Argumentation Schemes and Enthymemes in Multi-agent Systems

(Doctoral Consortium)

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ABSTRACT

Communication is one of the most important aspects of multi-agent systems. Recently, argumentation-based approaches have stood out among other communication techniques in multi-agent systems, receiving special interest from the community, given that such approaches provide an expressive form of communication allowing agents to justify their positions. However, the use of argumentation techniques can be limiting, given that the additional information exchanged by agents can overburden the communication infrastructure. Concerned about this issue, we have been working on an argumentation framework whereby agents are able to exchange fewer and shorter messages when engaging in dialogues. This is done by omitting information that is known to be common knowledge (e.g., information about a shared multi-agent organisation). In our framework, agents exchange *enthymemes* instead of the intended arguments, the enthymemes make reference to shared argumentation schemes (i.e., reasoning patterns from which the intended arguments were instantiated), and common organisational knowledge is used to guide argument reconstruction.

1. INTRODUCTION

Communication is essential in Multi-Agent Systems (MAS). Recently, argumentation-based approaches started to play an important role in MAS, showing promise as an approach to agent communication. In most approaches, agents use reasoning patterns to instantiate arguments, in order to: (i) reason about their mental attitude, e.g., goals, beliefs, etc.; and (ii) communicate with other agents using arguments. Different MAS could need different reasoning patterns for argumentation, which are commonly studied as Argumentation Schemes (AS). For example, there are AS that are specific for analysing the provenance of information [12], AS for reasoning about trust [10], AS for arguing about transplantation of human organs [11], and so forth. In this work, we propose an architecture where AS are specified on top of a MAS specification, and they are shared by all agents.

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The proposed architecture allows us to explore the use of enthymemes in multi-agent communication without losing the intended meaning of the messages (i.e., guaranteeing the mutual understanding of the messages exchanged by agents). *Enthymemes* are arguments in which one or more statements (that are part of the argument) are not explicitly stated [13]. They are realistic arguments, in the sense that real-world arguments (i.e., arguments used by humans) usually do not have enough explicitly presented premises for the entailment of the claim [1]. In MAS, when an agent receives an enthymeme, it can deduce the intended argument by looking for the missing parts, assumptions, etc., thus (possibly) recovering its intended meaning [3]. However, using enthymemes in MAS could bring some risk to agent communication, given that the "recontruction" of an argument from an enthymeme involves an agent interpreting what the arguer presumably meant to say [13]. Therefore, there is the possibility that an agent might misunderstand arguments from other agents.

Overall, using enthymemes could be beneficial for agent communication by: (i) allowing agents to exchange only the essential information needed for a particular purpose; and (ii) characterising more rational agents regarding communication. In this work, we propose the use of AS [13] to guide the construction of enthymemes by the utterer of arguments, as well as to guide the reconstruction of the intended arguments by the recipients of such enthymemes. Thus, agents are able to exchange only the content that is needed for them to understand each other in argumentation-based communication, in such a way that it can be ensured that the arguments will not lose content nor the intended meaning.

2. ARGUMENTATION SCHEMES IN MULTI-AGENT SYSTEMS

In our framework, AS are shared by agents through the organisational specification or semantic databases [2]. That is, besides their private knowledge, agents share organisational information and the AS available in that particular MAS, to which we refer here as $\Delta_{\texttt{Org}}$ and $\Delta_{\texttt{AS}}$, respectively. All knowledge available to an agent $\texttt{ag}_i$ is denoted by $\Delta_{\texttt{ag}_i}$.

Definition 1 (Argumentation Scheme). *An argumentation scheme is a tuple $\langle \mathcal{SN}, \mathcal{C}, \mathcal{P}, \mathcal{CQ} \rangle$ with $\mathcal{SN}$ the argumentation scheme name (which must be unique within the system), $\mathcal{C}$ the conclusion of the argumentation scheme, $\mathcal{P}$ the premises, and $\mathcal{CQ}$ the associated critical questions.*

Agents instantiate arguments from AS, using all information available to them (i.e., private and public knowledge).

DEFINITION 2 (ARGUMENT). *An argument is a tuple* $\langle S, c\rangle^{\theta}_{\mathtt{sn_i}}$*, where* $\mathtt{sn_i}$ *is the name of the argumentation scheme used,* θ *is a most general unifier for the premises in* $\mathcal{P}$ *and the agent's current belief base,* S *is the set of premises and the inference rule of the scheme used to draw* c *(the conclusion of the argument). That is,* S *includes all instantiated premises from* $\mathcal{P}$ *— i.e., for all* $p \in \mathcal{P}, p\theta \in \mathcal{S}$ *— and the inference rule corresponding to the scheme* $(\mathcal{P} \Rightarrow \mathcal{C})$*; the conclusion* c *is the instantiation* $\mathcal{C}\theta$ *such that* $S \models c$*.*

Using the knowledge available to them, agents are able to instantiate arguments for and against their mental attitudes (e.g., beliefs and intentions), as well as arguments for and against claims made during a dialogue. Looking for the arguments available to them, agents are able to arrive to well-supported conclusions [4]. In addition, agents are able to evaluate each argument, using the corresponding $\mathcal{CQ}s$ that are part of the AS used to instantiate that particular argument.

3. ENTHYMEMES

Considering the knowledge shared by agents in the MAS — i.e., $\Delta_{\mathtt{Org}}$ and $\Delta_{\mathtt{AS}}$ — they are able to use enthymemes (instead of arguments) in order to communicate to each other during dialogues.

DEFINITION 3 (ENTHYMEME). *Let* $\langle S, c\rangle^{\theta}_{\mathtt{sn}}$ *be an acceptable argument to agent* $\mathtt{ag_i}$*. An enthymeme for* $\langle S, c\rangle^{\theta}_{\mathtt{sn}}$ *is a tuple* $\langle S', c\rangle^{\theta}_{\mathtt{sn}}$*, where* $S' \subset S$ *and* $S' \subseteq (\Delta_{\mathtt{ag_i}} \setminus (\Delta_{\mathtt{Org}} \cup \Delta_{\mathtt{AS}}))$*.*

Based on the label $\mathtt{sn}$ and the most general unifier θ, an agent receiving an enthymeme is able to identify the missing premises[1]. Identifying the missing premises, agents will have the same understanding of the intended argument, given that all the omitted premises belong to the shared knowledge, (i.e., $\Delta_{\mathtt{Org}}$ and $\Delta_{\mathtt{AS}}$).

4. CONCLUSION

In this PhD thesis, we intend to explore AS in MAS, providing an argumentation framework whereby agents are able to instantiate arguments for both reasoning and communication. Our first results show that the infrastructure we proposed allows agents to exchange enthymemes instead of arguments, exchanging shorter messages and, depending on the protocol, fewer messages as well. Also, our approach guarantees that agents will have the same understanding of what has been communicated, i.e., messages will not lose the intend meaning in our approach.

From an initial analysis, it seems that the shared AS could be instantiated as defeasible inferences in the argumentation framework we have developed for an agent-oriented programming language [4, 7]. However, some AS have $\mathcal{CQ}s$ which are not directly related to the premises or the inference rule used to represent that particular instance of the AS, thus some investigation regarding the role of the $\mathcal{CQ}s$ in our framework is still needed. Also, regarding agent communication in our framework (i.e., "enthymeme-based communication"), we intend to formalise our framework following our previous work [6, 9, 8]. Some investigation regarding new protocols that support the use of enthymemes in agent communication is also future work.

[1]An example of an instantiated argument and its respective enthymeme, based on our approach, can be found in [5].

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