Liberalizing Protocols for Argumentation in Multi-agent Systems*

Gerard A.W. Vreeswijk
Dept. of Computer Science
Utrecht University, The Netherlands
gv@cs.uu.nl

ABSTRACT

This publication summarizes research on the the design and implementation of liberalized version of existing truth-finding protocols for argumentation, such as the standard two-agent immediate-response protocol for computing the credulous acceptance of conclusions in an argument system. In the new setup agents decide autonomously which issues need to be discussed, when to query other agents, when to keep on querying other agents, and when to settle for an answer. In this way, inter-agent disputes are regulated by the agents themselves, rather than that they follow an outlined protocol. The paper concludes with a prototype implementation and with a comparison of related work on conversation analysis and computational dialectic.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence—*Multi-agent systems*; I.2.3 [**Artificial Intelligence**]: Deduction and Theorem Proving—*Nonmonotonic reasoning and belief revision*

General Terms

Algorithms, Design, Experimentation

Keywords

Argumentation, Multi-agent dialogue, Scheduling, Communication

1. INTRODUCTION

Many MAS models require that agents are able to argue, for example to support their position in a negotiation or to explain a possibly controversial decision.

A great deal of research on defeasible reasoning and formal argumentation has been done in the past few years, and also a great deal of research on inter-agent inquiry dialogue has been accomplished. However, most research on argumentation in AI is devoted to single-agent algorithms and two-party dialogue systems that are sound and complete with respect to a particular argument semantics such as, e.g., the grounded extension semantics, or the preferred extension semantics [2, 10]. Research on inter-agent inquiry, on the other hand, is concerned with studying sequences of conversation at the speech act level that are useful, orderly, effective [3, 8] and sufficiently controllable by the agents that use them [1].

The purpose of the model proposed is to give the minimal means with which agents can engage in a dispute that is brought about by the agents themselves (agent-dialogue perspective) rather than that the agents follow a fixed and external protocol (defeasible argumentation perspective). The resulting system is suitable for parametrization, experimentation and analysis.

2. GLOBAL SETUP

The global setup consists of a set $\mathcal{A} = \{A_1, \ldots, A_n\}$ of agents ($n \geq 2$) and a public communication medium, T, called *the table*. T can be seen as a blackboard, or as "open air," by means of which agents are able to exchange messages in public. More specifically, T is a passive object with two essential methods, viz.

```
put(m: message)
get(t1: time, t2: time): setofMessages
```

By way of the second method agents can retrieve all messages that were uttered between time points t_1 and t_2.

Experiments are performed in runs. A run is a complete session in which agents are initialized by the programmer, and then exchange messages autonomously until no agent activity is observed within some fixed time period. At the start of each run each agent receives a number of propositions from the programmer to fill its belief base with. The initial goal base of each agent cannot be programmed and consists of one action, viz. `listen`.

An agent $A = (B, P, G)$ is a daemon that possesses a declarative belief base, B, a procedural belief base P, and a goal base, or agenda, G.

3. IMPLEMENTATION

To allow experiments with different set-ups, and to see whether the generated dialogues make any sense, we have implemented the model in the oo-scripting language Ruby.

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The purpose of the implementation is to experiment with different inputs and with different parameter settings. The reader is invited to consult the documentation or download the prototype or experiment with it online at the author's web site.

4. RESULTS

During our experiments, we noticed that all discussions terminate. This can be understood as follows. As a finite number of queries may be linked to a finite number of answers. Moreover, agents keep an account of which queries they have answered, so that eventually termination is ensured. We also observed that agents will reach a conclusion on accessible facts within a reasonable amount of turns.

Properties such as termination and response are proven formally in [6]. Intuitive results reported there indeed correspond with our model albeit our judgement is based on observation rather than on model analysis. Other results do not correspond to our model, for example that credulous agents can be convinced of everything, even of propositions contrary to their beliefs (Prop. 6.8, p. 367).

Even though discussions terminate, we noticed that traces of runs are extremely long, even for trivial input. This observation points to two further research problems.

1. The problem to maintain overview on the activity in a MAS.
2. Estimating the number of actions in a MAS based on the size of the input.

Investigation of these problems fall beyond the scope of this paper, but is further discussed in Section 6.

5. RELATED WORK

The term of liberal dispute was earlier coined by Prakken in an article on relating protocols for dynamic dispute with logics for defeasible argumentation [7].

Although it is arguably one of the simpler types of dialogue, inquiry has received less attention than negotiation or persuasion. An exception is the work by McBurney and Parsons [4] on scientific investigation. Our purpose is very similar to theirs.

The European SOCS project proposed a model of agency for global computing called the KGP model (knowledge, goals and plans) [9]. This model is particularly interesting because a number of researchers that worked on this model have a strong background in argumentation.

6. FUTURE WORK

A problem with our experiments is that it is difficult to monitor all the action. At present all activities are written to a linear log but this solution is unsatisfactory from multiple viewpoints, even for small input. Although there exist tools to monitor agent communication (e.g., JADE's message sniffers [5]), a larger problem is to monitor all preprocessing prior to message emission and all processing of messages once they are received. Currently, we have colored the output to create a global distinction. Each agent possesses its own color. Dark colored log entries relate to internal processing, while light colored log entries relate to agent activiteit that are more related to communication. Currently there are four such color categories.

7. CONCLUSION

In this paper we proposed a liberalized version of existing argumentation protocols. Within the resulting setup agents can construct arguments autonomously by participating in an inquiry dialog, thus bringing ideas of computational dialectic to bear in multi-party inquiry. It is the connection between the two disciplines that counts here. Obviously more work has to be done to consolidate and utilize this connection.

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