Agent Dialogues and Argumentation

(Extended Abstract)

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ABSTRACT

Agents have different interests and desires. Agents also hold different beliefs and assumptions. To accomplish tasks jointly, agents need to better convey information between each other and facilitate fair negotiations. In this thesis, we investigate agent dialogue systems developed with the Assumption-Based Argumentation (ABA) framework. In our system, agents represent their beliefs and desires in ABA. Information is exchanged via ABA arguments through dialogues. Main contributions include (1) understanding the connection between dialogues and argumentation frameworks and (2) applying argumentation dialogues in various agent applications.

Categories and Subject Descriptors

H.4 [**Information Systems Applications**]: Miscellaneous

General Terms

Algorithms

Keywords

Argumentation, Collective Decision Making

1. INTRODUCTION

Complex multi-agent systems are composed of heterogeneous agents with different beliefs and desires. Agents usually perform tasks in a joint manner to promote higher common welfare. However, various issues exist in agent interaction. For instance, agents reason with different assumptions to fill gaps in their beliefs. Since some assumptions may be incorrect, agents may be misinformed and decide on incompatable actions that lead to conflicts. Moreover, even if agents share the same information, they may still reach different decisions as they have different desires. We study dialogue systems that better communicate information among agents. We construct a generic dialogue system that contributes to the elimination of misunderstanding between agents. The dialogue system also helps agents to communicate and fulfill their desires.

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We use Assumption-Based Argumentation (ABA) [2] to represent agent beliefs and desires. ABA is a general-purpose, widely applicable form of argumentation where arguments are built from *rules* and supported by *assumptions*, and attacks against arguments are directed at the assumptions supporting the arguments, and are provided by arguments for the *contraries* of their assumptions. With well defined arguments and attacks, argumentation semantics, such as admissibility, can be defined in ABA, where an argument is admissible if it does not attack itself and attacks all arguments attacking it.

In this setting, we study how agreement can be reached by using information from multiple ABA frameworks (which agents are equipped with). We study how information captured in ABA frameworks can be communicated through dialogues and analyse the relation between dialogue outcomes and argumentation semantics.

2. MOTIVATING EXAMPLE

Imagine a scenario such as the following. Two agents, Jenny (**J**) and Amy (**A**), are planning a film night together and want to agree on a movie to watch. The agreement is reached through a dialogue, as follows:

> **J:** Let's see if *Terminator* is a good movie to watch.
> **A:** OK.
> **J:** I would like to watch a movie that is fun and has a good screening time.
> **A:** OK.
> **J:** To me, a movie is fun if it is an action movie.
> **A:** OK.
> **J:** And, *Terminator* is an action movie.
> **A:** OK.
> **J:** I also believe *Terminator* starts at the right time.
> **A:** Are you sure it is not going to be too late?
> **J:** Why?
> **A:** I don't know. I am just afraid so.
> **J:** It won't be too late if it finishes by 10 o'clock.
> **A:** I see. Indeed, *Terminator* finishes by 10 o'clock.
> **J:** OK.
> **A:** OK.

In this example, Jenny succeeds in persuading Amy to watch the movie she proposes. Amy had the opportunity to disagree and challenge Jenny, but Jenny managed to produce a compelling argument. In our framework, Jenny's argument for watchMovie($Terminator$) can be seen in Figure 1; and

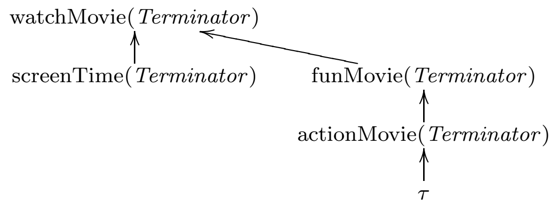

Figure 1: Jenny's argument about watching ***Terminator*****.**

$\langle J, A, 0, clm(\text{watchMovie}(t)), 1\rangle$
$\langle A, J, 0, \pi, 2\rangle$
$\langle J, A, 1, rl(\text{watchMovie}(t) \leftarrow \text{fun}(t), \text{screenTime}(t)), 3\rangle$
$\langle A, J, 0, \pi, 4\rangle$
$\langle J, A, 3, rl(\text{fun}(t) \leftarrow \text{actionMovie}(t)), 5\rangle$
$\langle A, J, 0, \pi, 6\rangle$
$\langle J, A, 5, rl(\text{actionMovie}(t)), 7\rangle$
$\langle A, J, 0, \pi, 8\rangle$
$\langle J, A, 3, asm(\text{screenTime}(t)), 9\rangle$
$\langle A, J, 9, ctr(\text{screenTime}(t), \text{late}(t)), 10\rangle$
$\langle J, A, 0, \pi, 11\rangle$
$\langle A, J, 10, asm(\text{late}(t)), 12\rangle$
$\langle J, A, 12, ctr(\text{late}(t), \text{finishbyTen}(t)), 13\rangle$
$\langle A, J, 13, rl(\text{finishbyTen}(t)), 14\rangle$
$\langle J, A, 0, \pi, 15\rangle$
$\langle A, J, 0, \pi, 16\rangle$

Table 1: Example Dialogue between Two Agents.

the dialogue is represented in Table 1[1].

3. METHODOLOGY

To realize the argumentation dialogue presented in our example, we develop a novel formal modelling of dialogues using ABA. In our dialogue model, agents can utter claims (to be debated), rules, assumptions and contraries. Thus, dialogues "build" shared ABA frameworks between the agents. Various forms of reasoning can then be performed over the ABA frameworks drawn from dialogues.

As illustrated in Table 1, a dialogue, $D^{a_1}_{a_2}(s)$, between two agents a_1 and a_2 for a claim s is a finite sequence of utterances of the form $\langle\ a_i,\ a_j,\ InReply,\ C,\ ID\ \rangle$, $i, j = 1, 2$, $i \neq j$, in which a_i is the agent making the utterance and a_j is the agent receiving the utterance, $InReply$ is the ID of the *target* utterance, C is the content and ID is the identifier[2]. In $D^{a_i}_{a_j}(s)$, a_i is the agent that makes the first utterance. In an utterance, the content is one of the following: (1) the claim, $clm(\_)$[3], (2) a rule, $rl(\_)$, (3) an assumption, $asm(\_)$ (4) a contrary $ctr(\_)$, and (5) a special symbol π that represents *pass*. For two utterances u_i and u_j, if the ID in u_i is the $InReply$ in u_j, then u_j is related to u_i such that one of the two cases holds (1) the content of u_i, C_i, is the parent of the content of u_j, C_j, in an argument; or (2) C_i is an assumption and C_j introduces a contrary of C_i. A dialogue completes by both agents uttering π consecutively.

The dialogue model is given in terms of (various kinds of) legal-move functions and outcome functions. Legal-move functions determine what utterances agents can make during a dialogue, whereas outcome functions determine whether a dialogue has been successful. These functions are defined in terms of *dialectical trees* underlying the dialogues (and implicitly constructed during them).

To prove soundness of our approach, we connect our dialogue model with the admissibility semantics for ABA. In particular, we prove that by constructing a joint ABA framework through a dialogue, the claim of a successful dialogue is supported by a set of admissible arguments within the joint ABA framework. Furthermore, this set of arguments is identified during the dialogue. This result relies upon a correspondence between dialectical trees and the concrete dispute trees introduced in [1].

The ABA framework drawn from the example dialogue is:

> **Rules:**
> watchMovie(X) $\leftarrow$ funMovie(X), screenTime(X)
> funMovie(X) $\leftarrow$ actionMovie(X)
> actionMovie(*Terminator*)
> finishbyTen(*Terminator*)
> **Assumptions:**
> screenTime(X)
> late(X)
> **Contraries:**
> $\mathcal{C}$(screenTime(X)) = late(X)
> $\mathcal{C}$(late(X)) = finishbyTen(X)

It can be seen that watchMovie($Terminator$) is supported by an argument in an admissible set with respect to the above ABA framework. This corresponds to Jenny having persuaded Amy, in that no objections have been raised that could not be addressed, and Jenny's view point is non-contradictory. Hence we conclude that the dialogue presented in Table 1 is *successful.*

Our dialogue model is generic in that it does not focus on any particular dialogue type, e.g. information seeking, persuasion or negotiation. In the example, we demonstrate persuasion as an application of our model. In [3] we demonstrate conflict resolution as another application.

4. CONCLUSION

In this thesis, we investigate argumentation dialogues. The main contribution of this thesis are (1) a generic formal model for ABA-based dialogues; (2) an investigation of dialogue and argumentation semantics; and (3) dialogue applications such as conflict resolution and persuasion.

Future work includes investigation of some other argumentation semantics, such as the ideal semantics, and further investigation on properties of various dialogue types, including information seeking and negotiation.

5. REFERENCES

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[1] t stands for Terminator.

[2] In Table 1, a_1 is J and a_2 is A.

[3] _ stands for an an anonymous variable as in Prolog.