Abstract argumentation and dialogues between agents

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1 Introduction

A multiagent system (MAS) is made up of multiple interacting autonomous agents. It can be viewed as a society in which each agent performs its activity, cooperating to achieve common goals, or competing for them. Thus, every agent has the ability to do social interactions with other agents establishing dialogues via some kind of agent-communication language, under some communication protocol [6].

Argumentation is suitable to model several kind of dialogues in multi-agents systems. Some authors are actually using defeasible argumentation to model negotiation processes between agents [3, 7]. Our current research activities are related to the use of argumentation in agent's interaction, such as negotiation among several participants, persuasion, acquisition of knowledge and other forms of social dialogue. Usually, argumentation appears as a mechanism to deal with disagreement between agents, for example when some conflict of interest is present. Argumentation can be used, not only to argue about something, but to know more about other agents: it is enough powerfull to play an important role in general social interaction in multi-agents systems. The kind of arguments used in dialogues, and their relationship, depends on the type of dialogue involved.

According to [8], dialogues can be classified in *negotiation*, where there is a conflict of interests, *persuasion* where there is a conflict of opinion or beliefs, *indagation* where there is a need for an explanation or proof of some proposition, *deliberation or coordination* where there is a need to coordinate goals and actions, and one special kind of dialogue called *eristic* based on personal conflicts. Except the last one, all these dialogues may exist in multi-agents systems as part of social activities among agents. Our aim is to define an abstract argumentation framework to capture the behaviour of these different dialogues, and we present here the main ideas behind this task and the new formal definitions. We are not interested in the logic used to construct arguments, nor the comparison method used. Our formulation completely abstracts from the internal structure of the arguments, considering them as moves made in a dialogue. We also consider multiagent systems as a set of multiple interacting autonomous agents.

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Definition 1.1 (Multiagent system). *A multiagent system is a set* $MS = \{A_1, A_2, A_3, ..., A_n\}$ *where every* A_i *is an agent.*

We do not commit to some specific agent architecture. In this line of investigation, it is sufficient to consider an agent as an entity that carries out actions, based on its goals, and that can be aware of information about its external situation, including the consequences of its actions.

2 Arguments and dialogues

Simply put, a dialogue is sequence of locutionary acts between two or more players. An argument is a tentative explanation for some proposition and when enunciated by agents it may be considered as a locutionary act. Here is a simple definition of dialogue between agents:

Definition 2.1 (Dialogue). *An argument dialogue* D *in a multi-agent system* MS *is a non-empty sequence of pairs*

$$[(Arg_0, Ag_0), (Arg_1, Ag_1), ..., (Arg_i, Ag_j)](i \geq 0)$$

where Arg_i *is an argument of agent* $Ag_j \in MS$*. Any pair* (Arg, Ag_k) *is called a* dialogue act *of* D*.*

When dialoguing, arguments can be used in several ways. They are used to rebutt arguments previously shown by the opponent, or to request information, or just simply to denote agreement. An argument must always be in relation with previous arguments in the dialogue. Usually, the term argumentation is related to *defeasible argumentation*, where any proposition will be accepted as true if there exist an argument A that supports it, and this argument is acceptable according to an analysis between A and its counterarguments. It is being used as a mechanism to achieve nonmonotonic reasoning, so we can also use defeasible argumentation to model the agent's internal process of deliberation. This form of argumentation can be also used to model negotiation dialogues. In this application, argumentation appears as a mechanism to deal with disagreement between agents, for example, when some conflict of interest is present. Under this situation, arguments are shown in the dialogue as a refutation of previous arguments.

For simplicity, we will consider dialogues between only two agents P and O. P always starts the dialogue, and both agents take turns to present arguments. What is supplied by each participant at each turn is a direct response to what was stated in the previous turn. When finished, any dialogue produces an outcome, which is established as *Agent X wins the dialogue*. We call the *partial balance* of a dialogue in course to the outcome obtained if the dialogue ends with the acceptance of last argument shown. The *partial balance* may be *favourable* or *unfavourable* to some player.

As stated before, there are some restrictions in the exchange of arguments. Suppose P enunciates the argument A_P and later, agent O enunciates the argument A_O. We say then that argument A_O is an *answer* (or *response*) to argument A_P in the actual dialogue. The most important question here is: what makes A_P an *answer*? Of course, the order in which arguments are presented is a necessary condition, but not a sufficient one. It is clear that

certain responses do not count as an answer. Some of them do not even qualify as a relevant reply. There must exists some previously established relation between A_O and A_P.

The set of possible answers is defined in different ways. For example, Douglas Walton states in [2] that four kinds of moves are especially important in dialectical systems: (a) the asking of questions, (b) the making of assertions, (c) the retracting of positions and (d) the putting forward of arguments. Under this classification, not every move is an argument, for example move (a). However, this kind of move asks for a justification in the form of an argument. Every assertion contains a proposition, so the second kind of moves may be considered arguments. In [3] any process of negotiation proceeds by the exchange of proposals, critiques, explanations and meta-information, and these are the only legal moves. All these moves are enunciated by the agents together with the corresponding explanation, as they are all considered arguments.

We distinguish several types of answers in a dialogue. This classification is based on the relevance of the argument in the dialogue in which is taking part. These are

- Negative answers: arguments in this set are argument that may change the outcome of the dialogue. Defeater arguments in persuasion dialogues are good examples of negative answers.
- Positive answers: arguments in this set can not change the outcome of the dialogue. A good example is an argument that states agreement on previous arguments, that is, a non-defeater argument.
- Required answers: arguments in this set are compulsory answers due to previous arguments. For example, giving information when requested by the other player. This kind of answers are not directly relevant to the outcome of the dialogue [1].

In this classification every answer is considered an argument, that is, a set of propositions (possibly empty) cited as a basis for support of a particular proposition. The asking of questions, or the requirement of information, is also considered an argument. A question may be stated as an imperative order, which is able to be represented by a proposition. For example, the question *"Why do you need service X?"*, may be rewrited as *"Explanation for request to service X is needed"*. Questions are considered positive answers, because any requirement of information is by itself not determinant in the dialogue.

The following example shows the use of different answers. It is extracted from [1], where it is used as an example of negotiation dialogue.

P:	*Please give me a nail.*	(P_1)
C:	*No.*	(C_1)
P:	*Why won't you give it to me?.*	(P_2)
C:	*Because I want to hang a mirror and for that I need a nail.*	(C_2)
P:	*I understand.*	(P_3)

The argument P_1 is the first argument in the dialogue. C_1 is a negative answer to P_1, with no explanation. P_2 is a positive answer to C_1 as it requests extra information. C_2 is a required answer, as it gives the information previously requested by P. Finally, P_3 is a positive answer of C_2, denoting agreement on the information received. The partial balance of the dialogue is *unfavourable* to P in every dialogue act.

[1] Note that the information given by these arguments may be relevant to the production of a new negative answer

The following dialogue shows diferent answers

P:	*Tweety flies because it's a bird, and every bird flies.*	*(P_1)*
C:	*Are penguins birds?.*	*(C_1, positive answer)*
P:	*Yes.*	*(P_2, required answer)*
C:	*Then not every bird flies*	*(C_2, negative answer)*

The partial balance of the dialogue is shown in the next table

(P_1) undefined
(C_1) favourable to P
(P_2) favourable to P
(C_2) unfavourable to P

If P can not enunciate an argument that is a negative answer to C_2, then the dialogue ends with unfavourable outcome to P. This is strongly requested in some systems based on defeasible argumentation, where only negative answers can be produced. For example, if P states that *"OK, penguins are not flying birds, but Tweety is not a penguin."*, which is a negative answer to C_2, then the partial balance is now *favourable* to P. Note that some arguments may be irrelevant to the dialogue, as they may request information that is not usefull to produce positive nor negative answers.

3 Basic framework

Any dialogue is a sequence of locutionary acts between two or more players. These locutionary acts, what we call *dialogue acts*, are related in some way. A preliminary definition of an abstract framework to model dialogues between agents is the next

Definition 3.1. *An abstract argumentation framework for dialoguing agents is defined as* $AF_{dial} =< Ags, S, PRel, NRel, CRel >$ *where* Ags *is the set of agents in the system,* S *is the set of all arguments produced by the agents, and* $PRel, NRel$ *and* $CRel$ *are binary relations defined on* S*, called positive relations, negative relations and compulsory relations.*

An element in S is a pair (A, Ag) where A is an argument produced by agent Ag. As stated before, we abstract from how the arguments are constructed. A dialogue D in the framework AF is a sequence $[DAct_1, DAct_2, ..., DAct_n]$ [2]where $DAct_i \in S$ and $(DAct_i, DAct_{i+1}) \in PRel \cup NRel \cup CRel$.

A dialogue protocols establishes the rules to be applied in the dialogue process. It usually defines the set of possible answers to every dialogue act. For example, a compulsory answer can never be the answer of a negative argument. The most known set of moves is defined in [5]. In our framework, the sets $PRel, NRel$ and $CRel$ denote all the possible answers to every dialogue act, so they are defining an important part of the protocol. In other words, these sets are *instances* of the protocol rules. This is a very important part of the framework, because a particular protocol may be *encoded* in these sets. Some elements may even be specified as schemas, such as the capacity of any agent of refusing to give information.

Our intention is to capture other forms of relations between arguments, including the classic defeat relation. The argumentation framework defined in [4] is a particular case of AF_{dial}, where $|Ags| = 1$, $PRel = \emptyset$ and $CRel = \emptyset$.

The argumentation framework ${AF_{dial}}^{Twy} =< Ag, S, PRel, NRel, CRel >$ where

[2] $DAct$ stands for *dialogue act*

$Ag = \{P, O\}$, $S = \{(P_1, P), (P_2, P), (C_1, C), (C_2, C)\}$
$PRel = \{((P_1, P), (C_1, C))\}$, $NRel = \{((P_2, P), (C_2, C))\}$,
$CRel = \{((C_1, C), (P_2, P))\}$

is the framework where the dialogue about Tweety is constructed. There is another special kind of argument relationship not included in this framework. This relationship denote the fact that some arguments can only be used when certain information is present in the dialogue, usually as an answer of a previous information request. For example, in ${AF_{dial}}^{Twy}$ the argument C_2 can not be used until the argument P_2 is introduced in the dialogue and accepted by C. Because of this dynamic construction of arguments, an element (Arg, Ag) in S is constructed using more than the knowledge base of Ag. The dialogue is a source of information by itself. However, agent C may know that any external confirmation of penguins being birds (that is, argument P_2) is enough to produce argument C_2. The agent then ask for that information using argument C_1.

4 Actual and future work

Our intention is to build an abstract argumentation framework to model several kinds of dialogues between agents. We have shown in this paper part of the basic elaborated framework. Complex dialogues are not included for space reasons. There is also a subset of negative answers called *fallacious answers*, which is not included here for the same reason. Some important issues are being addressed now. We are working on a refined argumentation framework with other special argument relationships, such as the strong dependency of some arguments on the dialogue in course. We are also working on the semantic of this basic argumentation framework. In order to find the set of accepted arguments, it is possible to build a function similar to that one defined in [4], mainly taking into account the role of every negative answer. The main goal here is to determine the winner of a given dialogue.
One of the most important elements of complexity in the evolution of a dialectical process is the number of players involved. All the dialogues shown in this paper are two-players dialogues. In the future, this argumentation framework will be extended to include n-ary relations between arguments, as usually needed in multiagent systems.

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