Hot Topics

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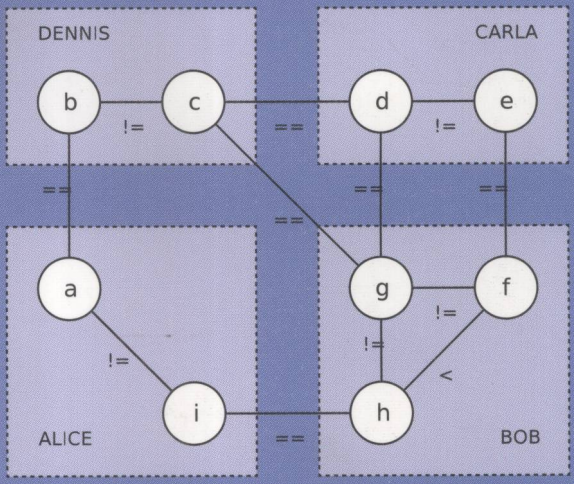
Nicolas Maudet
Simon Parsons
Iyad Rahwan (Eds.)

Argumentation in Multi-Agent Systems

Third International Workshop, ArgMAS 2006
Hakodate, Japan, May 2006
Revised Selected and Invited Papers



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Lecture Notes in Artificial Intelligence 4766

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Preface

This volume presents the recent developments of the growing area of research taking place at the interface of argumentation theory and multiagent systems. Argumentation can be abstractly defined as the interaction of different arguments for and against some conclusion. Over the last few years, argumentation has been gaining increasing importance in multiagent systems, mainly as a vehicle for facilitating "rational interaction" (i.e., interaction which involves the giving and receiving of reasons). This is because argumentation provides tools for designing, implementing and analyzing sophisticated forms of interaction among rational agents. Argumentation has made solid contributions to the practice of multiagent dialogues. Application domains include: legal disputes, business negotiation, labor disputes, team formation, scientific inquiry, deliberative democracy, ontology reconciliation, risk analysis, scheduling, and logistics. A single agent may also use argumentation techniques to perform its individual reasoning because it needs to make decisions under complex preferences policies, in a highly dynamic environment.

Following the success of its two first editions, the International Workshop on Argumentation in Multiagent Systems (ArgMAS 2006) took place for the third time in May 2006 in Hakodate, Japan, as a satellite workshop of the Autonomous Agents and Multiagent Systems conference. The workshop series is concerned with the use of the concepts, theories, methodologies, and computational models of argumentation in building autonomous agents and multiagent systems. In particular, the workshop aims at bridging the gap between the vast amount of work on argumentation theory and the practical needs of multiagent systems research. While the revised contributions of ArgMAS 2006 indeed constitute the backbone of this volume, it also includes revised versions of papers presented in recent conferences: Autonomous Agents and Multiagent Systems (AAMAS 2006), and the European Conference on Artificial Intelligence (ECAI 2006). These additional contributions were selected on the basis of their scientific quality and relevance to the topics emphasized here. Our objective has been to offer a comprehensive and up-to-date overview of this rapidly evolving landscape, as we did in the previous volumes of this series (LNAI 3366, LNAI 4049).

This book opens with a brief survey paper ("Argumentation in Multiagent Systems: Context and Recent Developments") by the editors, which aims at presenting the broad framework of the volume. Light is shed more specifically on a couple of "hot topics."

The rest of the book is then divided into two parts. The first one is dedicated to the exploration of the fundamentals and possible (and desirable in agent systems) extensions of argumentation-based reasoning ("Foundations and Explorations"). For instance, most argumentation frameworks do not really cater

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for the dynamic aspects of multiagent systems since they assume fixed knowledge bases to start with. Two papers of this volume specifically address this issue. Fukumoto and Sawamura investigate how argumentation may result in a modification of agents' beliefs. They tackle this problem by introducing a new learning method based on argumentation, developed in line with the logic programming paradigm, but necessitating different extensions. In the context of argumentation-based joint deliberation, Ontañón and Plaza study how learning agents can make use of past examples to generate arguments and counter-arguments as to what course of action should be taken in a given situation. Using a specific bilateral protocol, they show that the overall performance of the system is improved because joint predictions resulting from this process are typically more accurate than individual agent prediction. One other well-known limitation of Dung's original abstract framework is that it does not allow for coalitions of arguments to attack other arguments. Nielsen and Parsons explore which semantics can be defined when such a possibility is taken into account. While all the aforementioned papers are concerned with epistemic reasoning, Rahwan and Amgoud present an approach that puts together the different pieces of an argumentation-based agent. Indeed, different argumentation frameworks can be integrated to manage not only beliefs, but also desires and plans intended to achieve these desires. This capacity to reason on the basis of different attitudes is a crucial component of autonomous deliberative agents, as witnessed and argued by BDI-like agenthood theories. Finally, Harvey, Chang and Ghose show how argumentation can be used to enhance some aspects of distributed constraint satisfaction algorithms. Agents (variables) argue about partial assignments (of variables), by exhibiting counter-examples and making counter-proposals. The technique proposed in this paper makes it possible to resolve the problem of cycles without relying on a total ordering of the agents. In the last paper of this part of the volume, Karunatillake and colleagues present an empirical study of the use of argumentation-based negotiation as a means to manage conflict involving "social influences" in societies of agents. This kind of conflict will typically occur in environments where not all roles and relationships (and obligations attached to them) can be assumed to be known in advance. They show that, in this context of study, argumentation-based interaction is an improvement both in terms of efficiency and effectiveness over non-argumentative approaches.

The second part of the book is dedicated to a more specific but highly challenging question (as witnessed by the number of contributions related to that topic during the workshop): how should agents select arguments when engaged in complex interactions ("Strategic Issues")? Amgoud and Hamerlain regard the strategy problem as a two-step decision process: first select the prefered speech act, then select the best content to instantiate this speech act. What is shown in this paper is that these two steps involve different types of beliefs and goals. As a consequence, the formal framework for defining strategies is composed of two different systems, both grounded on argumentation theory. One especially important parameter of the resulting decision problems is provided by agents' generic profiles (e.g., cautious or adventurous), that is, attitudes regarding argument-

based comparison of candidate decisions. Mbarki, Bentahar, and Moulin make a slightly different distinction: they distinguish (dynamic) strategies (which involves global planning of an agent communication, in terms of sub-goals to be achieved), and tactics (which amounts to selecting the best argument with respect to the selected strategy). Each tactic is attached to a sub-goal selected at the strategy level. This articulation, often overlooked by other approaches, is at the core of the formal framework they propose. Oren, Norman, and Preece investigate two specific heuristics for dialogue move selection: one simply consists in revealing as little information as necessary in a given context; the second one involves a more sophisticated computation to assess the utility cost induced by revealing a given piece of information. Such heuristics make sense in particular in domains where privacy concerns are important, hence the need to understand more precisely how they can affect dialogue outcomes. Another interesting specific negotiation strategy is explored by Ramchurn et al. in the context of repeated interactions (that is, when agents typically interact more than once). Here, arguments are seen as promises of rewards in future interactions. Their strategy, which is based on a reward generation algorithm, achieves better outcomes than standard negotiation algorithms. On a slightly different tone, in the last paper of this book, Pasquier and colleagues develop an approach which accounts for the generative aspects of argumentative communication. Departing from the mainstream dialectical line of research, they ground their proposal on the notion of cognitive coherence, a theory coming from behavioral cognitive science.

We conclude this preface by extending our gratitude to the members of the Steering Committee, members of the Program Committee, and the auxiliary reviewers, who together helped make the ArgMAS workshop a success. We also thank the authors for their enthusiasm in submitting papers to the workshop, and for revising their papers on time for inclusion in this book.

May 2007

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Argumentation in Multi-Agent Systems: Context and Recent Developments

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Abstract. This chapter provides a brief survey of argumentation in multi-agent systems. It is not only brief, but rather idiosyncratic, and focuses on the areas of research that most interest the authors, and those which seem to be the most active at the time of writing.

1 Introduction

The theory of argumentation [81] is a rich, interdisciplinary area of research lying across philosophy, communication studies, linguistics, and psychology. Its techniques and results have found a wide range of applications in both theoretical and practical branches of artificial intelligence and computer science [14,74]. These applications range from specifying semantics for logic programs [20], to natural language text generation [21], to supporting legal reasoning [9], to decision-support for multi-party human decision-making [31] and conflict resolution [80].

In recent years, argumentation theory has been gaining increasing interest in the multi-agent systems (MAS) research community. On one hand, argumentation-based techniques can be used to specify *autonomous agent reasoning*, such as belief revision and decision-making under uncertainty and non-standard preference policies. On the other hand, argumentation can also be used as a vehicle for facilitating *multi-agent interaction*, because argumentation naturally provides tools for designing, implementing and analysing sophisticated forms of interaction among rational agents. Argumentation has made solid contributions to the theory and practice of multi-agent dialogues.

In this short survey, we review the most significant and recent advances in the field, with no intention of being exhaustive. Thus, we ignore recent work that extends the basic mechanisms of argumentation with new semantics [12], bipolar arguments [13], and the ability to handle sets of arguments [49]. Indeed, we have

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very little to say about *how to argue* and, instead, deal with *what one can argue about*, dealing with the uses of argumentation rather than the mechanisms by which it may be carried out[1], and restricting even that view to coincide with the topics of the other papers in this volume. In particular, this chapter first recalls some of the key notions in argumentation theory, and then outlines work on two major applications of argumentation in multi-agent systems, namely in the reasoning carried out by autonomous agents (Section 3) and in multi-agent communication (Section 4).

2 What Is Argumentation Good for?

According to a recent authoritative reference on argumentation theory, argumentation can be defined as follows:

> *Argumentation is a verbal and social activity of reason aimed at increasing (or decreasing) the acceptability of a controversial standpoint for the listener or reader, by putting forward a constellation of propositions intended to justify (or refute) the standpoint before a rational judge.* [81, page 5]

Let us decompose the elements of this definition that are most relevant to our discussion. First, the ultimate goal of argumentation is to resolve a "*controversial*" standpoint; controversial in the sense that it is subject to both "*justification*" or "*refutation*" depending on the information available. This distinguishes argumentation from the classical deductive reasoning viewpoint, in which proofs for propositions cannot be contested. Moreover, the nature of the "*standpoint*" can vary. While the classical study of argumentation has focused mainly on propositional standpoints — i.e. things that are believed or known — there is no reason why the standpoint is confined to be propositional. A standpoint can, in principle, range from a proposition to believe, to a goal to try to achieve, to a value to try to promote. That is, argumentation can be used for theoretical reasoning (about what to believe) as well as practical reasoning (about what to do).

Secondly, argumentation is an "*activity of reason*", emphasising that a particular process is to be followed in order to influence the acceptability of the controversial standpoint. This activity and the propositions put forward are to be evaluated by a "*rational judge*": a system that defines the reasonableness of these propositions according to some criteria. An important objective of argumentation theory is to identify such system of criteria.

In summary, argumentation can be seen as the principled interaction of different, potentially conflicting arguments, for the sake of arriving at a consistent conclusion. Perhaps the most crucial aspect of argumentation is the interaction between arguments. Argumentation can give us means for allowing an agent to

[1] Not least because one can potentially make use of any mechanism for argumentation in the service of any of the applications of argumentation.

reconcile conflicting information within itself, for reconciling its informational state with new perceptions from the environment, and for reconciling conflicting information between multiple agents through communication. It is for these reasons that argumentation has begun to receive great interest in the multi-agent systems community. In particular, argumentation lends itself naturally to two main sorts of problems encountered in MAS:

- **Forming and revising beliefs and decisions:** Argumentation provides means for forming beliefs and decisions on the basis of incomplete, conflicting or uncertain information. This is because argumentation provides a systematic means for resolving conflicts among different arguments and arriving at consistent, well-supported standpoints;
- **Rational interaction:** Argumentation provides means for structuring dialogue between participants that have potentially conflicting viewpoints. In particular, argumentation provides a framework for ensuring that interaction respects certain principles (e.g. consistency of each participant's statements).

In the next sections, we will discuss these applications in more detail and refer to some relevant literature. In particular, Section 3 deals with the topics of revising beliefs and making decisions, aspects that we can think of as being the concern of individual autonomous agents, while Section 4 deals with topics related to inter-agent communication and rational action, all aspects of argumentation that are decidedly multi-agent.

3 Argumentation for Reasoning in Autonomous Agents

Argumentation is a general process for reasoning. An autonomous agent that has to reason about could weigh arguments for and against different options in order to arrive at a well-supported stance. In this section, we discuss two main applications of argumentation to autonomous agent reasoning.

3.1 Argumentation for Belief Revision

One of the main challenges in specifying autonomous agents is the maintenance and updating of its beliefs in a dynamic environment. An agent may receive perceptual information that is inconsistent with its view of the world, in which case the agent needs to update its beliefs in order to maintain consistency. The major challenge of nonmonotonic reasoning formalisms [11] is to specify efficient ways to update beliefs. At the normative level, the AGM paradigm [29] specifies the rationality postulates that must be satisfied by an idealistic process of belief revision. On the operational level, formalisms for mechanising nonmonotonic reasoning include truth maintenance systems (TMS) [19], default logic [75] and circumscription [48].

Argumentation provides an alternative way to mechanise nonmonotonic reasoning. Argument-based frameworks view the problem of nonmonotonic reasoning as a process in which arguments for and against certain conclusions

are constructed and compared. Nonmonotonicity arises from the fact that new premises may enable the construction of new arguments to support new beliefs, or stronger counterarguments against existing beliefs. As the number of premises grows, the set of arguments that can be constructed from those premises grows monotonically. However, because new arguments may overturn existing beliefs, the set of beliefs is nonmonotonic. Various argument-based frameworks for nonmonotonic reasoning have been proposed in the last 20 or so years. Some of the most notable are the following [42,60,79,41,22,27,67][2].

While the above-mentioned frameworks have developed into a solid and mature sub-field of AI, their incorporation into *situated* autonomous agent reasoning remains an opportunity to be pursued. In order to do so, an adequate representation of the environment is needed, and a mechanism for integrating perceptual information into the belief-update mechanism is also required. Moreover, situated agents are required to update their beliefs in a timely fashion in order to take appropriate action accordingly.

3.2 Argumentation for Deliberation and Means-Ends Reasoning

An autonomous agent does not only maintain a mental picture of its environment. The agent is faced with two additional tasks: the task of *deliberation* in which it decides what state of the world it wishes to achieve — namely its goal — and the task of *means-ends reasoning* in which it forms a plan to achieve this goal. Argumentation is also potentially useful for tackling both these challenges.

Recently, argumentation has been applied to deliberation. For example, argumentation has been used as a means for choosing among a set of conflicting desires [1] and as a means for choosing between goals [3]. Another argument-based framework for deliberation has been presented by Kakas and Moraitis [39]. In this approach, arguments and preferences among them are used in order to generate goals based on a changing context. In addition, argumentation can be used to support standard BDI [73] models, as in [56].

More generally, as shown by Fox in his work since [26][3], argumentation provides a framework for making decisions. Just as one makes arguments and counter-arguments for beliefs, one can make arguments and counter-arguments for actions. While such a framework sounds as though it must be at odds with approaches based on decision theory [34], Fox and Parsons [28] provide an argumentation framework that reconciles the two approaches. In this system, argumentation is used to reason about the expected value of possible actions. In particular, one argument system is used to arrive at a stance on beliefs, while another argument system identifies the *outcomes* of possible actions. Together, arguments over beliefs and the results of actions can be combined to create arguments about the *expected value* of possible actions. This approach was later refined in [53].

[2] For comprehensive surveys on argument-based approaches to nonmonotonic reasoning, see [14,68].

[3] Though this line of work, summarised in [52], did not explicitly use the term "argumentation" until [27], with hindsight it is clear that argumentation is exactly what Fox and his colleagues were using.

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