An Approach to Utility Based Negotiation between Semantic Web Services

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Abstract: - Before taking the services of a service provider, the service requester may need to negotiate with it on various issues. A utility-based negotiation approach capable of providing negotiation between participating semantic web services has been presented in this paper. A communication model describing the negotiation process has been presented. The paper also presents the algorithms for various activities involved in the negotiation process. The work also proposes a novel concept of negotiation-feedback using a novel data-structure, Agreement Table. This concept can be helpful in expediting the negotiation process by decreasing the number of negotiation steps in which the agreement is reached. An evaluation of the work has been presented and a prototype system providing negotiation between semantic web services has been implemented.

Key-Words: - semantic web; utility; semantic web service, negotiation.

1 Introduction

Before taking the services from service provider (SP), in addition to performing the discovery, selection and composition processes, the service requester (SR) may also needs to perform the negotiation with the SP to establish an agreement over the various service-attributes such as price, quality, time-period, reliability etc. Negotiation is the process by which two or more parties make joint decision. The involved parties first verbalize demands and then move toward an agreement through a process of concession formation or search for new alternatives [1]. A lot of works related to the negotiation process have been reported in the literature such as ([2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], and [16]). But, most of them either not considers the negotiation from the perspective of SWSs or only deals with the theoretical aspects of negotiation between SWSs. This paper mainly focuses on the presentation of an approach for utility-based negotiation. In our earlier works, [17] and [18], we have presented a utility-model for calculation of the utilities of SR and SP. This work will provide the negotiation approach based upon the utility model presented by these earlier works.

The main contribution of paper is listed as below:

- A utility based negotiation approach for negotiation between SWSs.
- The algorithms for various activities involved in the negotiation process along with the communication model for negotiating services have been presented.
- A novel concept of negotiation-feedback using a novel data-structure, Agreement-Table, has been proposed which can expedite the negotiation process.
- The work has been evaluated and a system providing negotiation between semantic web services (SWSs) has been implemented.

The remainder of this paper is organized as follows. Section-2 presents the proposed utility-based negotiation approach. The presented work has been evaluated and a negotiation based system has been implemented in the Section-3. Section-4 provides the conclusion to the paper.

2 Utility-based Negotiation Approach

In this section, we have proposed a utility based approach for negotiation between SWSs. It involves the process of offering proposals with incremental concession from both SR and SP to each other until an acceptable agreement is obtained or the numbers of negotiation steps exceed the threshold limit. The acceptability of proposal is checked based upon the utility of SR and SP. A communication model for negotiation between SP and SR has also been presented.

2.1 Communication Model

The proposed negotiation approach involves the use of multiple attributes of SWSs for negotiation. The proposal between SP and SR contains the values for multiple attributes and the decision of agreement is taken based upon their combined value. A utility value is used which is dependent on the values of all the attributes and represents the preference of corresponding SWS. Utility theory is the appealing form of representing inputs to decision-making under uncertainty for automated systems because it can readily be mapped onto numerical optimization-based approaches [19]. The initial values of various attributes and conditions for termination of negotiation between SWSs can be fetched from their corresponding service profiles. The communication model for the proposed utility model is shown in Figure 1. Figure shows the communication between SR and SP during the negotiation using Communicative Acts of FIPA [20]. As shown in Figure 1, the negotiation process starts with the request from SR to SP for providing the services. If the request is refused by the SP, the process is terminated. But, if the SP agreed to provide services, the SR sends a call to SP to send an initial proposal for starting the negotiation. At this step also, if the call for initial proposal is refused by the SP, then negotiation process got terminated, otherwise SP responses with an initial proposal to the SR. Now, if this proposal is acceptable to the SR, then it is informed to the SP. SP informs the SR about various parameters of agreement and the negotiation is terminated. In the case of rejection by SR, the SR sends a new proposal to SP. Now, SP checks the proposal and if acceptable, informs the SR with acceptance. The values of various agreement-parameters are informed by the SR to SP and the process is terminated. But in the case of rejection by SP, a new proposal is sent by the SP to SR. This process continues until either the proposal acceptable to both SP and SR occurs or the number of negotiation-steps exceeds the threshold limit. In the presented negotiation approach, the utility values for SR and SP can be calculated using the utility calculation models presented in [17] and [18].

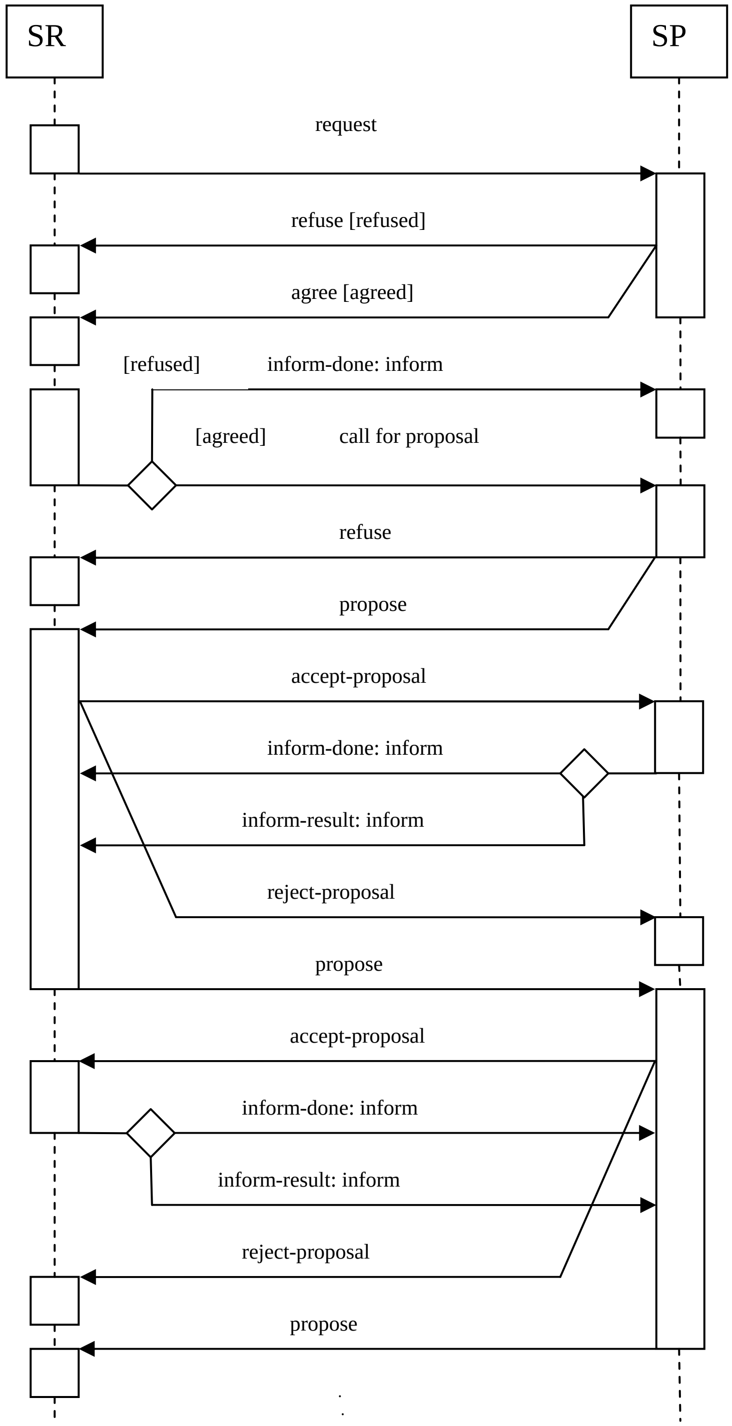

Figure 1: Communication Model using FIPA Communicative Acts

2.2 Negotiation Environment

Figure 2 shows the environment in which the proposed utility based negotiation is performed between SWSs. The environment contains a set of SPs that offer computer-based services to their clients i.e. SRs, which may themselves be service providers. Each SP is an independent entity with attached service profiles and motivated by some business concerns such as achieving profitability and hence demands some payment for providing services. However, to keep the things simple, only a single SP is shown in the Figure 2.

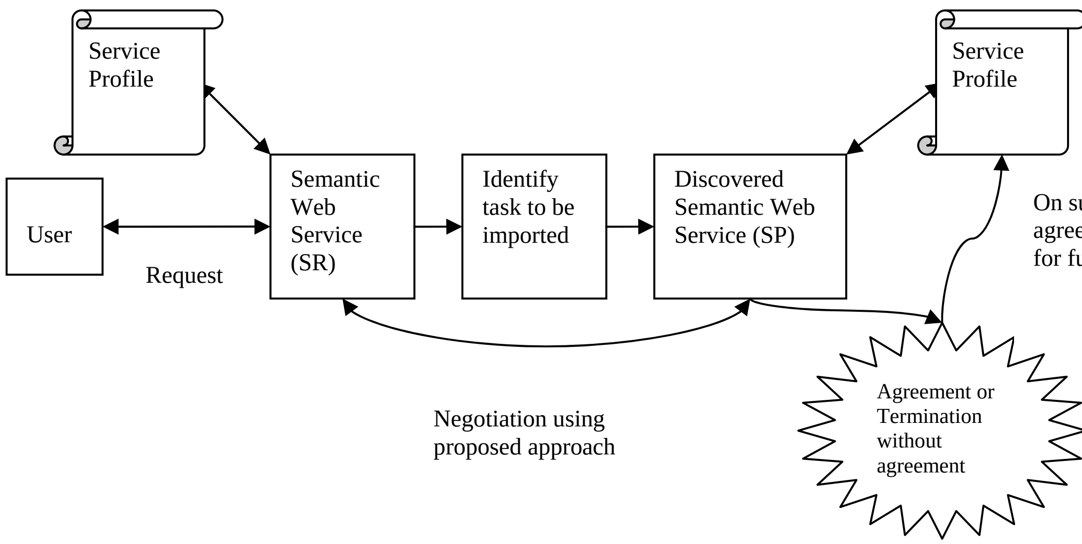

Figure 2: Utility based Negotiation in Semantic Web based System

2.3 Agreement Table

The proposed negotiation approach also involves a feedback-system, which on successful negotiation stores the agreement into the Agreement-Table (AT). AT is a data-structure maintained by the SP in its service profile and holds the values of various attributes of the latest agreement with a SR. An example AT is shown in the Figure 3. Each entry of AT for a SP contains following elements:

i. Service Requester Identifier (SR)
ii. Agreement values for the latest agreement between the corresponding SR and given SP.

The values stored in the AT can be used in the future negotiations. For example, in the case a SR, which has taken the services from the reference SP in past, request SP for negotiation to take its services, then SP can fetch the already stored agreement from the AT corresponding to given SR and can start negotiation from this agreement. This will have high possibility that this agreement will be acceptable to SR in first offer or it will be acceptable in a few negotiation steps. Thus, a lot of time and efforts will be saved.

2.4 Various Algorithms

The algorithms for generating a new proposal by SP and SR are shown in the Figure 4 and Figure 5 respectively. Figure 6 shows the algorithm for checking the acceptance of offer of SP/SR by SR/SP. The algorithm uses a function for calculating the utility of SR/SP, the detailed implementation of which will be described in the next sub-section. It is to mention that the method for calculation of utility is different for SP and SR. The algorithm for checking the termination conditions of the negotiation process is shown in Figure 7. The negotiation process is terminated when either the acceptable offer is obtained or the number of negotiation steps exceeds a threshold. As algorithm shows, the number of negotiation steps is decided by the values of the variables which are used to increase or decrease the initial attribute-values. Smaller the values of these variables, more will be the number of steps permissible in negotiation process.

Algorithm: Generation of New Proposal by SP
standard proposal: stan_p (standard price), stan_q (standard quality), stan_t (standard time-period)
current proposal: pro_p (proposed price), pro_q (proposed quality), pro_t (proposed time-period)
previous proposal : pre_p (previous price), pre_q (previous quality), pre_t (previous time-period)
delt_p: a short price-value
delt_q: a short quality-value

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delt_t: a short period of time
ratio_p: a small number used to increase the standard price
ratio_q: a small number used to decrease the standard quality
ratio_t: a small number used to increase the standard time-period

begin
        if (first proposal)
              //set values for the first proposal from SP
                pro_p = ratio_p * stan_p;
                pro_q = ratio_q * stan_q;
                pro_t = ratio_t * stan_t;
        else
              //set values for other new proposals from SP in due course of negotiation
                if( pre_p > stan_p)
                      pro_p = pre_p – delt_p;
                        pro_q = pre_q;
                        pro_t = pre_t;
                else
                        if (pre_t > stan_t)
                                pro_p = pre_p;
                                pro_q = pre_q;
                                pro_t = pre_t – delt_t;
                        else
                                if (pre_q < stan_q)
                                        pro_p = pre_p;
                                        pro_q = pre_q + delt_q;
                                        pro_t = pre_t;
                                end-if
                        end-if
                end-if
        end-if

end
```

Figure 4: Generation of New Proposal by SP

Algorithm: Generation of New Proposal by SR

```
standard proposal: stan_p (standard price), stan_q (standard quality), stan_t (standard time-period)
current proposal: pro_p (proposed price), pro_q (proposed quality), pro_t (proposed time-period)
previous proposal : pre_p (previous price), pre_q (previous quality), pre_t (previous time-period)
delt_p: a short price-value
delt_q: a short quality-value
delt_t: a short period of time
ratio_p: a small number used to decrease the standard price
ratio_q: a small number used to increase the standard quality
ratio_t: a small number used to decrease the standard time-period

begin
        if (first proposal)
              //set values for the first proposal from SR
                pro_p = ratio_p * stan_p;
                pro_q = ratio_q * stan_q;
                pro_t = ratio_t * stan_t;
        else
              //set values for other new proposals from SR in due course of negotiation
                if (pre_p < stan_p)
                        pro_p = pre_p + delt_p;
                        pro_q = pre_q;
                        pro_t = pre_t;
                else
                        if (pre_t < stan_t)
                                pro_p = pre_p;
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                        pro_q = pre_q;
                        pro_t = pre_t + delt_t;
                else
                        if (pre_q > stan_q)
                                pro_p = pre_p;
                                pro_q = pre_q - delt_q;
                                pro_t = pre_t;

                        end-if
                end-if
        end-if
    end-if
end
```

Figure 5: Generation of New Proposal by SR

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Algorithm: Checking Proposal
received proposal: rec_p (price in received proposal), rec_q (quality in received proposal), rec_t (time-period in received proposal)
utility_v: variable to store utility value

begin
    utility_v = calculate_utility(rec_p, rec_q, rec_t);
    // Detail procedure for calculate_utility() function is described in next sub-section.
    // The formulation for calculate_utility() is different for SP and SR

   if (utility_v >=1)
        received proposal is acceptable;
   else
        received proposal is not acceptable;
   end-if
end
```

Figure 6: Checking the proposal for acceptance

```
Algorithm: Checking Termination Condition for Negotiation Process
utility_v: utility value for the received proposal
standard proposal: stan_p (standard price), stan_q (standard quality), stan_t (standard time-period)
latest sent proposal: last_p (price in latest sent proposal), last_q (quality in latest sent proposal), last_t (time-period in latest sent proposal)

begin
    if( utility_v >= 1)
    // utility more than or equal to 1 implies that the received proposal is acceptable
     //so accept the proposal and terminate negotiation process with agreement

        terminate negotiation
    end-if

    if (last_p = stan_p AND last_q = stan_q AND last_t = stan_t)
    // negotiation-steps exceed the maximum threshold limit.
    // the number of steps in threshold limit is decided by the values of
    // delt_p, delt_q, delt_t, ratio_p, ratio_q, and ratio_t as defined
    // in the algorithm for generating new proposal.

        terminate negotiation
    end-if
end
```

Figure 7: Checking Termination Condition for Negotiation Process

3 Evaluation and Implementation

The work mainly presents a utility based negotiation approach for SWSs. The proposed approach can be evaluated by comparing it with existing similar works.
The proposed MAN mainly focuses on the presentation of communication model and utility model for negotiation process. The paper presents a utility based multi-attribute negotiation for SWSs. Many reported works are available on the utility based multi-attribute negotiation for multi-agent systems, but a little works are only available providing negotiation strategies between SWSs. Remainder of this section presents the evaluation of proposed work by comparing it with existing similar works.
[3] have presented the utility based multi-attribute negotiation for multi-agent systems. They have presented the concept of financial utility and ease utility in the negotiation process. But, their work does not consider the negotiation from the perspective of SWSs. Also, they have not used the concept of storing the successful agreements for future use. Similarly, the work by [4] has presented the multi-dimensional, multi-step, multi-attribute negotiation from multi-agent perspectives only. Their work also suffers from the same drawback as that of work by [3]. [5] in their work have presented a Secure Content Exchange Negotiation System (SCENS) for multi-agent systems which consists of the three layers: layer one for web-based negotiation support system, layer two providing negotiation web services to end user, and layer three providing open and automated negotiation environment. They have discussed only first two layers, but have not provided details on the negotiation and communication environment. Further, their presented utility function is just a simple weighted sum of values of various attributes, without considering other involved factors. The work presented in this paper tries to fulfill some of the shortcomings enumerated above. The work presents a utility based, multi-attribute negotiation model for negotiation between SWSs. The proposed work has presented a communication model for the negotiation between SR and SP using FIPA Communicative Acts [20]. The step-wise-step description of the negotiation process along with the algorithms for various activities has been presented. Further, the presented negotiation model proposes a feedback system by presenting a new data-structure, agreement table. It can expedite the negotiation process by reaching the agreement in lesser number of negotiation-steps. Hence, the presented negotiation approach for SWSs is more reliable, can provide more accurate decision-making, can fasten the process, and is more in line with the practical manual negotiation process.

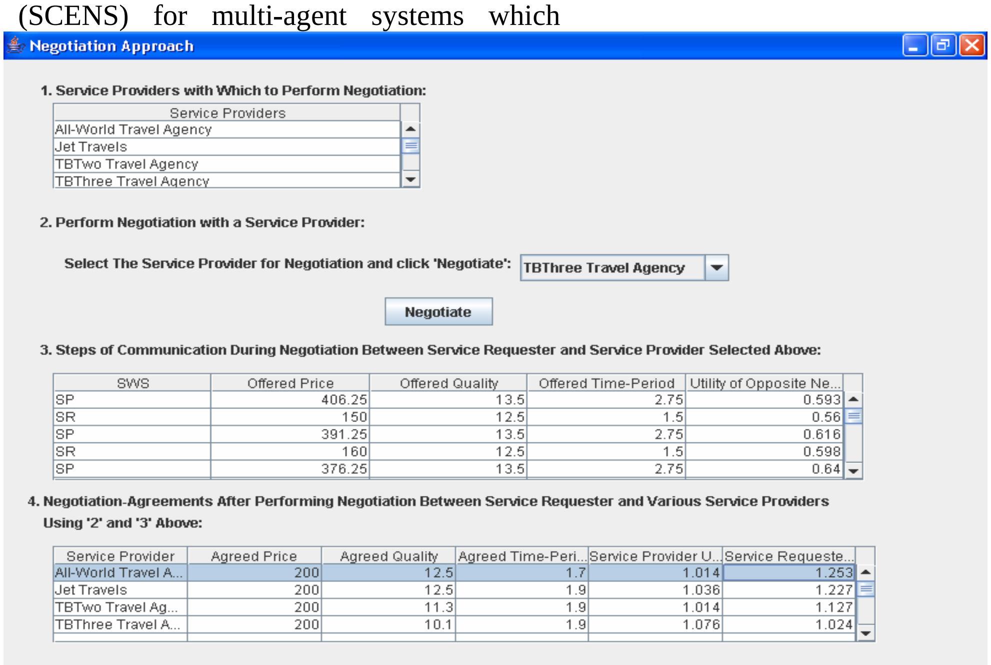

Figure 8: Negotiation-Agreements with various SPs

We have implemented a system for the problem of travel-booking providing negotiation between SWSs using proposed negotiation apporaoch. The problem involves the booking of a flight for organizing a trip between two cities. The process consists of firstly discovering the potentials SPs which can provide the services for booking the flight between the required stations, after that the negotiation process starts with the discovered SPs. The implemented system has used the proposed negotiation approach for the negotiation process. Figure 8 shows the result of negotiation with various SPs.

4. Conclusion

In this paper, mainly a utility based negotiation approach for negotiation between semantic web services has been presented. Along with the communication model and algorithms for various activities in negotiation process, the paper also proposes a negotiation feedback system. The feedback-system can expedite the negotiation process by decreasing the number of negotiation-steps in which agreement is reached. Based upon the proposed models, a prototype system providing negotiation between semantic web services has been implemented. The work has also been evaluated by comparing it against the existing similar works. Our future works involve enhancing further the proposed negotiation-approach.

References

[1] O'Hare, G. M. P., Jennings, N.R. (1996) *Foundations of Distributed Artificial Intelligence, Chapter Negotiation Principles*, John Wiley and Sons.

[2] Stamoulis, G.D., Kalopsikakis, D., Kyrikoglou, A., Courcoubetis, C. (1999) 'Efficient Agent-Based Negotiation For Telecommunications Services', *Proc. Of Global Telecommunications Conference (GLOBECOM '99)*, IEEE, Vol. 3, pp.1989-1996.

[3] Jonker, C.M., Robu, V., Treur, J. (2007) 'An Agent Architecture for Multi-Attribute Negotiation Using Incomplete Preference Information', *Journal of Autonomous Agent and Multi-Agent Systems*, Springer, Vol. 15, issue 2, pp. 221-252.

[4] Zhang, X., Lesser, V., Podorozhny, R. (2005) 'Multi-Dimensional, Multi-Step Negotiation for task Allocation in a Cooperative System', *Journal of Autonomous Agent and Multi-Agent Systems*, Springer, Vol. 10, No. 1, pp. 5-40.

[5] Makedon, F., Ye, S., Zhao, Y. (2003) 'On the Design and Implementation of a Web-based Negotiation System', *9th Panhellenic Conference in Informatics (PCI2003),* Thessaloniki, Greece.

[6] Huang, P., Sycara, K. (2002) 'A Computational Model For Online Agent Negotiation', *Proc. of the 35th Hawaii International Conference on System Sciences – 2002,* IEEE Computer Society, IEEE.

[7] Rebstock, M., Thun, P. (2003) 'Interactive Multi-Attribute Electronic Negotiations in the Supply Chain: Design Issues and an Application Prototype', *Proc. of the 36th Hawaii International Conference on System Sciences (HICSS'03)*, IEEE Computer Society, IEEE.

[8] Xiaolong, X., Yaowu, W., Qiping, S. (2006) 'Agent based Multi-attribute Negotiation for Large-Scale Construction Project Supply Chain Coordination', *Proc. of the 2006 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT 2006 Workshops)(WI-IATW'06)*, IEEE Computer Society, IEEE.

[9] Rebstock, M. (2001) 'Efficiency and Flexibility of Multi-Attribute Negotiations -The Role of Business Object Frameworks', *Proc. Of International Workshop on Database and Expert Systems Applications, 2001*, IEEE, pp. 742 – 746.

[10] Fei, Y., Chen, W. (2007) 'A Multi-agent, Multi-object and Multi-attribute Intelligent Negotiation Model', *Fourth International Conference on Fuzzy Systems and Knowledge Discovery (FSKD 2007)*.

[11] Lai, G., Li, C., Sycara, K. (2006) 'Efficient Multi-Attribute Negotiation with Incomplete Information', *Group Decision and Negotiation*, Springer, Vol. 15, pp. 511–528.

[12] Lai, G., Sycara, K. (2009) 'A Generic Framework for Automated Multi-attribute Negotiation', *Group Decision and Negotiation*, Springer, Vol. 18, pp. 169–187.

[13] Chen, J., Anane, R., Chao, K., Godwin, N. (2002) 'Architecture of an Agent-based Negotiation Mechanism', *Proc. Of the 22nd International Conf. on Distributed Computing Systems Workshops,* IEEE.

[14] Paurobally, S., Tamma, V., Wooldridge, M. (2005) 'Cooperation and Agreement between Semantic Web Services', *W3C Workshop on*

Frameworks for Semantics in Web Services, Innsbruck, Austria.

[15] Olmedilla, D., Lara, R., Polleres, A., Lausen, H. (2004) 'Trust Negotiation for Semantic Web Services', *In Proc. of the 1st Int'l Workshop on Semantic Web Services and Web Process Composition*, San Diego, CA, USA, pp. 81-95.

[16] Nejdl, W., Olmedilla, D., Winslett, M. (2004) 'PeerTrust: Automated Trust Negotiation for Peers on the Semantic Web', *In Proc. of the Workshop on Secure Data Management in a Connected World (SDM '04) in conjunction with 30th International Conference on Very Large Databases.*

[17] Kumar, S., Mastorakis, N. E., A Utility Model for Negotiation between Semantic Web Services, 8th WSEAS Int. Conf. on Telecommunications and Informatics (TELE-INFO'09), Turkey, 2009.

[18] Kumar, S., Mastorakis, N. E., Towards A Utility based Computational Model for Negotiation between Semantic Web Services, Submitted to WSEAS Transactions on Computers, 2009.

[19] Wilkes, J. (2008) 'Utility Functions, Prices, and Negotiation', Technical Report, HP Laboratories, HPL-2008-81, *www.hpl.hp.com/techreports/2008/HPL-2008-81.pdf*, 2008.

[20] FIPA TC C (2008) 'FIPA Communicative Act Library Specification', *http://www.fipa.org/specs/fipa00037/*, [Accessed Oct 10, 2008].