21
S2	0.27
S4	0.52

Table XI: Value of mango sellers' offers according to criteria

The seller S4 is the match for given preferences with the highest value. As one can recall, the price criteria was dominant and the rating for price of S4 was very much strong, the outcome inclined more to S4 even if the preference over location was not good for S4.

For each preference matrix, after normalization, consistency verification [28] is performed. Consistency Ratio (CR) is calculated as described in method and verified

whether or not CR < 0.1. For each matrix, the condition holds, which states that preferences specified by the buyer are consistent.

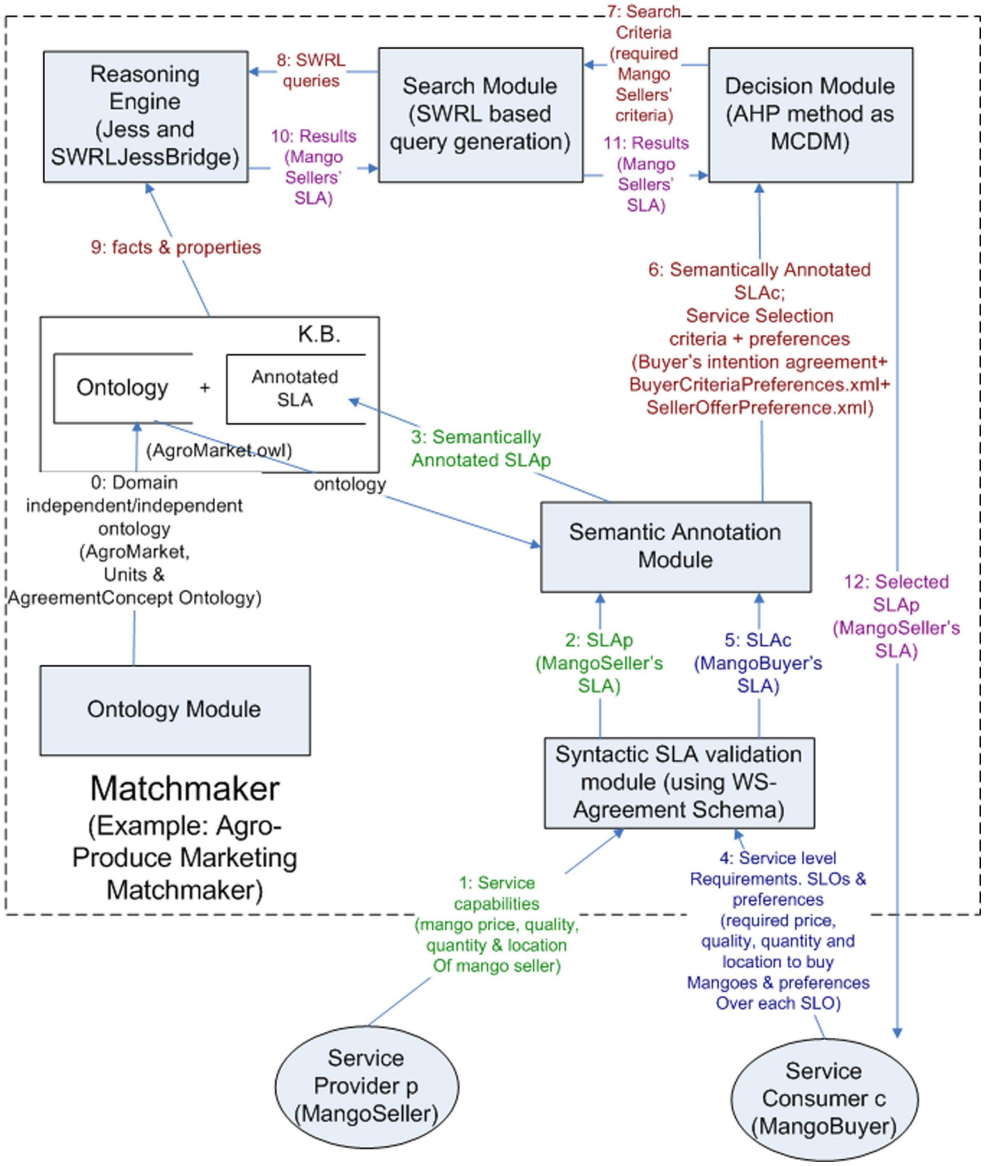

Figure 4.3: Realization of service selection architecture in Agro-Produce Market System

In the current experiment scenario the Agro-Produce Marketing Matchmaker (Figure 4.3) is implemented as a reference implementation for service selection architecture discussed in Chapter 3.3.

In a given implementation, the matchmaker is assumed to be provided with the SLAs and the preferences over SLOs and offers according to AHP method. The higher level entity such as a broker or a negotiator is assumed to be responsible for gathering all the required information from the consumer. The broker or negotiator uses the capability of matchmaker in order to decide the suitable offer for the buyer.

As a result of the selection process, Offer4 of the seller S4 is prescribed. From service description term, the buyer can extract the service detail such as End Point Reference (EPR), PortType etc and construct the service call. He may submit his revised offer or willingness to go with the selected service offer. The seller on receiving the offer can either accept or reject the proposal. With this the possibility of negotiation of the offers is left open.

Chapter 5

Dynamic Service Selection In Service Composition

So far the authors have covered how to select a service based on the criteria provided to the selection mechanism. Now focus is shifted to selection of a set of services constituting a process.

A business process is a business scenario where a set of parties, their roles, interactions, transactions, states, control flow etc. are expressed as a work-flow. A process is divided into set of task, performed by some actors. Each task can be implemented as components realizing a set of business objectives. As theses components can be exposed as web services interfaces discovery, selection, composition and execution of service affects the overall business process.

Service composition is static when workflow is designed priori. Here an abstract process is expressed as a business interaction protocol with the message exchange and coordination while interaction is defined in advance. On the other hand, dynamic service composition is autonomous composition generated on the fly suitable for creating application dynamically.

In any case, creating an executable process from workflow requires set of services to be selected. The automation for this requires decision mechanism for choosing suitable partners. Automation in decision making faces of the problems such as gap in terminology used by people. The authors propose use of semantic web technology to define the world concepts and selection of services according to the business guarantees to achieve maximum overall benefits to solve service composition better.

The authors are focusing on constructing contract of an executable process, in which each participants and their responsibilities are covered. The selection of a service in composition is based on how good a service provider guarantees over business objectives. A contract of such nature helps reserving in advance the business transaction and also the resources. Also it covers transaction details suitable for predicting the outcome of the process over some parameters.

5.1 Establishing Agreement over Executable Process

A process level agreement in service composition defines the relationship among services, the partners and the guarantees over the services while executing the whole process.

Following are steps we propose to establish an agreement.

1. **Identify the workflow:** To define the process, identification of partner services and their collaboration in process is first important phase. For that WS-BPEL [33], WSCL [34] or other workflow language can be used. None support the business agreement yet [35]. Use of semantic web technology in description of service is advantageous, such as DAML-S and WSDL-S. Generally a process composed of a set of services can be expressed as,

   $\text{Process}_p = \text{PartnerService}_1 \bigoplus \text{PartnerService}_2 \bigoplus ... \text{ PartnerService}_n$

2. **Identify the process parameters:** This refers to the parameters which affect the overall process performance e.g. cost, profit, loss etc to name a few. Defining the criteria over the parameters helps to achieve the objective better. In general the process parameters can be enumerated as PParam_{p1}, PParam_{p2} ... PParam_{pm}.

3. **Identify each service parameters:** For each service defined in workflow the parameters which affects the selection of given service is the next stage. Creating the ontology for each parameter helps better searching while finding best match.

For a service PartnerService$_i$ the service parameters can be enumerated as SParam$_{i1}$, SParam$_{i2}$ ... SParam$_{ik}$.

4. **Identify relationship among service parameters and process parameters:** In workflow, usually services(tasks) are cascaded and/or paralleled and followed one after the other. So the guarantee of one service might affect the outcome of other services and as a result, the performance of the overall process. Thus it is important to identify the relationship of such service parameters. In such cases, the preference of one service parameters over other service parameters would be able to guide the selection of individual services.

   A process parameter, defined as simple summation over the related all individual service parameter can be expressed as,

   PParam$_{pi}$ = SParam$_{1i}$ + SParam$_{2i}$ + ... SParam$_{ni}$

   It may be possible that some of the service parameters do not contribute to the process parameters. In general a process parameter can be specified as,

   PParam$_{pi}$ is related to(Param$_1$, Param$_2$, ..., Param$_k$). Where each individual parameter Param can be expressed as an expression over some service parameters SParam.

5. **Choose the order of selecting each services in selection:** At this stage one needs to choose which service to select first and rest in order. In many cases the services follows the natural order such as chronology. If selection of one service affects the selection over some other criteria in other service, as pointed out earlier, then service with highly preferred criteria should be selected and the rest followed in that order.

6. **Create intention agreement for each service:** Define the desired criteria for each service as SLOs. Also one can define the penalties and other business values in agreement as required. We assume that service providers have created their SLAs priori and annotated SLAs are stored in Knowledge Base as discussed in 3.3.

7. **Search services over desired criteria:** There might be some parameters which are mandatory in the selection. While selecting individual services, create queries which eliminate the service offers which does not satisfy such criteria.

8. **Select individual services:** Assign weight age to each service parameters in selection process. Also for each service selection criteria, compare the service offers using MCDM methods and find the best valued service offer.

5.2 Example Scenario of Service Composition

We have consider scenario from Agro-produce marketing where Rice is the central commodity in various phases like trading, farming, processing, storage and transportation. Considering a scenario where an exporter wants to export rice variety Basmati.

Requirement: A commodity exporter wants to export #kg(quintal) of Basmati rice. The cost of goods should be not more than #Rs per kg(quintal) The Basmati rice should be of export quality.

In fulfilling our requirement, various rice procurement processes can followed as given below. By selecting one of the process, an instance of it can be created by selecting dynamically the services of the required service providers described in process.

Abstract processes.

Process 1: Directly purchase rice from whole seller merchants from desired market (Location) of required quality, quantity and price. Transport it to better storage option till exported. Better transportation and storage are required to minimize post harvest losses.

Actors/services: Rice Seller, Rice Buyer (Exporter), Transporter, Storage Provider.

Process 2: Purchase rice Paddy of good quality from desired market transport it to desired rice mill for milling. Rice-Miller processes the paddy and produce rice of desired quality with minimum losses possible. Pack the rice in required packing material. Transport it to better storage option till exported. Better milling, packing, transportation and storage are required to minimize post harvest losses.

Actors/services: Rice Paddy Seller, Rice Buyer (Exporter), Rice Miller, Transporter, Storage provider.

Process 3: Make a contract with the farmer in advance (future contract) for required quantity, quality of harvested paddy at given price. Process it at some rice mill, pack it and transport it to desired storage. Better harvested paddy quality is required so as to produce good quality of grains.

Actors/services: Farmer, Rice Buyer (Exporter), Rice Miller, Transporter, Storage provider.

Process 4: Make a contract with farmer for land and labor only. Agriculture inputs such as seeds, fertilizers, pesticides, harvest machineries etc are managed by the exporter himself. Agriculture inputs providers can also provide desired all/some/none inputs with price and other parameters fixed in advance. Harvested paddy is processed at Rice mill and transporter & storage providers are used as required.

Actors/services: Farmer, Rice Buyer (Exporter), Agriculture input provider, Rice Miller, Transporter, Storage provider.

We consider **Process 3** as shown in Figure 5.1 for dynamic service composition. The parameters affecting each service providers are mentioned in Table I.

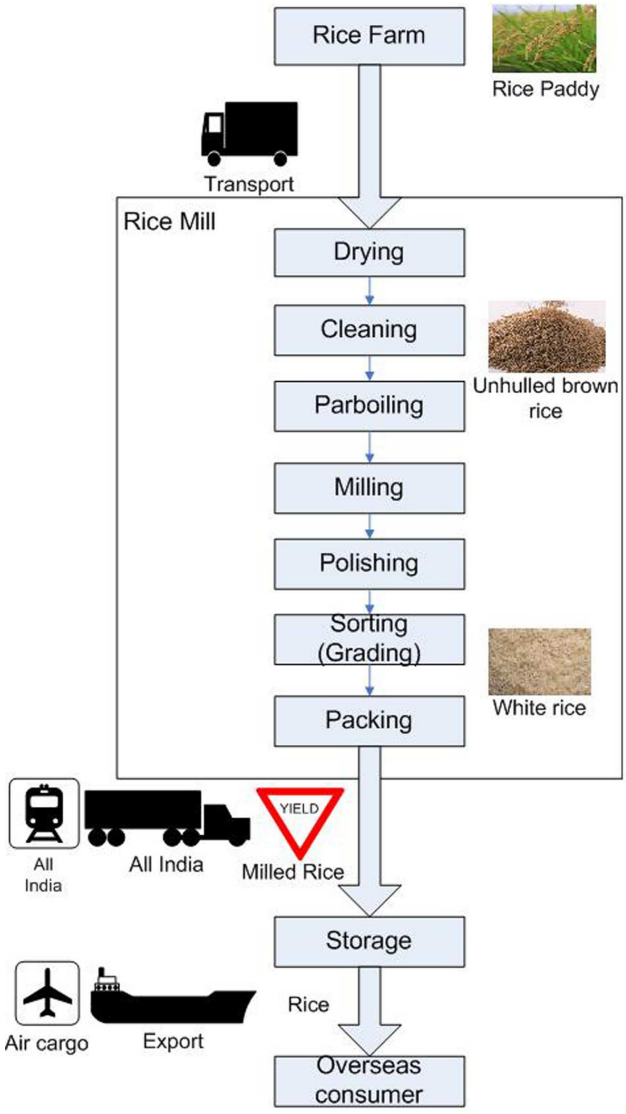

Figure 5.1: Rice production process

Service Provider	Service Parameters	
Farmer	Farm Location	
	Rice Paddy Price	
	Rice Paddy Quantity	
	Rice Paddy Quality	Paddy Size Min Moisture Max Moisture Admixture Foreign Matter Damaged Immature Color
Rice Miller	Location	
	Milling Price	
	Rice Milling Quality	Max Loss Difference in Paddy- to Grain Head Rice
	Milled Rice Grain Quality	Foreign Matter Admixture Broken Damaged Discolored- Chalky Immature Green Max Moisture Max Paddy Grain Min Length-breath Ratio
Storage Provider	Storage Location	
	Storage Price	
	Storage Quality	Max Loss Moisture Maintained
Transporter	Transportation Price	
	Transportation Loss	
	Transportation Speed	

Table I: Different service providers and their service parameters in the process of Rice Contract Farming.

The Ontology describing parameters listed in Table I is constructed as shown in Fig 5.2 and Fig 5.3.

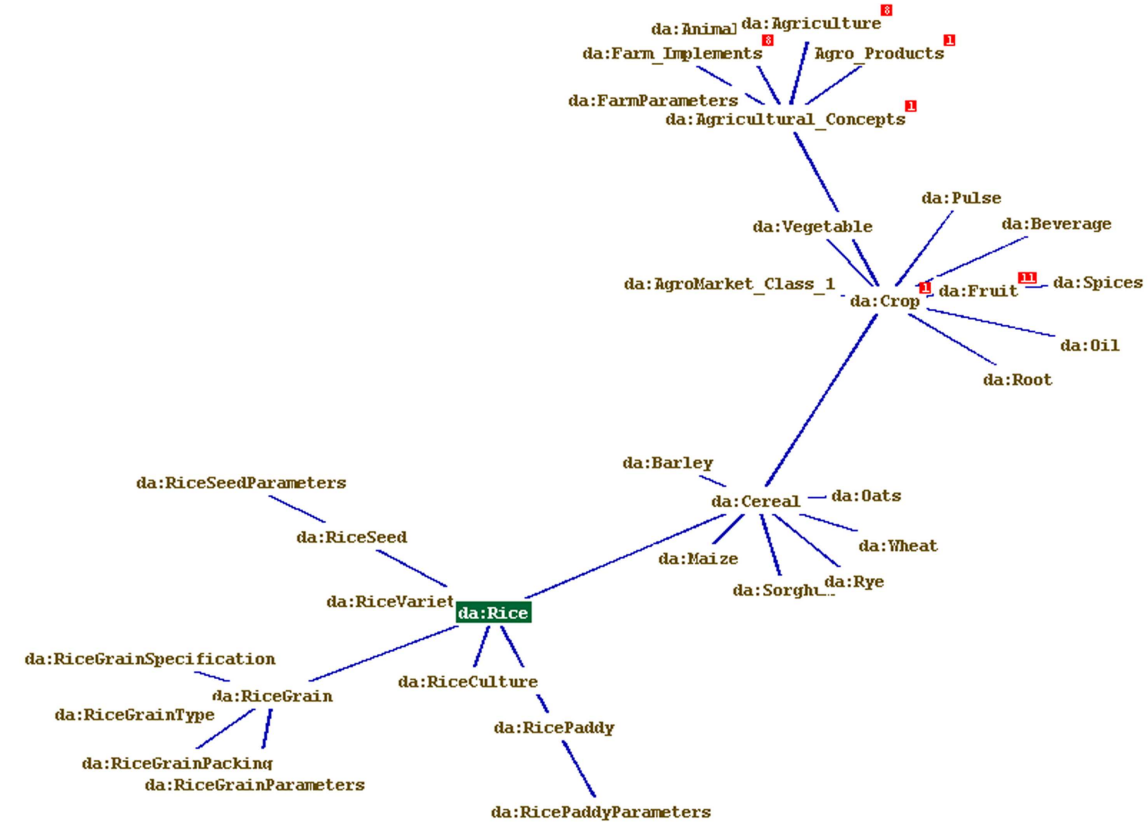

Figure 5.2: Ontology describing rice parameters

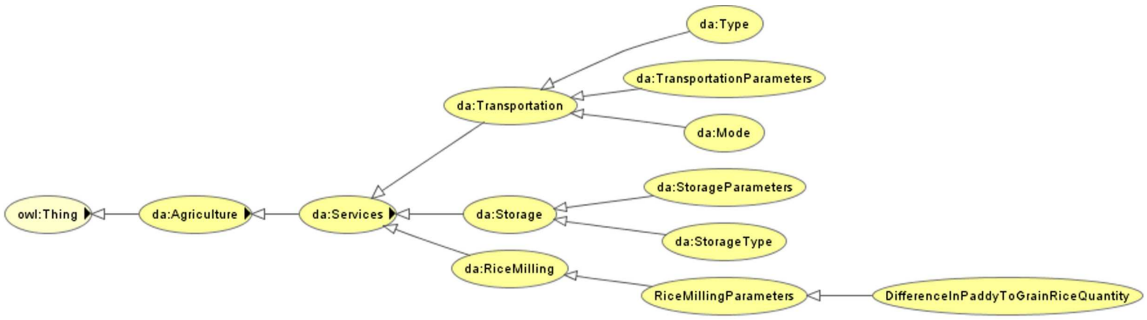

Figure 5.3: Ontology describing transportation, storage and rice milling services' parameters

To maximize the profit rice price, loss and quality through out the process needs to optimized. The process parameters can be computed in part as,

$$TotalCost = Paddycost + Millingcost + Transportationcost + Storagecost$$

$$TotalLoss = Harvestloss + Millingloss + Storageloss + Transportationloss.$$

The most important part of the process are selection of paddy provider(**farmer** here) and the **rice miller**.

Quantity and loss: Exclusion of the harvest loss and milling loss from expected harvested paddy quantity is the yield. To increase that, selection of farmer with optimum paddy quantity and selection of rice miller with minimum losses independently is sufficient.

Quality: Without the good quality of paddy, the required rice grain quality cannot be thought. Yet guarantee over milled rice grain is necessary to get the export quality of rice after polishing. The guarantee on both, paddy quality and milled rice quality are required, selection of farmer and rice miller independently is sufficient.

Yield price: Selection based on least cost of paddy and leased cost of rice milling is required.

The rest service providers, **transporter** and **storage provider** affect mainly the cost and loss. If we denote Transportation Cost with TC then,

$$TC_{Total} = TC_{FarmToMill} + TC_{MillToStorage}$$

It is interesting to note that location farm, mill and storage is crucial in minimizing the transportation cost and affects the selection of farmer, rice miller and storage provider. Decision has to be taken to give whom more priority. The rice farmer is the most crucial partner in the process to provide the best quality, quantity and priced paddy and so the transportation cost can be bared up to given limit for better deal in other criteria. It is better to find the miller near to the farmer. The storage provider has to be near to the desired port so as to export it immediately whenever desired. This also identifies the partner selection order, i.e. farmer first, then the rice miller near to farmer, third the storage provider and at last transporter can be selected.

Now after identifying the preferences over the parameters, it is now desired to express the importance as weight age in each service selection. As suggested before,

AHP method can be used to specify that weight age.

Some of the criteria which are must to the selection is directly applied as the query to filter out unnecessary offers. Based on the process parameters and the their relation to individual parameters, the individual service criteria weight age is constructed. Rest for each service selection similar process discussed in the last chapter is followed.

5.2.1 Farmer Selection

The farmers' offers for selection are searched in knowledge base by given query. Table II contains detailed offers of the farmers.

$$AgreementOffer(?a) \wedge hasContext(?a, ?c) \wedge hasActor(?c, ?actor) \wedge$$

$$abox : hasClass(?actor, da : Farmer) \rightarrow query : select(?a)$$

Farmers' Offers	Farm Location	Paddy Price Rs/Kg	Expected Paddy Quantity	Harvested Paddy Quality						
				Size mm	Moisture		Admixture %	Foreign Matter%	Damaged Immature%	Color
					Min%	Max%				
Farmer-Offer1	jalandhar	70	23000	6.9	25	30	40	9	15	Green Brown
Farmer-Offer2	Amritsar	70	20000	7.1	25	30	30	7	10	Green Brown
Farmer-Offer3	Agra	75	22000	7.1	25	30	30	7	10	Green Brown

Table II: Farmers' offers for Rice Paddy parameters

The harvested paddy quality parameters are combined so that combined quality parameters' preference over price, quantity and location of farmer can be specified using the AHP measurement scale as show in Table III.

Criteria	FarmLocation	PaddyPrice	PaddyQuantity	PaddyQuality
FarmLocation	1	1/4	1/2	1/5
PaddyPrice	4	1	3	2
PaddyQuantity	2	1/3	1	1
PaddyQuality	5	1/2	1	1

Table III: Comparison of criteria for Farmer

Weight age of each criteria is computed by AHP method is is shown in Table IV.

Criteria	Value
FarmLocation	0.085
PaddyPrice	0.45
PaddyQuantity	0.18
PaddyQuality	0.26

Table IV: Weightage of each criteria for Farmers

As one can see that price is given the maximum wieghtage and the location is least preferred if better price and quality of paddy is encountered during selection.

Now, after specifying the selection criteria weghtage, preference over each individual criteria among each offer is computed as shown below.

1. Farm location:

Price	F1	F2	F3
F1	1	1/3	1/7
F2	3	1	1/5
F3	7	5	1

Table V: Price preference among farmers

2. Rice paddy price:

Location	F1	F2	F3
F1	1	1	3
F2	1	1	3
F3	1/3	1/3	1

Table VI: Location preference among farmers

3. Rice paddy quantity:

Quantity	F1	F2	F3
F1	1	3	1
F2	1/3	1	1/3
F3	1	3	1

Table VII: Quantity preference among farmers

4. Rice paddy quality:

Quality	F1	F2	F3
F1	1	1/3	1/3
F2	3	1	1
F3	3	1	1

Table VIII: Quality preference among farmers

After normalizing each matrix of alternative farmer criteria comparison and finding the weights for each farmer for given criteria, the final matrix for criteria/farmer is as shown as below.

Farmers	Farm Location	Paddy Price	Paddy Quantity	Paddy Quality
F1	0.08	0.42	0.42	0.14
F2	0.19	0.42	0.14	0.42
F3	0.72	0.14	0.42	0.42

Table IX: Farmers-criteria rating

Dot product of of each row vector in table IX with weight vector of table IV gives the value for a given farmer. Farmer_2 is selected with max value.

Farmers	Value of Offer
F1	0.32
F2	0.35
F3	0.32

Table X: Value of farmers' offers according to criteria

5.2.2 Selection of Rice-Miller

The rice millers' offers for selection are taken as shown in Table XI using the SWRL query,

$$AgreementOffer(?a) \wedge hasContext(?a, ?c) \wedge hasActor(?c, ?actor) \wedge$$

$$abox : hasClass(?actor, da : RiceMiller) \rightarrow query : select(?a)$$

Rice Millers' Offers	Rice Miller's Location	Rice Milling Price Rs/Kg	MillingQuality		MilledRice GrainQuality						
			Max Loss %	Difference in Paddy to Grain Head Rice%	Foreign Matter %	Admixture %	Broken %	Damaged Discolored Chalky Immature Green%	Max Moisture %m/m	Max Paddy Grain	Min Length to Breath Ratio
Miller-Offer1	Jalandhar	10	5	2	0.4	5	7	0.30	14	0.2	3
Miller-Offer2	Delhi	10	7	3	0.3	5	5	0.25	14	0.1	3.5
Miller-Offer3	Agra	12	5	2	0.3	5	5	0.25	14	0.1	3.5

Table XI: Rice Millers' offers for Rice Milling

Parameter MillingQuality refers the quality of the milling process to reduce the milling losses. Whereas MilledRiceGrainQuality parameters are combined to represent the quality of the rice grain after polishing is done. The comparison matrix of selection criteria for miller is constructed as show in Table XII.

Criteria	MillingLocation	MillingPrice	MillingQuality	RiceGrainQuality
MillingLocation	1	3	2	1/2
MillingPrice	1/3	1	1	1/2
MillingQuantity	1/2	1	1	1
RiceGrainQuality	2	2	1	1

Table XII: Comparison of criteria for Rice Miller

Weight age of each criteria is computed by AHP method is is shown in Table XIII.

Criteria	Value
MillingLocation	0.31
MillingPrice	0.15
MillingQuality	0.20
RiceGrainQuality	0.33

Table XIII: Weightage of each criteria for Rice Miller

As one can see that MilledRiceGrainQuality is given the maximum weight age. Next is the location almost equal to the grain quality. The preferred location would be nearer to the rice farm. Milling losses are next and the price of milling is the last in weight age.

The comparison of each offers of rice millers over individual criteria can be computed as in Section 5.2.1 and the value of each miller's offer can be computed similarly. The offer with the highest value is selected.

5.2.3 Selection of Storage Provider

For the experiment, the different storage providers' offers for selection are selected as shown in Table XIV by constructing the query,

$$AgreementOffer(?a) \wedge hasContext(?a, ?c) \wedge hasActor(?c, ?actor) \wedge$$

$$abox : hasClass(?actor, da : StorageProvider) \rightarrow query : select(?a)$$

Storage Providers' Offers	Storage Location	Storage Price Rs/Kg/Day	Storage Quality	
			MaxLoss %	Moisture Maintained % m/m
Storage-Offer1	Delhi	10	10	14
Storage-Offer2	Agra	10	12	14
Storage-Offer3	Mumbai	12	10	14

Table XIV: Storage Providers' offers for rice storage

The storage quality here directly refers to the losses during storage. The comparison matrix of selection criteria for storage provider is shown as show in Table XV.

Criteria	StorageLocation	StoragePrice	StorageQuality
StorageLocation	1	3	4
StoragePrice	1/3	1	3
StorageQuantity	1/4	1/3	1

Table XV: Comparison of criteria for Storage Provider

Weightage of criteria in selecting storage is computed using AHP method as in Table XVI.

Criteria	Value
StorageLocation	0.61
StoragePrice	0.27
StorageQuality	0.12

Table XVI: Weightage of each criteria for Storage Provider

Here the location is preferred most. Location near to the port, for example makes it easy to export whenever required.

The comparison of each offers of storage providers over individual criteria can be computed as in Section 5.2.1 and the value of each storage provider's offer can be computed similarly. The offer with the highest value is selected.

5.2.4 Selection of Transporter

The offers of some transporters, selected on the basis of transportation provided to 'All Over India', are listed in Table XVII.

$$AgreementOffer(?a) \wedge hasContext(?a, ?c) \wedge hasActor(?c, ?actor) \wedge$$

$$abox : hasClass(?actor, da : Transporter) \wedge hasSLO(?a, ?s) \wedge$$

$$hasExpression(?s, ?e) \wedge hasParameter(?e, Transportation_Type) \wedge$$

$$hasValueObject(?e, TransporterType\_AllIndia) \rightarrow query : select(?a)$$

Transport Offers	Price Rs/Kg/Km	Loss %	Speed Km/Day
Transporter-Offer1	6	5	500
Transporter-Offer2	5	5	600
Transporter-Offer3	4	5	500

Table XVII: Transporters' offers for Rice Transportation

The criteria comparison is shown in Table.

Criteria	Loss	Price	Speed
Loss	1	1/4	1/3
Price	4	1	3
Speed	3	1/3	1

Table XVIII: Comparison of criteria for Storage Provider

The weightage of each criteria for transportation can be computed as,

Criteria	Value
Loss	0.12
Price	0.61
Speed	0.27

Table XIX: Weight age of each criteria for Transporter

The comparison of each offers of transporter over individual criteria can be computed as in Section 5.2.1 and the value of each transporter's offer can be computed similarly. The offer with the highest value is selected.

Chapter 6

Conclusions and Future Work

6.1 Conclusions

The authors have proposed the solution of the service selection problem as matching of the SLAs. WS-Agreement schema is useful in specifying the SLAs containing the guarantees over service parameters. The problem of service selection is reduced to find the best SLA satisfying the requirement of the service consumer.

The thesis proposes an architecture for the service selection. An experiment scenario from Agro-produce market system is taken where selection of mango seller is done on the basis of cost, quality and other criteria of mango. The selection process is divided into two phases.

Service offer submission by service providers: Use of ontology language such as OWL provides an effective way to represent the service level objectives. Agreement offer objects such as SLOs represented in knowledge base using ontological concepts serves better searching later.

Selection of best provider offer based on intention of service consumer: From intention agreement of service consumer the search criteria are extracted and query is constructed using rule language such as SWRL for searching offers for desired criteria. For selection over multiple SLOs, multi criteria decision making (MCDM) methods such as AHP is helpful in choosing a best seller.

The service selection is also useful in service composition where multiple services are required to formulate a process. During service composition, whether it is static

or dynamic, identifying the best service partner is crucial in any business scenario. Having a good contract in advance, serves better to project the business objectives. Dynamic service selection using agreement helps identifying services with required guarantees to optimize the overall process performance. An experiment scenario of Agro-produce market system is taken. The commodity rice procurement process is discussed where multiple services partners such as farmers, rice-millers, transporters and storage providers need to be selected to optimize overall cost and quality of rice. When selection of one service provider affects the other service selections, preferences over services and the order of selection needs to be taken into account.

6.2 Future Work

During the tenure of thesis work, implementation of experimental service selection scenario(Chapter 4) and service selection to realize service composition scenario(Chapter 5) are executed. The Ontology defining the concepts of Agro-Produce market system is constructed in OWL-DL. The offer submission functionality is developed using Protege to work out the experiment. Automation in semantic annotation of SLAs is left as future work.

Service selection for service composition is discussed with an example of constructing commodity rice procurement process and generating the process level agreement(Chapter 5). Preferences over selection criteria is decided manually. Also from the rice procurement problem, the order of service selection is constructed manually. A work on building DSS (Decision Support System) having capabilities of defining the preferences and the order of service selection using RuleML (Rule Markup Language) is being explored.

Efforts are required to integrate service selection functionality to the service composition and execution engine. The application of other methods for MCDM, like TOPSIS [24], ELECTRE [26], Goal Programming [25] etc for implementing decision making module is in process. The comparison of results of MCDM methods is required to identify the effectiveness of the each method.

By and large realization of domain specific service broker and service negotiator utilizing the matchmaker functionality is left as a future work.

Appendix A

Appendix

A.1 Preference over Selection Criteria by Consumer

Inside OfferPreference.xml file Tag <GuranteeTermList> contains list of guarantee terms. Preferences over guarantee terms are specified using AHP measurement scale inside Tag <Comparision>.

```
<?xml version="1.0" encoding="UTF-8"?> <OfferPreference>
<GuranteeTermList>
    <GuaranteeTerm name="GT_Price"/>
    <GuaranteeTerm name="GT_Location"/>
    <GuaranteeTerm name="GT_Quantity"/>
    <GuaranteeTerm name="GT_Size"/>
</GuranteeTermList>
<Comparisions>
    <GT_Price>
        <GT_Price value="1" />
        <GT_Location value="3" />
        <GT_Quantity value="5" />
        <GT_Size value="4" />
    </GT_Price>
    <GT_Location>
        <GT_Price value="1/3" />
        <GT_Location value="1" />
        <GT_Quantity value="3" />
        <GT_Size value="2" />
    </GT_Location>
    <GT_Quantity>
        <GT_Price value="1/5" />
        <GT_Location value="1/3" />
```

```
        <GT_Quantity value="1" />
        <GT_Size value="1" />
    </GT_Quantity>
    <GT_Size>
        <GT_Price value="1/4" />
        <GT_Location value="1/2" />
        <GT_Quantity value="1" />
        <GT_Size value="1" />
    </GT_Size>
</Comparisions></OfferPreference>
```

A.2 Preference over Service Offers of Service Providers

<ServiceProviderOfferList> contains the sellers' offers in consideration. <GuranteeTermList> specifies the list of guarantees, compared while selecting best seller's offer. Inside <Comparisions> for each guarantee, seller's offers from <ServiceProviderOfferList> are compared using AHP's measurement scale.

```
<?xml version="1.0" encoding="UTF-8"?>
<ServiceProviderOffersPreference> <ServiceProviderOfferList>
    <ServiceProviderOffer name="ServiceProviderOffer_1"/>
    <ServiceProviderOffer name="ServiceProviderOffer_2"/>
    <ServiceProviderOffer name="ServiceProviderOffer_4"/>
</ServiceProviderOfferList>

<GuranteeTermList>
    <GuaranteeTerm name="GT_Price"/>
    <GuaranteeTerm name="GT_Location"/>
    <GuaranteeTerm name="GT_Quantity"/>
    <GuaranteeTerm name="GT_Size"/>
</GuranteeTermList>

<Comparisions>
    <GT_Price>
        <ServiceProviderOffer_1>
            <ServiceProviderOffer_1 value="1"/>
            <ServiceProviderOffer_2 value="1/3"/>
            <ServiceProviderOffer_4 value="1/7"/>
        </ServiceProviderOffer_1>
        <ServiceProviderOffer_2>
            <ServiceProviderOffer_1 value="3"/>
```

```
            <ServiceProviderOffer_2 value="1"/>
            <ServiceProviderOffer_4 value="1/5"/>
        </ServiceProviderOffer_2>
        <ServiceProviderOffer_4>
            <ServiceProviderOffer_1 value="7"/>
            <ServiceProviderOffer_2 value="5"/>
            <ServiceProviderOffer_4 value="1"/>
        </ServiceProviderOffer_4>
    </GT_Price>
    <GT_Location>
        <ServiceProviderOffer_1>
            <ServiceProviderOffer_1 value="1"/>
            <ServiceProviderOffer_2 value="1"/>
            <ServiceProviderOffer_4 value="3"/>
        </ServiceProviderOffer_1>
        <ServiceProviderOffer_2>
            <ServiceProviderOffer_1 value="1"/>
            <ServiceProviderOffer_2 value="1"/>
            <ServiceProviderOffer_4 value="3"/>
        </ServiceProviderOffer_2>
        <ServiceProviderOffer_4>
            <ServiceProviderOffer_1 value="1/3"/>
            <ServiceProviderOffer_2 value="1/3"/>
            <ServiceProviderOffer_4 value="1"/>
        </ServiceProviderOffer_4>
    </GT_Location>
    <GT_Quantity>
            <ServiceProviderOffer_1>
            <ServiceProviderOffer_1 value="1"/>
            <ServiceProviderOffer_2 value="3"/>
            <ServiceProviderOffer_4 value="1"/>
        </ServiceProviderOffer_1>
        <ServiceProviderOffer_2>
            <ServiceProviderOffer_1 value="1/3"/>
            <ServiceProviderOffer_2 value="1"/>
            <ServiceProviderOffer_4 value="1/3"/>
        </ServiceProviderOffer_2>
        <ServiceProviderOffer_4>
            <ServiceProviderOffer_1 value="1"/>
            <ServiceProviderOffer_2 value="3"/>
            <ServiceProviderOffer_4 value="1"/>
        </ServiceProviderOffer_4>
    </GT_Quantity>
```

```
    <GT_Size>
        <ServiceProviderOffer_1>
            <ServiceProviderOffer_1 value="1"/>
            <ServiceProviderOffer_2 value="1/3"/>
            <ServiceProviderOffer_4 value="1/3"/>
        </ServiceProviderOffer_1>
        <ServiceProviderOffer_2>
            <ServiceProviderOffer_1 value="3"/>
            <ServiceProviderOffer_2 value="1"/>
            <ServiceProviderOffer_4 value="1"/>
        </ServiceProviderOffer_2>
        <ServiceProviderOffer_4>
            <ServiceProviderOffer_1 value="3"/>
            <ServiceProviderOffer_2 value="1"/>
            <ServiceProviderOffer_4 value="1"/>
        </ServiceProviderOffer_4>
    </GT_Size>
</Comparisions> </ServiceProviderOffersPreference>
```

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Glossary

Agro-Produce Market System	Market system established by APMCs in various talukas and districts where sellers and buyers participate in wholesale and retail trade of Agro-Produce
AHP	The Analytical Hierarchy Process developed by Thomas Saaty (1980) is a decision making method allowing to model complex problem into hierarchical structure showing the relationships of the goal objectives (criteria) sub-objectives and alternatives. [23]
Jess	Rule Engine for Java Platform to build systems having the capacity to reason using the knowledge supplied in the form of declarative rules.
MCDM	Multi-Criteria Decision Making. Set of methods to support decisions where multiple criteria are involved.
OWL	The Web Ontology Language OWL is a semantic markup language for publishing and sharing ontologies on the World Wide Web. [8]
QoS	Quality of Service is an obligation accepted and advertised by a provider entity to service consumers. [37]
SLA	Service Level Agreement. An agreement expressing relationship between service provider and consumer over web service usage.

SLO Service Level Objective.A service attribute-value pair expressing level of service e.g. QoS and it's value

SOA Service Oriented Architecture. A set of components which can be invoked and whose interface descriptions can be published and discovered. [37]

SOAP Simple Object Access Protocol. The formal set of conventions governing the format and processing rules of a SOAP message. These conventions include the interactions among SOAP nodes generating and accepting SOAP messages for the purpose of exchanging information along a SOAP message path. [37]

SWRL The Semantic Web Rule Language is a is a combination of OWL web ontology language such as OWL-DL and OWL-Lite and Rule Markup Language.[9]

UDDI Universal Description Discovery and Integration (UDDI) is a platform-independent XML-based registry for businesses worldwide to list themselves on the Internet. UDDI is an open industry initiative sponsored by OASIS enabling businesses to publish service listings and discover each other and define how the services or software applications interact over the Internet.

Web Service A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP-messages typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards. [37]

WS-Agreement Web Service Agreement. A specification established by GRAAP (Grid Resource Allocation and Agreement Protocol WG) of OGF (Open Grid Forum) to define structure of web service agreement and a simple protocol to create SLA.

WS-BPEL Web Service Business Process Execution Language. The WS-BPEL specification provides a language for formally describing business processes and business interaction protocols. WS-BPEL was designed to extend the Web Services interaction model to support business transactions. [33]

WS-Policy The Web Services Policy Framework provides a general purpose model and corresponding syntax to describe the policies of a Web Service. [16]

WSCL Web Service Choreography Language allows the abstract interfaces of web services i.e. the business level conversations or public processes supported by a web service to be defined.

WSDL Web Service Description language is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information. [3]