Decision-Making in Multi-agent Multi-issue Negotiation Using Analytic Hierarchy Process

Djamila Boukredera[1] and Kamal Hariche[2]

[1] Bejaia University, LMA Laboratory, Algeria,
boukredera@hotmail.com,
[2] Bejaia University, Commercial department, Algeria,
hariche_kamal@yahoo.fr

Abstract. In this paper, we propose to use the Analytic Hierarchy Process (AHP) to enhance consensus in bilateral multi-issue negotiation where one agent has no knowledge about the preferences of the other agents. This work focuses on mediated negotiation, where two agents try to reach an agreement over a range of qualitative and quantitative issues. We assume that the mediator agent adopts the AHP method to construct the ranking of the alternatives based on both agents' preferences defined beforehand. Based on a case study, we show how AHP, can be used as a qualitative and quantitative evaluation method to provide a simple and effective decision making leading to an efficient and timely conflict resolution.

Keywords: Multi-criteria decision making, AHP, Mediation, Negotiation

1 Introduction

Real-world negotiation problems are often complex, since they require evaluation and decision-making based on multiple issues of qualitative and quantitative nature, involving temporal constraints and dealing with decentralized relevant information. In such environments with incomplete information, mediated-negotiations have been proved to be faster and more efficient than non mediated ones [2][4][5]. The aim of any mediation scenario is to help the negotiators reach a mutually beneficial pareto-optimal agreement which is better to all agents than opting out the negotiations. In this study, we consider the bilateral mediated-negotiation over multiple issues and where each agent knows his own preferences with regards to the possible alternatives but no precise knowledge about the other agent's preferences. Moreover, there may be some conflicts between the preferences of both parties. To help the negotiators conclude the negotiation timely and efficiently, the mediator has to find the pareto-optimal solution based on both negotiators' preferences. Ranking alternatives is, hence, of a great importance and is a more complex process when dealing with qualitative and quantitative issues. In such cases, AHP is a famous method developed to optimize multi-criteria decision-making in distributed systems[1] [3]. Based on an objective mathematical analysis technique, AHP has been very effective in making complicated, often irreversible decisions. In this paper, we propose that the mediator agent adopts the AHP method to represent the agents' preferences, to rank alternatives based on them, and to select and propose the highly ranked alternative by both negotiators'preferences which he believes to be the fairest at a given stage of the negotiation.

2 The negotiation protocol

For the sake of simplicity, we assume that the issues and their possible values are predefined and, hence, do not require a preliminary negotiation. Each agent sends the mediator his preferences over the set of issues. The mediator applies AHP method twice to rank and sort the possible alternatives according to each agent preferences. The two sorted lists are then created and the mediator determines a joint sorted list which should contain all the pareto-optimal alternatives in regard to both agents'preferences. The mediator selects and proposes to both agents the highly ranked alternative from the joint list. Each agent can either accept or reject the offer. In the case of both sides accepting the offer, the negotiation ends with a success. However, in the case where one (or both) agent rejects the offer then the mediator checks the negotiation deadline; if the time limit for negotiation has not exceeded, he proposes the next alternative in the joint sorted list. This process may iterate until an acceptation from both sides is achieved or the deadline is over or the joint list is empty. In the two last cases, the negotiation ends with a failure.

3 Analytic Hierarchy Process

Developed by Saaty[1], AHP aims to help the decision-maker find the alternative that best satisfy their goals while taking into consideration issues that can be or cannot be quantified. It is a form of multi-criteria analysis that is used to resolve complex decisions that require structuring, measurements, and synthesis. This method involves a series of steps summarized as follows:

1. Define the main objective and specify the set of issues for selecting the alternatives.
2. Build the decision hierarchy and formulate pairwise comparison matrix that produce weighting scores to measure how much importance criteria and alternatives have with each other.
3. Use the Eigen value method to calculate relative priorities.
4. Check the matrix consistency in order to ensure the decision consistency.
5. Aggregate relative weights to obtain the overall ranking of the alternatives which represents the crux of the method.

4 The Mediator Decision-making

The goal of the mediator is to find an agreement that fits all parties. He has therefore to weight and prioritize all the possible alternatives with respect to both agents'preferences. To ensure this task in such environment, we propose the use of AHP method. Initially, the mediator sets up the problem by building the hierarchy structure of the decisions. He then applies AHP to rank and sort the possible alternatives with respect to each agent preferences. At the end of this step, the mediator obtains two different sorted lists of the alternatives. He carries out the removal of non pareto-optimal solutions and creates a joint sorted list based on the sum of ranks in each of the separated sorted lists[2]. The first alternative of this joint list is therefore proposed to both agents.

5 Case study

Let us consider a simple case study where two agents with different preferences have to choose the best laptops'supplier for their factory. Figure 1 shows the decision hierarchy of the case study whereas Figure2 (a) and Figure2 (b) summarize the relative weights of criteria according to agent1 and agent2 respectively. In this example, 17 alternatives

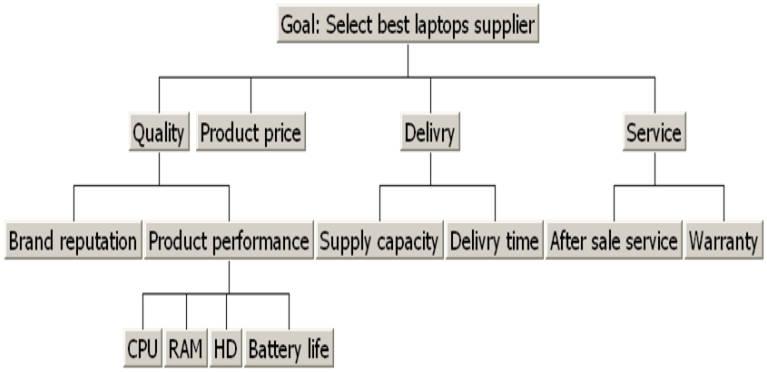
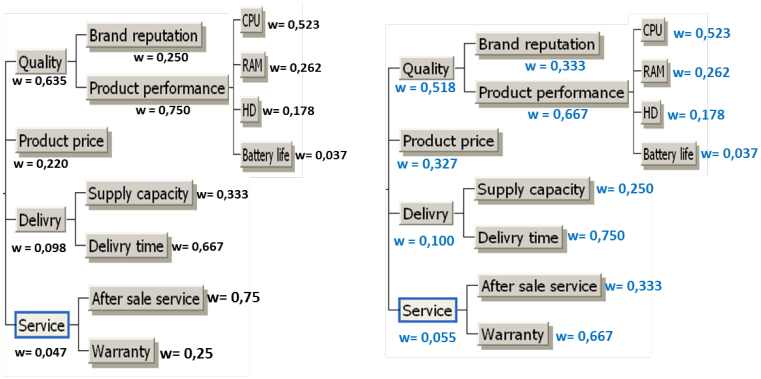


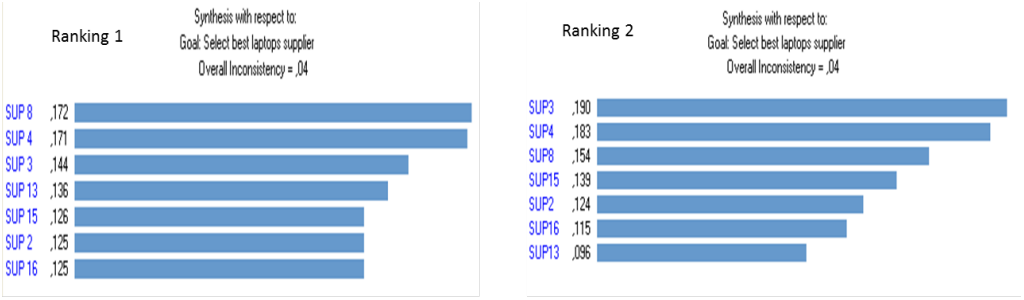
Fig. 1: Decision Hierarchy



(a) Relative weights of criteria for agent1 **(b) Relative weights of criteria for agent2**

Fig. 2: Relative weights of criteria according to Agent1 and agent2

have been ranked and sorted. After the removal of the irrelevant ones only 7 alternatives left as illustrated in Figure3 (a) and Figure3(b). Once the joint sorted list is created the alternative "Sup4" is proposed to both agents since it is the highly ranked one according to both agents.



(a) Alternatives' ranking according to agent1 preferences **(b) Alternatives' ranking according to agent2 preferences**

Fig. 3: Alternatives' Ranking according to Agent1 and Agent2

6 Conclusion

Ranking alternatives in qualitative and quantitative multi-issue negotiation under incomplete information represents one of the most critical challenges facing the designers of automated negotiations. To cope with this issue, we propose to integrate the AHP method in the decision-making process of the mediator agent. This method has yet been proved to be the most suitable one in such contexts. Several simulations have been conducted using the example given above and the obtained results show the at each time the mediator selects and proposes the best pareto-optimal solution which should fit to both agents. In doing so, the mediator effectively helps the negotiators to conclude the negotiation on time and generally with success.

References

1. Saaty, T. L., (1980), The Analytic Hierarchy Process, McGraw-Hill, New York. International, Translated to Russian, Portuguese, a nd Chinese, Revised editions, Paperback (1996, 2000), Pittsburgh: RWS Publications.
2. M. Chalamish and S. Kraus, (2012) AutoMed: an automated mediator for multi-issue bilateral negotiations, Autonomous Agents and Multi-Agent Systems May 2012, Volume 24, Issue 3, pp 536-564.
3. S. Koul, A. Saraswat and R. Verma, Evaluation and Ranking of Supplier at a Service Firm Using Analytic Hierarchy, Published in: Information and Communication Technologies (WICT), 2011 World Congress on Process.
4. E. de la Hoz, M. Klein and I. Marsa-Maestre, Hierarchical Clustering and Linguistic Mediation Rules forMultiagent Negotiation, Proceedings of the 11th International Conference on Autonomous Agents and Multiagent Systems (AAMAS 2012), Conitzer, Winikoff, Padgham, and van der Hoek (eds.), 4-8 June 2012, Valencia, Spain.
5. Y. Tanoto, M. Santoso, and E. Hosea, Demand Side Management of Household's Lighting Considering Energy Use and Customer Preference: a Preliminary Study, International Journal of Engineering and Technology (IJET), ISSN : 0975-4024, Vol 5 No 3 Jun-Jul 2013.