Uttering Only What is Needed: Enthymemes in Multi-Agent Systems

(Extended Abstract)

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ABSTRACT

One of the most important aspects of multi-agent systems is communication. Among the communication techniques in multi-agent systems, argumentation-based approaches have received special interest from the community, because they provide a rich form of communication by means of agents exchanging arguments. However, the additional information exchanged by agents could have an extra weight on the communication infrastructure, restricting the usage of argumentation techniques. In this work, we introduce an argumentation framework whereby agents are able to exchange fewer and shorter messages when engaging in dialogues by omitting information that is common knowledge (e.g., information about a shared multi-agent organisation). In particular, we use the idea of *enthymemes*, as well as referring to shared argumentation schemes (i.e., reasoning patterns from which such arguments were instantiated) and common organisational knowledge to guide argument reconstruction. We argue that the approach makes argumentation-based communication more efficient in the sense that agents can exchange fewer messages with shorter content, yet without any loss in the intended arguments.

1. INTRODUCTION

Enthymemes are arguments in which one or more statements — which are part of the argument — are not explicitly stated, i.e., they are arguments with "missing premises" or even "missing conclusions" [19]. 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]. This is because there is common knowledge that can be assumed by the arguers which allows them to encode arguments into a shorter message by ignoring the common knowledge [1]. Further, when an agent receives an enthymeme, it can deduce the intended argument, in a process of reconstruction of such argument, looking for the missing parts, assumptions, etc., in order to recover its intended meaning [5]. However, attributing unstated information to an arguer is a dangerous form of inference, given that this depends on interpreting what the arguer presumably meant to say [19], and this needs to be treated carefully, in order not to change the actual meaning of exchanged arguments. Changing the meaning of arguments uttered by agents in multi-agent systems could be disastrous, considering the rigour expected in multi-agent communication techniques.

Although using enthymemes can be dangerous in distorting the meaning of arguments in agent communication, if the involved process can ensure that arguments do not lose the intended meaning, enthymemes can be beneficial for agent communication, allowing agents to exchange only the essential information needed for a particular purpose. In this work, in order to deal with this inherent problem in using enthymemes, we propose to use argumentation schemes [19] as common organisational knowledge to guide the construction of enthymemes by the proponent of arguments, as well as to guide the reconstruction of the intended argument by the recipients of those enthymemes. Thus, agents are able to exchange only the content that is essential for them to understand each other through argumentation-based communication, and it can be ensured that the arguments will not lose content or the intended meaning.

2. ARGUMENTATION SCHEMES IN MULTI-AGENT SYSTEMS

In our work, argumentation schemes are shared by agents through the organisational specification or semantic databases [3], representing domain dependent reasoning patterns. Examples of domain dependent argumentation schemes are found in [17, 12, 16].

To exemplify our approach, we use the argumentation schemes *Argument from Position to Know* [18], but here making reference to organisational concepts: "Agent `ag` is currently playing role R (its position) that implies knowing things on a certain subject domain S containing proposition A [**Major Premise**]. `ag` asserts that A (in domain S) is true (or false) [**Minor Premise**]. A is true (or false) [**Conclusion**]".

The associated critical questions are: **CQ1**: Does playing role R imply knowing whether A holds? **CQ2**: Is `ag` an honest (trustworthy, reliable) source? **CQ3**: Did `ag` just assert that A is true (or false)? **CQ4**: Is `ag` playing role R?

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.*

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Argumentation schemes can be represented in structured argumentation using defeasible inferences, as described in [13]. The argumentation scheme above could be resented as the following defeasible inference, based on [8, 10]:

$$\texttt{role}(\texttt{Ag},\texttt{R}),\texttt{knows}(\texttt{R},\texttt{S}),\texttt{asserts}(\texttt{Ag},\texttt{A}),\texttt{about}(\texttt{A},\texttt{S}) \Rightarrow \texttt{A}$$

Agents instantiate arguments from argumentation schemes using the private and public knowledge available to them. We use $\Delta_{\texttt{Org}}$ to represent organisational information, $\Delta_{\texttt{AS}}$ the shared argumentation schemes, and $\Delta_{\texttt{ag}_\texttt{i}}$ to represent all knowledge available to agent $\texttt{ag}_i$.

Definition 2 (Argument). *An argument is a tuple $\langle S, c\rangle^{\theta}_{\texttt{sn}_\texttt{i}}$, where $\texttt{sn}_\texttt{i}$ 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 $p \in \mathcal{P}, p\theta \in \mathcal{S}$ — as well as the inference rule corresponding to the scheme ($\mathcal{P} \Rightarrow \mathcal{C}$); the conclusion c is the instantiation $\mathcal{C}\theta$ such that $S \models c$.*

For example, imagine that all agents know that an agent named `john` is playing the role of a `doctor` — `role(john,doctor)` — within the organisational structure. Further, the agents know that doctors know about cancer — `knows(doctor,cancer)`. Therefore, if `john` asserts that "*smoking causes cancer*" — `asserts(john,causes(smoking,cancer))`, and causes of cancer are a subject matter related to cancer — `about(causes(smoking,cancer),cancer)`, all agents are able to conclude that smoking causes cancer — `causes(smoking,cancer)`. In this example, the organisational structure within the system ensures that all agents know that agent `john` plays role `doctor` within that organisational structure, and that doctors know about cancer, because it is one of the features of that role. Also, they might know that causes of cancer are a subject related to cancer, for example given the domain knowledge shared by them in the system. However, not all agents will know that the agent `john` has asserted that smoking causes cancer, just the ones `john` has communicated with.

3. ENTHYMEMES

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

In our example, an argument contains, in its support, all premises and inference rules needed to entail the conclusion, and it could be constructed as (we use `[` and `]` to delimit the inference rules):

$\langle$`{role(john,doctor), knows(doctor,cancer), asserts(john,causes(smoking,cancer)), about(causes(smoking,cancer),cancer), [role(Ag,R), knows(R,S), asserts(Ag,A), about(A,S) ⇒ A]}, causes(smoking,cancer)`$\rangle^{\theta}_{\texttt{position\_to\_know}}$

where $\theta = \{\texttt{Ag} \mapsto \texttt{john}, \texttt{R} \mapsto \texttt{doctor}, \texttt{S} \mapsto \texttt{cancer}, \texttt{A} \mapsto \texttt{causes}(\texttt{smoking},\texttt{cancer})\}$. The corresponding enthymeme is as follows (considering the common knowledge presented in Figure 1):

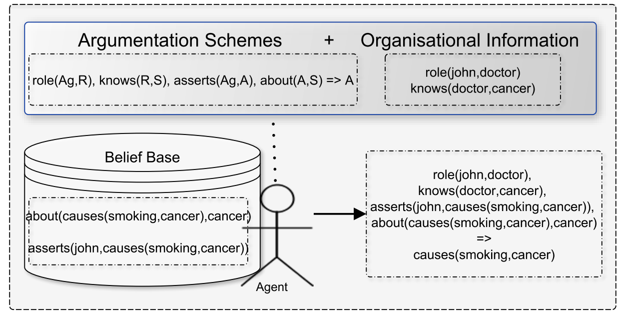

Figure 1: Constructing arguments using argumentation schemes and organisational information.

$\langle$`{asserts(john,causes(smoking,cancer)), about(causes(smoking,cancer),cancer)]}, causes(smoking,cancer)`$\rangle^{\theta}_{\texttt{position\_to\_know}}$

Based on the label `position_to_know` and the most general unifier θ, an agent receiving that enthymeme is able to identify the missing premises and therefore conclude that `causes(smoking,cancer)`, given that all missing premises are organisational information and, therefore, common knowledge. Making reference to shared argumentation schemes and using well defined speech acts for argumentation-based communication (e.g., [11, 9]), agents are able to (i) exchange less content; (ii) exchange fewer messages; and (iii) both agents, sender and receiver, will have the same understanding of the uttered arguments.

4. CONCLUSION

In this work, we introduced an argumentation framework, where agents exchange only the information needed to ensure that both sides, the proponent and recipient, will have the same understanding of the uttered arguments. Our approach allows agents to exchange fewer messages with shorter content, which could be very useful both for making argumentation-based communication more efficient as well as avoiding network overload. Improving the efficiency of argumentation-based communication has potential impact in applications using argumentation techniques, and decreasing network usage can support applications that depend on restricted network bandwidth, for example applications running on mobile devices such as [14, 4]. Our approach, even though it has been based on the organisation-centred paradigm — i.e., using organisational information and argumentation schemes as common organisational knowledge, other approaches to describing common knowledge such as [2, 1] could also be used without major changes.

In future work, we intend to investigate the role of trust relations among agents, including how information on trust could be used in agent interaction using enthymemes. For example, an agent could accept arguments received from a reliable source even without all the premises needed to draw that particular claim. Thus agents could take advantage of the trust relation, exchanging even shorter content for those trusted agents. Examples of work combining argumentation with information about trust can be found in [12, 15, 6, 7].

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REFERENCES

[1] E. Black and A. Hunter. Using enthymemes in an inquiry dialogue system. In *Proceedings of the 7th international joint conference on Autonomous agents and multiagent systems-Volume 1*, pages 437–444. International Foundation for Autonomous Agents and Multiagent Systems, 2008.

[2] E. Black and A. Hunter. A relevance-theoretic framework for constructing and deconstructing enthymemes. *Journal of Logic and Computation*, 22(1):55–78, Feb. 2012.

[3] A. Freitas, A. R. Panisson, L. Hilgert, F. Meneguzzi, R. Vieira, and R. H. Bordini. Integrating ontologies with multi-agent systems through CArtAgO artifacts. *IEEE/WIC/ACM International Joint Conferences on Web Intelligence (WI) and Intelligent Agent Technologies (IAT)*, v. 2, pg. 143–150. IEEE, 2015.

[4] A. Koster, A. L. Bazzan, and M. de Souza. Liar liar, pants on fire; or how to use subjective logic and argumentation to evaluate information from untrustworthy sources. *Artificial Intelligence Review*, pages 1–17, 2016.

[5] J.-G. Mailly. Using enthymemes to fill the gap between logical argumentation and revision of abstract argumentation frameworks. *CoRR*, abs/1603.08789, 2016.

[6] V. S. Melo, A. R. Panisson, and R. H. Bordini. Argumentation-based reasoning using preferences over sources of information. In *fifteenth International Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, pages 1337–1338, 2016.

[7] V. S. Melo, A. R. Panisson, and R. H. Bordini. Trust on beliefs: Source, time and expertise. In *eighteenth International Workshop on Trust in Agent societies*, pages 31–42, 2016.

[8] A. R. Panisson and R. H. Bordini. Knowledge representation for argumentation in agent-oriented programming languages. *Brazilian Conference on Intelligent Systems, BRACIS*, pages 13–18, 2016.

[9] A. R. Panisson, F. Meneguzzi, M. Fagundes, R. Vieira, and R. H. Bordini. Formal semantics of speech acts for argumentative dialogues. In *Thirteenth Int. Conf. on Autonomous Agents and Multiagent Systems*, pages 1437–1438, 2014.

[10] A. R. Panisson, F. Meneguzzi, R. Vieira, and R. H. Bordini. An Approach for Argumentation-based Reasoning Using Defeasible Logic in Multi-Agent Programming Languages. In *11th Int. Workshop on Argumentation in Multiagent Systems*, 2014.

[11] A. R. Panisson, F. Meneguzzi, R. Vieira, and R. H. Bordini. Towards practical argumentation in multi-agent systems. *Brazilian Conference on Intelligent Systems, BRACIS*, pages 98–103, 2015.

[12] S. Parsonsa, K. Atkinsonb, K. Haighc, K. Levittd, P. M. J. Rowed, M. P. Singhf, and E. Sklara. Argument schemes for reasoning about trust. *Computational Models of Argument: Proceedings of COMMA 2012*, 245:430, 2012.

[13] H. Prakken. An abstract framework for argumentation with structured arguments. *Argument and Computation*, 1(2):93–124, 2011.

[14] D. Schmidt, A. R. Panisson, A. Freitas, R. H. Bordini, F. Meneguzzi, and R. Vieira. An ontology-based mobile application for task managing in collaborative groups. In *Florida Artificial Intelligence Research Society Conference*, pages 522–526, 2016.

[15] Y. Tang, K. Cai, P. McBurney, E. Sklar, and S. Parsons. Using argumentation to reason about trust and belief. *Journal of Logic and Computation*, 22(5):979–1018, 2011.

[16] P. Tolchinsky, K. Atkinson, P. McBurney, S. Modgil, and U. Cortés. Agents deliberating over action proposals using the proclaim model. In *International Central and Eastern European Conference on Multi-Agent Systems*, pages 32–41. Springer, 2007.

[17] A. Toniolo, F. Cerutti, N. Oren, T. J. Norman, and K. Sycara. Making informed decisions with provenance and argumentation schemes. In *Proceedings of the Eleventh International Workshop on Argumentation in Multi-Agent Systems*, 2014.

[18] D. Walton. *Argumentation schemes for presumptive reasoning*. Routledge, 1996.

[19] D. Walton, C. Reed, and F. Macagno. *Argumentation Schemes*. Cambridge University Press, 2008.