

# A Bayes Net Approach to Argumentation

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## Abstract

Argumentation-based negotiation approaches have been proposed to present realistic negotiation contexts. This paper presents a novel Bayesian network based argumentation and decision making framework that allows agents to utilize models of other agents. Our goal is to use Bayesian networks to capture the opponent model through an incremental learning process and use the model to generate more effective arguments to convince the opponent to accept favorable contracts.

## Introduction

Automated negotiation has drawn significant attention in multiagent systems research (Kraus, Sycara, & Evenchik 1998; Jennings *et al.* 2001). Agents are typically assumed to have correct and complete knowledge of preferences, and the negotiation context as well as agents' preferences are held constant during the course of negotiation. In real-life negotiation scenarios, however, individual preferences are not static. Agents might also have incorrect beliefs about the world or may not be cognizant about all pertinent attributes. In such situations, agents can influence each other by argumentation to influence their belief state.

Most existing argumentation based negotiation frameworks are logic or rule-based (Kraus, Sycara, & Evenchik 1998; Parsons, Sierra, & Jennings 1998; Rahwan, Sonenberg, & Dignum 2003). While these approaches provide a formal framework with provable properties, we believe there is a need for alternative frameworks that can better capture the uncertainty and complexity of real-life negotiations. In particular, the factors influencing an agent's decisions may be incompletely known and be gradually revealed to a negotiator. Accordingly, negotiation frameworks should incorporate approximate opponent models represented in a form that can capture complex relationships between domain attributes and can be efficiently updated based on information revealed during negotiation.

The specific research questions we are interested in include the following:

- When processing an offer or a counter-offer, what decision mechanisms should an agent use to decide whether to accept

a proposal, argue about its last proposal, or generate a new proposal?

- How are arguments for negotiation generated/selected?
- Should an agent try to persuade the other agent by reward, threat, etc.
- How does the agent's model of the opponent influence its argumentation and proposals?
- How and when does an agent update its belief about the other agent or about the negotiation issues based on received arguments and offers?

We propose to use a Bayesian network model (Jensen 1996) to represent the influences of different factors on agent decisions. An agent's knowledge of such causal factors and their relative importance is captured in the topology of the network as well as the prior and conditional probability assignments. Initial approximate knowledge of an agent is incrementally refined based on actual negotiation experiences. We focus on the decision mechanism that allows a modeling agent to use its knowledge represented as a Bayesian network to determine negotiation offers and select arguments to influence the opponent to accept offers that has been rejected. The goal is to use the Bayes net model of the opponent to select and manipulate the negotiation context to maximize the chance of a preferred offer being accepted by the other party.

## Architecture and Decision procedure

We present the decision architecture of the agents in Figure 1. We have proposed the use of Bayesian networks for representing the *Opponent's belief model*. We group the arguments into different categories such as *conflict-arg*, *emphasizing-arg*, *persuasive-arg* and *justification*. We will illustrate the different arguments using the scenario of a travel agent who is contacted by a buyer agent to purchase an airline ticket. *Conflict-arg* is an argument that is presented if there is a conflict in belief about some variable and the opponent rejects this agent's earlier proposal for the "wrong belief" about this variable. For example, the buyer agent rejects an offer by the travel agent citing the reason that the corresponding airline has a poor luggage handling reputation. The travel agent uses a *conflict-arg* to contradict this belief. *Emphasizing-arg* is an argument to emphasize particular attributes in the offer to influence the opponent to accept

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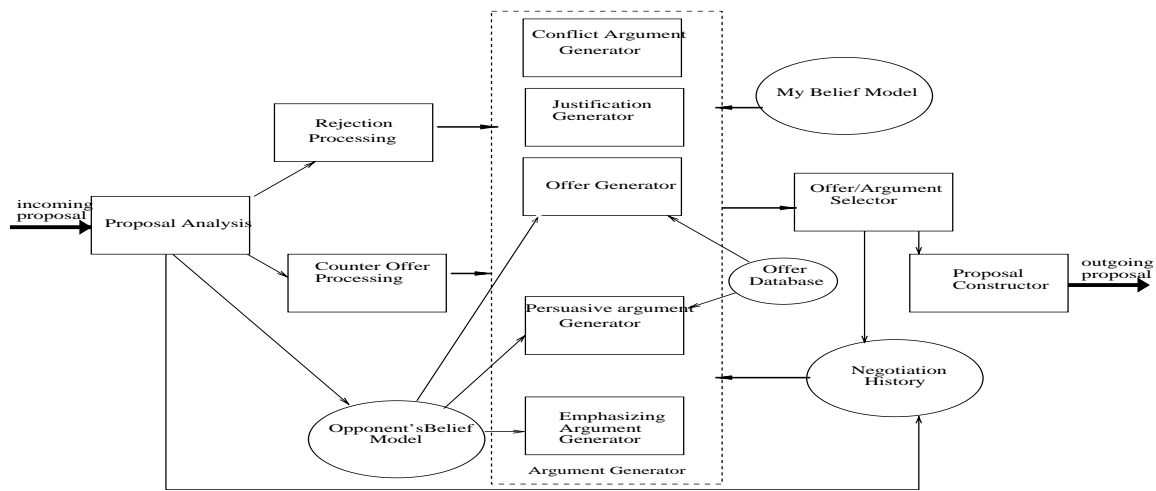


Figure 1: Decision Architecture of the arguing agent.

the previous offer. For example, suppose the buyer agent rejects an offer from the travel agent because of the extended waiting time in the transit. The travel agent can emphasize the 5-star accommodation provided during the wait. This attribute is not new to the offer but was not highlighted prior to this point in the negotiation process. A *justification* is used to reinforce the agent's previous offer by introducing auxiliary information about that offer. Suppose the buyer agent was rejecting the offer because of high price. The travel agent justifies the high price factor by citing the current peak travel season. *Persuasive-arg* is an argument that shows threat or reward to persuade the opponent to accept the offer. For example, the travel agent can offer a rebate of \$100 for the next purchase if the buyer accepts the current offer.

For brevity, our decision mechanism for the argument (or proposal) generation based on the architecture shown in Figure 1 is summarized in the following steps:

1. Receive proposal from the opponent.
2. Analyze whether it is a counter proposal or rejection or counter argument. Update own belief model and opponent's belief model.
3. In case the opponent shows a "wrong" belief to reject previous proposal, the agent generates *conflict-arg*. Though it does not repeat an argument if it is presented earlier.
4. If there it is possible to justify the reason for which the other agent has rejected the previous proposal then *justification* is generator to justify its stand.
5. Otherwise, the agent computes based on the opponent's belief model, the expected utilities of the following options: (a) generating *emphasizing-arg* which is to emphasize the other facilities in the previous offer which was not explicit in the set of issues, (b) different persuasive arguments (*persuasive-arg*) like *threat* or *reward*, (c) the best counter offer and the utility of the opponent's offer. Finally choose argument or offer that produces maximum expected utility.

We have outlined a framework using which an opponent model can be used to generate arguments that are likely to convince the opponent to accept proposed offers. The use of Bayes nets allow us to formally capture the complex interrelationships between domain issues and their influence on the opponent's decisions. Such models allow agents to efficiently arrive at profitable negotiated settlements. Such models can also be updated based on negotiation history and can serve as useful repositories for dealing with steady customers.

We have presented an asymmetric negotiation model, with a knowledgeable domain expert interacting with a user agent. We plan to extend this model for peer-to-peer level interaction scenarios where both the agents can trade arguments. In particular we are interested in applying such techniques in P2P environments for resource procurement and exchange.

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