Novel Models for Multi-Agent Negotiation based Semantic Web Service Composition

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Abstract: Multi-agent based semantic web service composition involves the composition of semantic web services considering each of the agent capability to serve a particular service request. This paper presents the two variations of semantic web service composition process based on the timing of negotiation in composition process. The variations are based on the concept that the negotiation between the service requester and the service providers has been performed before the selection of final service provider or after the final service provider has been selected. Further, based upon one of the model, a novel multi-agent based semantic web service composition approach has been presented.

Keywords: agent, composition, negotiation, semantic web.

1 Introduction

Semantic web is the extension of current web in which information is given well defined meaning better enabling the computer and people to work in cooperation. Semantic Web Services (SWSs) have modular structure and can be published, located or called (invoked) through the web. The different services can be combined with other homogeneous or heterogeneous services to form complex web applications. So, the interfaces, properties, capabilities, and effects of SWSs are encoded in a machine-understandable form to allow an easy integration of heterogeneous services. This process of generating aggregated service by the integration of independent available component services for satisfying a client request that can not be satisfied by any single available service is called as Semantic Web Service Composition.

In the multi-agent based SWS composition system, each of the agent capability serves a particular request. This paper is based upon the understanding that the negotiation in the agent

based SWS composition process can be performed before the selection of final service provider for a task. The paper presents two possible models for MAS based SWS composition process. The work also presents a novel MAS based SWS composition approach based on one of the presented model. The work in this paper is the extended version of our earlier work in [1]. A similar work has been presented by the work in [2]. However, the work in [2] is based upon the different understanding. No other works in the literature was found which share the same understanding. The paper has been structured as follow. Apart from introduction in section-1, section-2 introduces multi-attribute negotiation in brief. Section-3 presents proposed composition models. In section-4, a novel SWS composition approach based upon one of the proposed model has been presented. Section-5 presents some implementation issues regarding the presented approach. The paper has been concluded in section-6.

2 Multi-Attribute negotiation

Negotiation is the process by which a group of agents come to a mutually acceptable agreement on some matter. It is the process of making a joint decision by two or more parties. Among others, the negotiation object is considered to be the one of most important topic in automatic negotiation research. Negotiation object defines the range of issues over which the agreement must be reached. The object may contain a single issue such as price or it may contain multiple issues such as price, timing, quality etc. The negotiation approach, the negotiation-object of which contains multiple issues, is called as multi-attribute negotiation approach. Further, the values of various issues in negotiation-object may be fixed or flexible to change [3]. They may be called as non-negotiable or negotiable issues respectively.

3 Multi-Agent Negotiation based SWS Composition Models

In this section, we have presented two models for agent based SWS composition process. These models basically vary on the timing of performing the negotiation between service requester agent (SRA) and service provider agent (SPA). Two models for the agent based SWS composition process are possible based upon the use of coordinator agent on not [2] in the composition process. So, there are following variations in the composition process:

1. SWS composition without coordinator agent and performing the negotiation between SRA and the selected SPA only.
2. SWS composition without coordinator agent and performing the negotiation between SRA and all the discovered SPAs before selection of final SPA.
3. SWS composition with dedicated coordinator agent and performing the negotiation between SRA and the selected SPA only.
4. SWS composition with dedicated coordinator agent and performing the negotiation between SRA and all the discovered SPAs before selection of final SPA.

5. SWS composition with coordinator agent that also perform some tasks and performing the negotiation between SRA and the selected SPA only.
6. SWS composition with coordinator agent that also perform some tasks and performing the negotiation between SRA and all the discovered SPAs before selection of final SPA.

The cases 1 (Fig. 1), 3 (Fig. 2), and 5 (Fig. 3) uses the same architectures as described by the work in [2] for the composition process. Figure 4 shows model for composition process, in which no coordinator agent is used and the negotiation is performed between the SRA and various discovered SPAs for a task before the final selection is performed (case 2). In this model, if required, the input request from User Agent U is directly decomposed by the system into atomic task/activities $Task_1$, $Task2$, $Task_3$ ... $Task_n$, based on its ontological description. After that, for each of the atomic task, the candidate software agents, who are acting as semantic web service components, are discovered. The negotiation is performed with each of the discovered SPAs. The negotiation-agreements of the SPAs with which the negotiation is successful, are rated to perform the selection of best SPA. SPA_1, SPA_2, SPA_3 ... SPA_n are the discovered service provider agents (SPA) for task $Task_1$. The user agent U, now negotiate with each of the SPA and the selection is performed on the SPAs with successful negotiation. The same process is performed for each of the decomposed tasks. The arrangement for the negotiation can take place using FIPA Contract Net Protocol [4] and SPA can accept task by means of agent's communication interface built upon FIPA-ACL [5]. Service is invoked by the SPA via the interface specified by its binding description.

Figures 5 and 6 shows the composition model for which a coordinator agent is used that control the complete SWS composition process. This model further has two variations of using an independent dedicated coordinator agent (case 4) and using a coordinator agent which in addition to coordinating the composition process also perform some of the atomic tasks (case 6), as shown by Figures 2 and 3 respectively.

In the case 4, the user agent U gives input request into the composition system, which is then specified in the terms of ontology. Using the parameters specified in the ontology description of request, the candidate coordinator agents are discovered and finally a best one is selected. The selected coordinator agent C now decides from ontology description, if the input request is atomic activity or it is complex one. In case, the request is complex one, it is decomposed into atomic tasks $Task_1$, Task2, $Task_3$ ... $Task_n$. However, before decomposing the request, C can perform a validation over the input request to check if all the parameters, preferences and constraints specified in the request are proper or not. Now, Coordinator agent C discovers the corresponding service provider agents SPA_1, SPA_2, SPA_3 ... SPA_n for the atomic task $Task_1$.
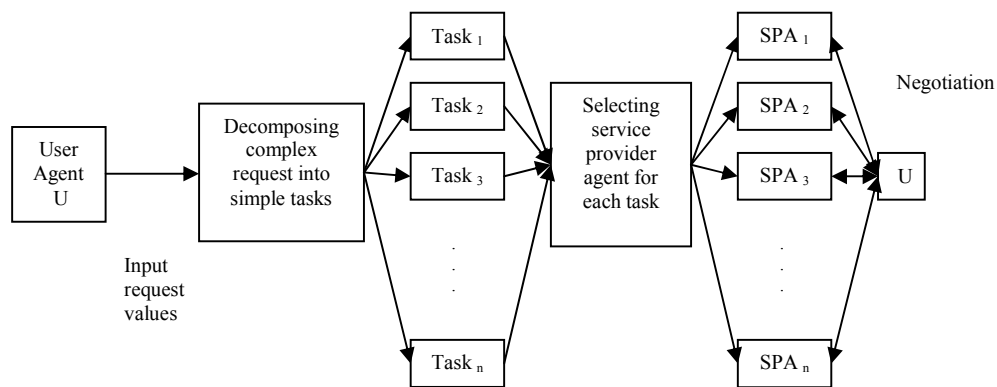
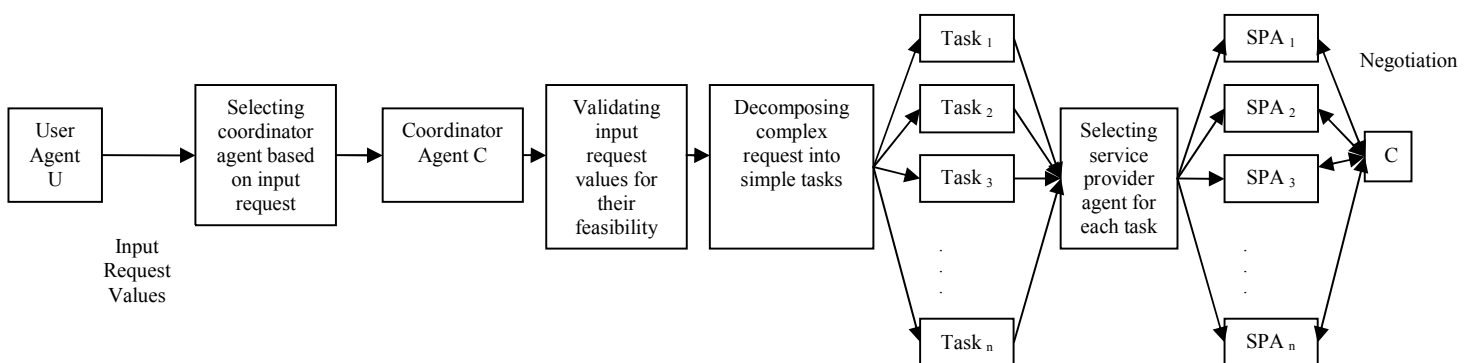Figure 1: SWS Composition system for case 1

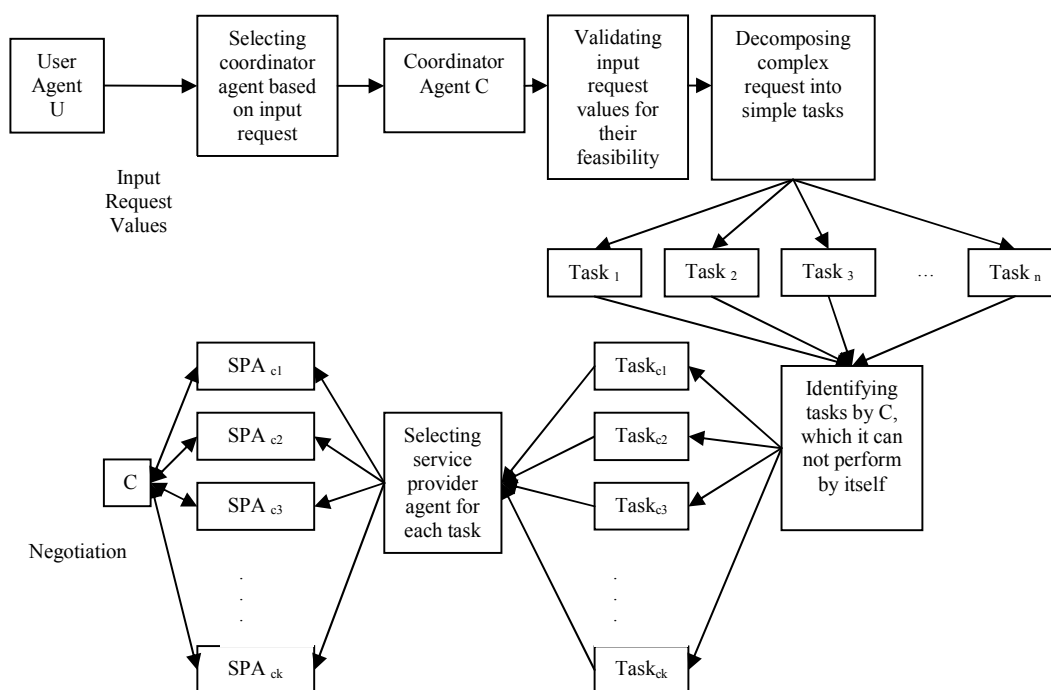
Figure 2: SWS Composition System for case 3

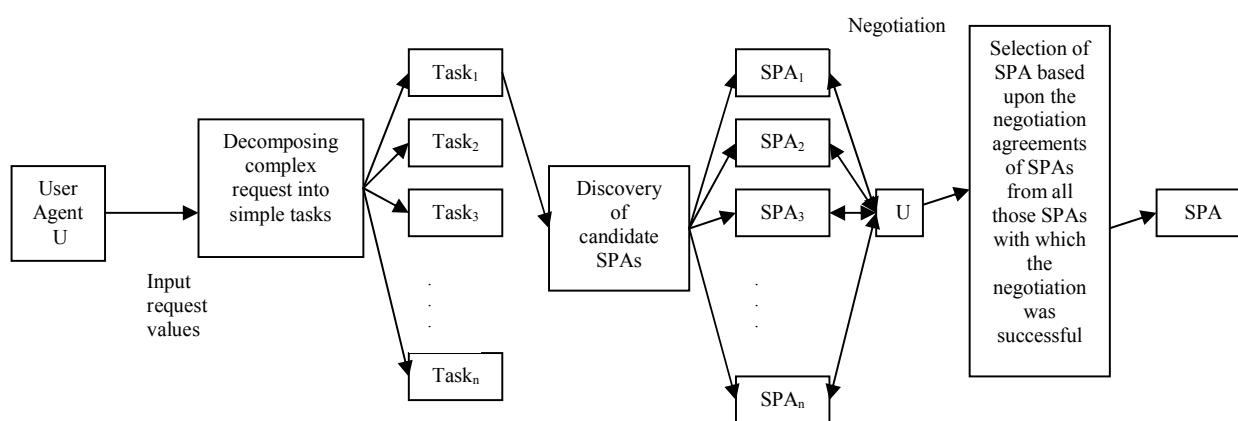Figure 3: SWS Composition System for case 5
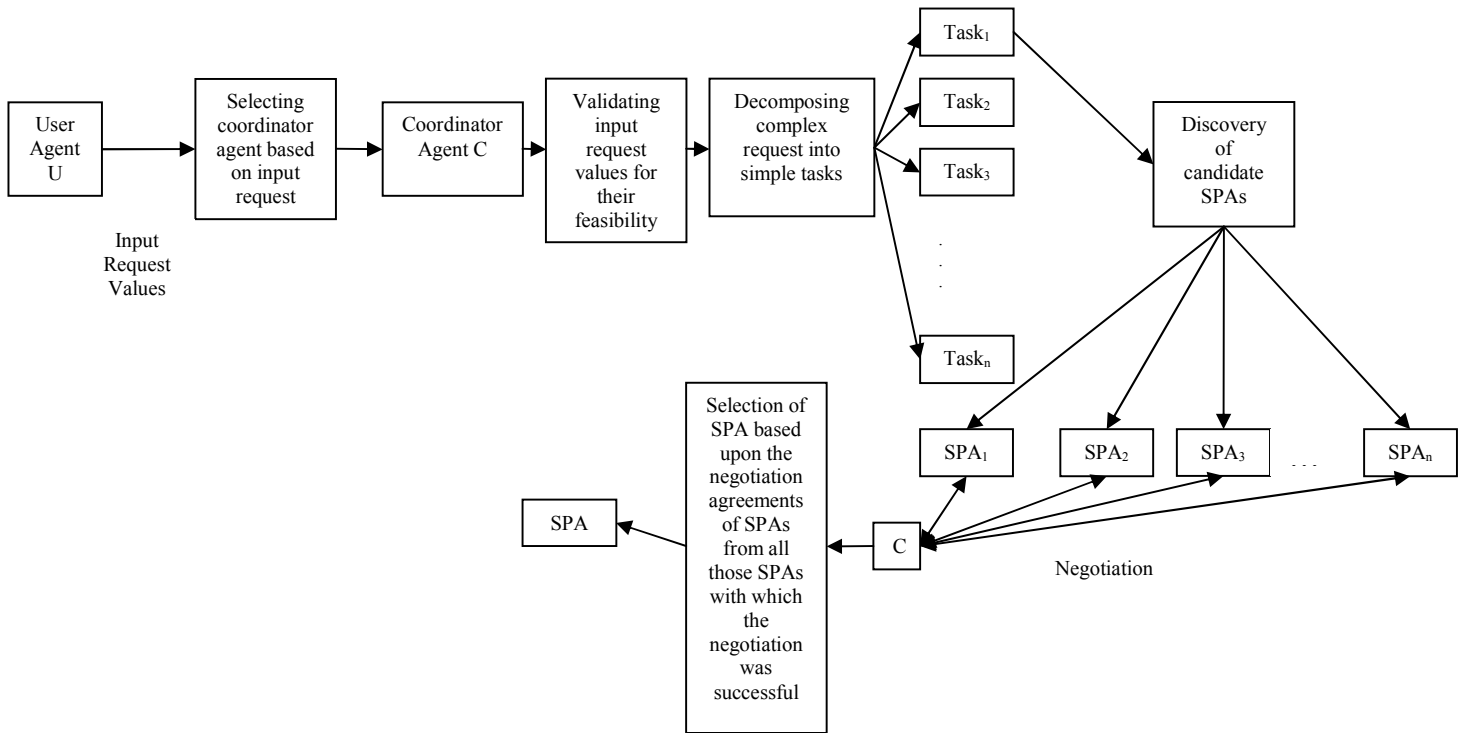

Figure 4: SWS Composition System for case 2

Figure 5: SWS Composition System for case 4

The coordinator agent C, now negotiate with each of the SPA and the selection is performed on the SPAs with successful negotiation. The assignment of the task to the selected SPA and its invocation is performed in the similar way as described for the case 2. The same process is performed for each of the decomposed tasks. The composition process for the case 6 works similar to the process depicted above for the case 4 except that in this model, the coordinator agent C can perform some of the tasks, in addition to coordinating the composition process.

Most of the works on SWS composition available in the literature involves the selection of most appropriate SPA for a task and then performing the negotiation with it (cases 1, 3, and 5). But, in the presented composition models (cases 2, 4, and 6), firstly the negotiation is performed with all the discovered SPAs and after that the selection is performed on them using there various agreed quality parameters. The advantage of this approach is that this will result into more reliable and favorable selection, as the selection has been performed for the best from among the all acceptable and most favorable agreements. The models for the case-4 and case-6 also have some advantages over the model for case-2 due to the use of coordinator agent [2].
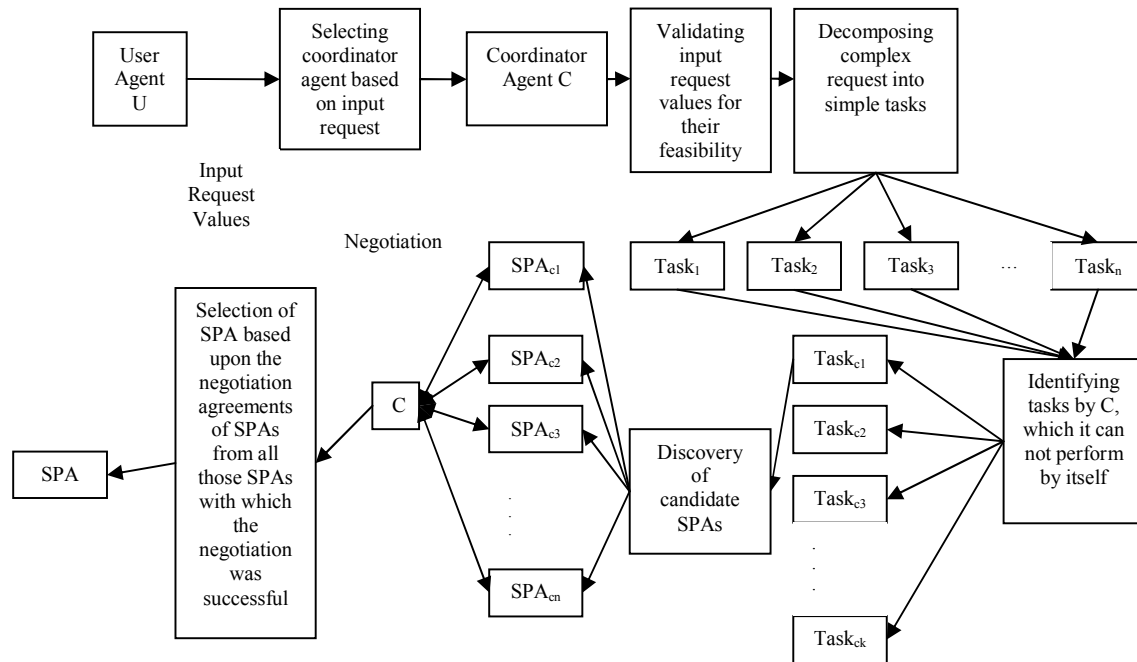
Figure 6: SWS Composition System for case 6

4 Multi-Agent Negotiation based Composition Approach

In this section, we present a novel multi-agent negotiation based composition approach. The presented approach is based on the model shown in Figure 5 and described in preceding section, which uses an independent dedicated coordinator agent for controlling the various activities in composition process. A layout of the presented approach is shown in Figures 7(a) and 7(b). The system mainly consists of following three types of agents:

- Service Requester Agent (SRA)
- Coordinator Agent (CA)
- Service Provider Agent (SPA)

SRA has the responsibility to perform the request to CA. The request by SRA is then specified in the term of ontology, which is then used by the CA. An intelligent CA has various properties and capabilities. CA is a modular, self-contained software component wrapping coordination services, with ontological service description. It has the capability of validating the constraints, preferences, and other higher level parameters of the input request by the SRA. It has the capability

of validating if the input activity is atomic or complex. In case it is complex, interpreting it as task comprising of various atomic activities of varying granularity and decomposing it into atomic tasks according to their ontology description. CA can negotiate with the SPAs using some negotiation approach, resulting into some common agreement over the various service-attributes. Further, it can evaluate and assess the SPAs based upon the nature of their negotiation-agreements. It makes arrangement for outsourcing the activity to SPAs based on FIPA Contract Net Protocol [4] and agent's communication interface built upon FIPA-ACL [5].

An intelligent SPA has various properties and capabilities.

- SPA is a self-contained, modular agent wrapping services in the form of software components, with the corresponding ontological service description.
- The purpose of SPA is decided by the services it wraps.
- It is able to understand the meaning of activity, it has to perform.

- SPA joins the composition process, only for the time its service is required.

Figure 7(a) and 7(b) shows the layouts of the presented composition approach for CA and SPA selection respectively. The model has the novelty in the aspect that in this model, the negotiation has been performed with all the discovered SPAs for as task and after that the selection is performed from among the all successful SPAs. The advantage of this aspect is that in this case, the selection has been performed for the best from among the all the acceptable agreements, so it will result into more reliable and accurate selection.
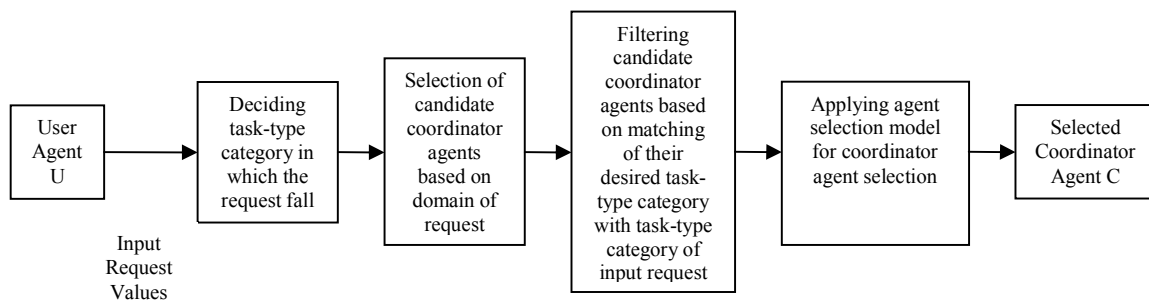

Figure 7(a): Coordinator agent selection

The presented approach involves sending a request from the SRA, user agent U, to the system, which is further represented in the term of ontologies. The parameters in the request are used to decide the domain and further the task-type category within the domain of the request. The domain of request is used to discover the entire candidate CAs after matching from their published ontological service profiles. The candidate CAs are further filtered based on the matching that if the task-type category of the input request is matching with any of the category mentioned in the set of desired task-type categories of the candidate CA or not. The matchmaking here can be performed based on LARKS [6] or service discovery techniques based on UDDI protocol [7] or semantic matching [8] based on ontology profiles like in DAML-S [9], OWL [10] or using any other service matching method. Various techniques of discovery [11] can be applied here like keyword matching, controlled vocabulary matching, semantic matchmaking etc. The system can be made to proceed with the exact match, plug-in match, subsumption match, or intersection match as required in the process. An index of selection (IoS) is then calculated for each of the filtered CAs using an agent selection model and the CA with maximum IoS is selected as the coordinator C for given composition problem. At this stage, U can perform negotiation with C based on FIPA Contract Net Protocol [4]. C accept task from U by means of agent's communication interface built upon FIPA-ACL [5]. All of the remaining activities further in the process are coordinated by C; however, it can perform negotiation with U during the process, if required and allowed [2]. C acquires the conditions of negotiation from U by means of agent's communication interface built upon FIPA-ACL [5]. Now, C performs a validation over the parameters, preference, and constraints to check their feasibility. It also determines from the input request, if it is an atomic activity or complex one. In case the input request is complex task, then C decomposes it into atomic tasks, $Task_1$, $Task_2$, $Task_3$ ... $Task_n$, of varying granularity. Now for each atomic task, the candidate SPAs are discovered and filtering over discovered SPAs are performed based on their IOPE matching with the required task. The matchmaking at this stage can be performed in the similar way as described above for the CA. The negotiation is then performed with all the filtered SPAs. The negotiation with all the SPAs may not be successful. So at this stage, a set of SPAs is obtained with which the negotiation has been successful and that has generated a set of agreed attributes. IoS is then calculated for each of such SPA based upon the values of various attribute in their negotiation agreements and the

agent with maximum IoS is selected as service provider. Figure 7(b) shows this process for $Task_1$ only, however, it is performed for each atomic task in the same manner. Various attributes used in the selection process are those on the basis of which negotiation has been performed. Some of such

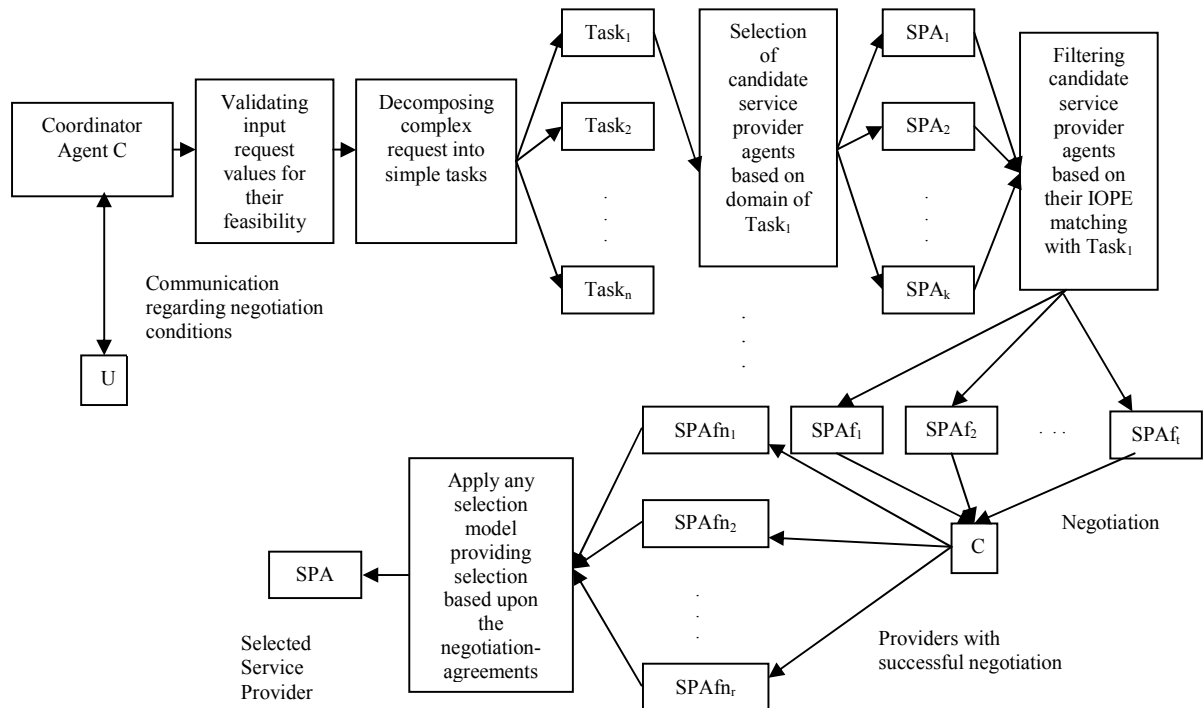attributes are price, response-time, quality, reliability etc.

Figure 7(b): SPA agent selection and composition

5 Implementation

In this section, we have dealt with the issues involved in the implementation of a SWS composition system based upon the presented composition approach. We have implemented a composition system taking education planning problem as an application of semantic web technology [12]. The education planning problem for taking admission for higher education involves various activities like Counseling and Preparation, Institute Tracking, Admission Consultancy, Financing, Transportation Booking, and Map and Weather Information. All these activities can be assigned to different SPAs. The profiles of both

coordinator as well as other task-specific agents can be developed using any semantic web service description language like RDF/RDF-S [13], DAML/DAML-S [14], OWL [10] etc. Some of the semantic web tools like Protégé [15], Jena [16] and Altova SemanticWorks [17] provide the support for developing the profiles in either RDF/RDF-S or OWL. Jena Ontology API provides an easy to use APIs (Application Programming Interfaces) for ontological profile development and good reasoning support. These profiles are then published on the web and can be accessed or manipulated by the semantic web service composition system. Structure of sample profiles prepared using Jena Ontology APIs and observed

in Altova SemanticWorks for a coordinator agent for education planning is shown in Figure 8. Figure also shows that the ontology in the profiles is well-defined under OWL-Full RDF/OWL level. The reasoning in the system is performed using Jena's *OWLReasoner*. However, Jena also provides several *Reasoner* types to work with different types of ontology.
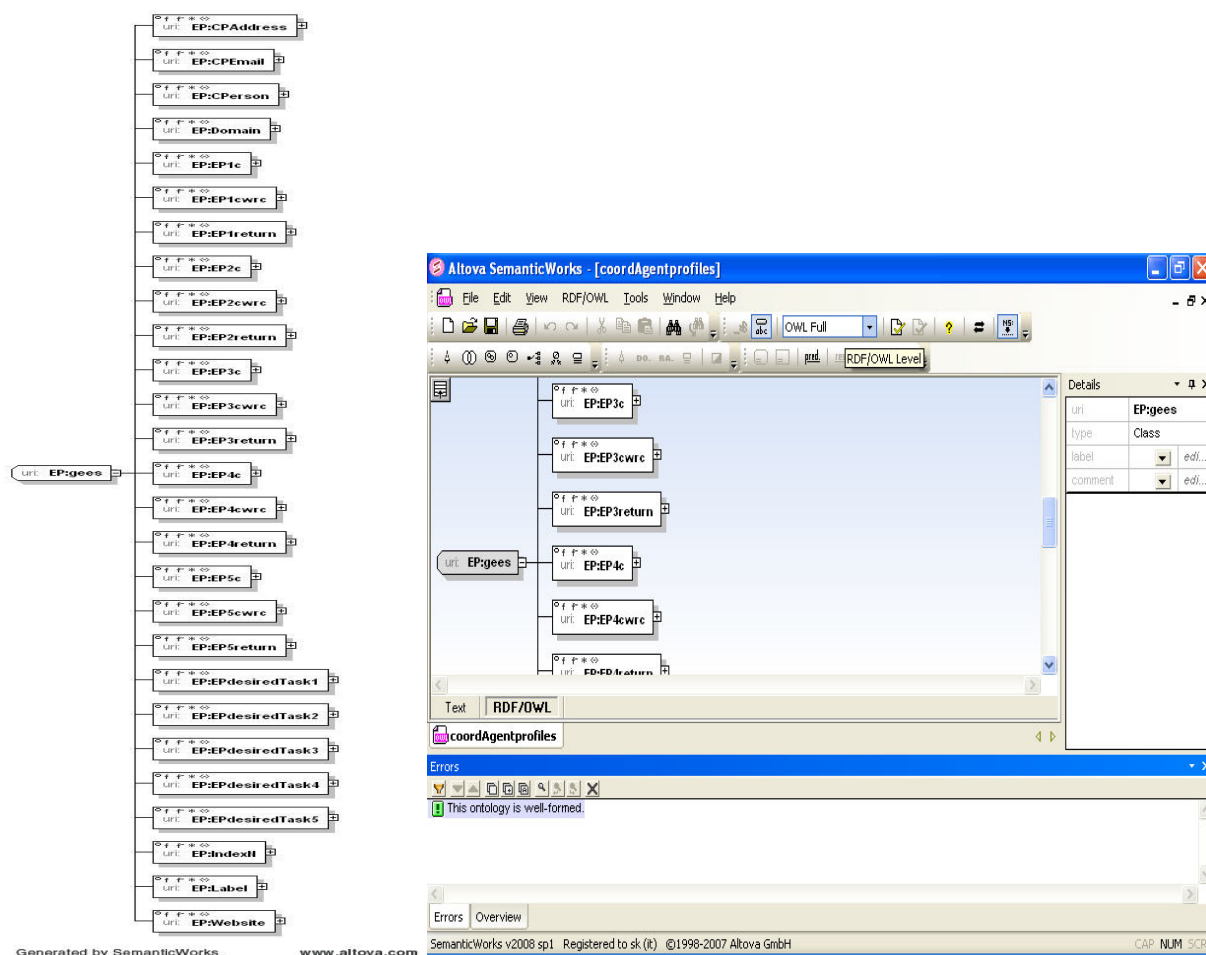

Figure 8: Coordinator Agent profile

The system implemented using Java and related tools easily access the service profiles and uses the Jena APIs for interrogating, manipulating, or querying the profiles. The querying support provided by the Jena APIs, which is internally implemented in query language SPARQL [18] is used for querying over the profiles. The query language RDQL [19] can also be used with Jena for availing the advanced querying support. For handling the large service profiles the persistent ontologies of Jena ontology APIs can be used. The implemented system mainly uses the exact-match approach in discovery process. The composite input ontology in the system mainly have three components: Qualification Input like course in which admission is sought, entrance examination score, qualifying examination score; Additional Admission Requirements like session of admission, date of birth, gender; and Preference and Constraints like finance needed or not, map needed or not, budget constraint, travel class constraint etc. Then the further steps for the selection of a coordinator agent such as domain based filtering, agent's desire based filtering and rating using a cognition based mathematical indexing are implemented and a coordinator agent

is selected [20]. This agent then perform decomposition of the request based on input task ontology and a SPA for each task is selected using different steps from the presented composition approach like domain based filtering, IOPE filtering, negotiation with filtered SPAs, and selection from the SPAs with successful negotiation based upon their negotiation agreements. The validation of input and communication with user-agent regarding negotiation conditions is also implemented in the system.

For elaborating the implementation, we have shown the output of different steps for selection of coordinator agent in Figure 9 and for selection of a Finance Service Provider Agent in Figure 10, otherwise these steps do not require user-interaction. As shown in Figure 9, the agent 'Get-Educated Education Services' has maximum index of selection and hence it is selected as coordinator agent. Figure 10 shows that agent 'Kuber Financers' with maximum index of selection get selected as Finance Provider Agent. Jade [18], a Java based agent-development environment, can be used to develop the agents and to establish communication between them. Jade also provide the environment for implementing the FIPA Contract Net Protocol [4] for negotiation between the agents involved in the system. The SPAs for other tasks in the composite input-request are also selected in the same way. The selected agent are now interfaced to each other and are invoked to take their respective services.

Figure 9: Coordinator Agent Selection

Figure 10: Selection of Financing Service Agent

6   Conclusion

The paper presents the models for agent based SWS composition varying on the timing of negotiation between the SRA and SPAs. These models are based on the concept that instead of performing the negotiation between the SRA and the selected SPA, the negotiation can be performed between the SRA and the discovered SPAs. After that, the selection can be performed from all the SPAs with successful negotiation. It is found that the SWS composition in this process is more accurate and reliable, as the selection has been performed for the best from among all of the acceptable agreements. The paper also presents a SWS composition approach based upon the one of composition model that uses the dedicated coordinator agent and performs negotiation between SRA and all the discovered SPAs before selection of final SPA. In the paper, we have implemented a SWS composition system based upon the presented approach.

References

[1] Kumar, S., Mastorakis, N. E. (2010) 'Multi-Agent Negotiation based Semantic Web Service Composition Models, *9th WSEAS Int. Conf. on Software Engineering,, Parallel and Distributed Systems, Cambridge' 10, U.K.*

[2] Kumar, S., Mishra, R. B. (2008) 'Multi-Agent based Semantic Web Service Composition Models', *Journal of Computer Science, Infocomp,* Vol. 7, Issue 3, pp. 42-51.

[3] Jennings, N. R., Faratin, P., Lomuscio, A. R., Parsons, S., Wooldridge, M. J., Sierra, C. (2001) 'Automated Negotiation: Prospects, Methods and Challenges', *Int Jl. Of Group Decision and Negotiation , Kluwar Academic Press Publishers,* Vol. 10, Issue 2, pp. 199-215.

[4] Smith, Davis (2009) 'Foundation for Intelligent Physical Agents, FIPA Contract Net Interaction Protocol Specification', *http://www.fipa.org/specs/fipa00029/SC00029 H.html,* Web-Site accessed on Dec. 10, 2009.

[5] FIPA Architecture Board (2009) 'Foundation for Intelligent Physical Agents. FIPA Communicative Act Library Specification', *http://www.fipa.org/specs/fipa00037/SC00037 J.html,* Web-Site accessed on Dec. 10, 2009.

[6] Sycara, K., Widoff, S., Klusch, M., Lu, M.J. (2002) 'LARKS: Dynamic Matchmaking among Heterogeneous Software Agents in Cyberspace', *Autonomous Agents and Multi-Agent Systems,* Vol. 5, pp. 173-203.

[7] OASIS (2008) 'OASIS UDDI Specifications TC - Committee Specifications', *http://www.oasis-open.org/committees/uddi-spec/doc/tcspecs.htm,* website accessed Feb 13, 2008.

[8] Paolucci, M., Kawamura, T., Payne, T., Sycara, K. (2002) 'Semantic Matching of Web Service Capabilities', *In: Proc. Of Int. Semantic Web Conference (ISWC, 2002), Italy.*

[9] The DAML Services Coalition (2009) 'DAML-S: Semantic Mark-up for Web Services', *http://www.daml.org/services/daml-s/2001/10/daml-s.pdf*, Website accessed on Dec. 10, 2009.

[10] McGuinness, D.L, Harmelen, F.V. (2009) 'OWL Web Ontology Language Overview', *http://www.w3.org/TR/owl-features/,* Website accessed on Dec. 11, 2009.

[11] Stollberg, M., Haller (2005) 'A. Semantic Web Services Tutorial', *3rd International Conference on Web Services (ICWS 2005).*

[12] Kumar, S., Kumar, K., Jain, A. (2009) 'A Semantic Web Technology based Framework for Educational-Offer Selection in Higher Education', *International Journal of Metadata, Semantics and Ontologies, Inderscience, U.K.*, Vol. 4, Issue 3, pp. 165-182.

[13] Herman, I., Swick, R., Brickley, D. (2008) 'Resource Description Framework (RDF)', *http://www.w3.org/RDF/,* Website accessed Feb 28, 2008.

[14] DARPA (2008) 'The DARPA Agent Mark-up Language', *http://www.daml.org/,* Website accessed Feb 28, 2008.

[15] Stanford Center for Biomedical Informatics Research (2008) 'Protégé', *http://protege.stanford.edu/,* Website accessed March 01, 2008.

[16] HP Labs Semantic Web Programme (2009) 'Jena- A Semantic Web Framework for Java', *http://jena.sourceforge.net/,* Website accessed Dec. 01, 2009.

[17] Altova (2009) 'SemanticWorks Semantic Web tool - Visual RDF and OWL editor', *http://www.altova.com/products/semanticworks/semantic_web_rdf_owl_editor.html,* Website accessed Nov. 10, 2009.

[18] Prudhommeaux, E., Seaborne, A. (2008) 'SPARQL Query Language for RDF', *http://www.w3.org/TR/2008/REC-rdf-sparql-query-20080115/ .*

[19] Seaborne, A. (2004) 'RDQL - A Query Language for RDF', *http://www.w3.org/Submission/2004/SUBM-RDQL-20040109/ .*

[20] Kumar, S., Mishra, R. B., (2008) 'A framework towards semantic web service composition based on multi-agent systems', *International Journal of Information Technology and Web Engineering, IGI Global, USA*, Vol. 3, Issue 4, pp. 59-81.

[21] Telecom Italia Lab (2008) 'Java Agent Development Framework', *http://jade.tilab.com/,* Website accessed March 01, 2008.