Capturing the behaviour of inter-agent dialogues

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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 [13]. Argumentation has been used to model several kind of dialogues in multi-agents systems, such as negotiation or coordination [1, 7, 8, 5, 9].

Our current research activities are related to the use of argumentation in agent's interaction, as a form of social dialogue. According to [15], 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 this dialogues may exist in multi-agents systems as part of social activities among agents. We also study the use of argumentation formalisms to model the internal process of reasoning of an agent, often called *monologues*.

Our aim is to define an abstract argumentation framework to capture the behaviour of these different dialogues. We are not interested in the logic used to construct arguments. 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.

Definición 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. An agent is modeled by a framework including the necessary elements to carry out dialogues: a set of arguments, an argument conflict criteria and a comparison criteria, which is used to decide on argument conflicts. Both criterions are used to establish argument defeat relations.

Definición 1.2 (Agent). *An agent A_i is the triplet $< Args_i, \mathcal{C}_i, \sigma_i >$ where $Args_i$ is a set of arguments, $\mathcal{C}_i \subseteq Args_i \times Args_i$ and $\sigma_i : Args_i \times Args_i \rightarrow 2^{Args_i}$.*

Arguments are abstract entities, as in [2], denoted by uppercase letters. If A is an argument, then A^- is a subargument of A, and A^+ is a superargument of A. No reference to the underlying logic is needed. It is sufficient to know that arguments support conclusions, which are denoted here by lowercase letters. The fact that an argument may contradict another argument is represented in the framework by the conflict relation $\mathcal{C}_i$. The comparison criteria is represented by σ_i.

Definición 1.3. *An agent's argument comparison criterion is a function $\sigma : S \times S \rightarrow 2^S$, where S is the set of arguments built by the agent and*

$$\sigma(A,B) = \begin{cases} \{A\} \ or \\ \{B\} \ or \\ \{A,B\} \ or \\ \{\} \end{cases}$$

If $\sigma(A,B) = \{A,B\}$ then A and B are arguments with equal relative strength. If $\sigma(A,B) = \{\}$ then A and B are incomparable arguments.

The comparison criterion takes two arguments A and B and decides which argument is preferred. It may be considered the agent's intelligence core, because is the only element that may be different in every agent in the system and σ defines the outcome of internal argumentation: the set of accepted arguments in $Args_i$. Finally, the most relevant relation in argumentation frameworks is the *defeat* relation (or $attack$ relation, as in [2]), built upon the $\mathcal{C}$ relation and function σ. An argument A defeats an argument B, denoted $A \xrightarrow{d} B$ if and only if $(A,B) \in \mathcal{C}$ and $\sigma(A,B) = \{A\}$. In this case, A is called the "defeater argument" and B is called the "defeated argument". However, not every move in a dialogue must be a refutation of previous ones.

2 The structure of abstract dialogues

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

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

$$[(Arg_0, Ag_1), (Arg_1, Ag_2), ..., (Arg_i, Ag_j)] \ (i \geq 0)(1 \leq j \leq n)$$

where Arg_i is an argument structure 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. Whenever an agent needs to explain a claim, arguments can be used. For simplicity we will apply here some restrictions to the number of dialoguing agents, and to the dynamics of the dialogue. We will consider dialogues between only two agents $P = < Args_P, \mathcal{C}_P, \sigma_P >$ and $O = < Args_O, \mathcal{C}_O, \sigma_O >$. The dialogue process is a subclass of *persuasion dialogues*, stated as follows: 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. This means that there is only one argument to be challenged at a given time (an extension to this model can be found in [8]). When finished, any dialogue produces an outcome, which is established as *Agent X wins the dialogue*. The *partial balance* of a dialogue in course is 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.

Two main problems arise in this scenario. First, we need to define what is considered an *answer* to a previous argument. This is a very important issue in our research, and a very dificult one, due to the abstraction level applied. As stated before, some answers are an attempt to refute previous moves in the dialogue. Some formalisms capturing this kind of moves are presented here. But it is clear that some locutionary acts are only intended to get external information or provide it when requested by others. Some observations about this, and a preliminary approach can be found in [7]. The second problem is related to the agent's internal decision process. We need to establish how an argument Ar_i will be selected by an agent A_i to be presented in the dialogue. Our abstract agents provide a *choice function* denoting the inner preference structure suitable to model dialectical analysis. But this function is probably different for every agent, so it may be considered part of any answer. In this way, the agent says not only the required answer, but also why it was chosen. This situation is more clear when the agents are involved in persuasion dialogues, as briefly shown in the next sections, but also more complicated when considering conflictive preferences.

3 Dialogue acts

One of the most important issues in inter-agent dialogues is to specify what is an *answer* to a previous move presented in a dialogue D. Usually, this specification takes part of what is known as the *dialogue protocol*, a set of rules defining a well-formed dialogue. In the protocol, it is stated what to say and when to say it. There are a lot of dialogue protocols defined in the literature ([1, 10] are good examples). The set of possible answers is defined in different ways. The most known set of moves is defined in [12]. Philosopher Douglas Walton states in [14] 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. In [10] 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 together with the corresponding explanation, as they are all considered arguments.

In our abstract argumentation framework for dialoguing agents, part of the protocol can be specified as a function $\rho : Args_P \cup Args_O \rightarrow \wp(Args_P \cup Args_O)$, such that $\rho(A)$ is the set of possible answers to argument A. The participation order may be defined as a function $\delta(MS) \rightarrow MS$ where MS is the set of agents in the system. In our restricted dialogue framework, $\delta(P) = O$ and $\delta(O) = P$. Here is a simple, preliminary definition of abstract dialogue framework:

Definición 3.1 (Abstract Dialogue Framework). *An abstract dialogue framework ADF is a tuple* (MS, ρ, δ) *where* $MS = \{A_1, A_2, ..., A_n\}$ *is a set of agents,* $\rho : \bigcup_1{}^n Args_i \rightarrow \bigcup_1{}^n Args_i$ *is the function encoding the possible answers to a dialogue act, and* $\delta : MS \rightarrow MS$ *is a function establishing the participation order in the dialogue.*

This framework is suitable to model several kinds of inter-agent dialogues, such as negotation, persuasion or indagation. In many cases, some arguments of an agent A_i represent questions, assertions or compulsory answers, and no conflict nor comparison analysis is applied[1]. These arguments are not determining conflictive dialogue acts, so its practical usage only depends on the protocol function. It is important to note that an agent A_i in the framework is defining a conflict relation and a preference criteria over the set of arguments that A_i is able to produce. However, in order to interact whith other agents, these elements need to be extended to include external arguments. For simplicity, we will consider here that every $\mathcal{C}_i$ is the projection on the set $Args_i$ of a global binary relation $\mathcal{C}_{MS}$ defining the conflict between any pair of arguments in the framework[2] (i.e, $\bigcup_1{}^n Args_i$). The function σ_i is also defined over this set, but it still may be different to other σ_j in the framework.

4 Thinking before speaking

In two-agents persuasion dialogues[3], agent P states a proposition p and its support in the form of an argument. At every turn, each agent tries to find a counterargument for the last argument shown by the other agent. No questions nor information request is established in all the process, just assertions as refutations to the last move. In our framework, this restriction can be defined for an argument A as

$$\rho(A) = \{B : \exists i, 0 \leq i \leq n, (A, B) \in \mathcal{C}_i, \sigma_i(A, B) = \{B\}\}$$

This function is considering all the arguments in the framework, because it captures the set of all the possible answers to a move in a dialogue. However, an agent A_i is able to enunciate arguments belonging to $Args_i$, so the answers available to agent A_i, denoted ρ_i are

$$\rho_i(A) = Args_i \cap \rho(A)$$

The agent A_i must find an argument in this set to be presented in the dialogue. Several perspectives may be applied in the selection process. Some of them are defined in [11]. What is important here is the agent's trust level for every possible answer. Therefore, A_i must start an internal dialectial analysis, challenging every candidate in order to discard those defeated by an accepted argument. Even then, a selection method to decide among accepted arguments is needed.

Some conflictive situations may arise. For example, suppose that agent O uses σ_O to find the answer A_O to A_P, an argument enunciated by P. Now agent P uses σ_P to find the answer A'_P to the last argument, A_O, and suppose O is only able to find again A_O as an answer to A'_P. An equilibrium is found at this moment: no agent wants to change its preferences, nor select another argument, because what was previously said cannot be refuted nor strengthened by defense. Both preference

[1]These locutionary acts are considered empty arguments, i.e., there is no need for proof nor support for its conclusions.

[2]In some complete defined systems, as [4], this set is the binary relation derived by contradiction under classical negation.

[3]Actually, in a subclass of persuasion dialogues

criteria are contradictory about A_O and A'_P and therefore the dialogue can not end succesfully[4]. As shown in previous work [8], the state of the dialogue in progress is always needed to make a better decision, so the input of function σ may be extended to include information on the arguments exchanged. Formal characterizations of this equilibrium are being defined.

Our current research is devoted to analize this scenario: dialoguing agents whith possibly contradictory preference (or choice) functions. The main idea is to deal with two different levels of undecision. It is possible to find undecision in the internal reasoning process, or *monologue*. This may be called "*undecision at agent level*" and fallacy is the main involved concept. As shown above, it is also possible to find undecision in the dialectical process, or *dialogues*. We called this "*undecision at dialogical level*". Some formalisms may be applied in the case of dialogical undecision. For example, the use of *social functions*. A social welfare function is a rule which gives us a *preference for society* based on the preferences of the citizens. For example, in a democratic community, a particular social welfare function is used, which says that *society prefers* policy x to policy y if more people voted for x than y. It is important to define a method for combining different preference relations into a single relation that makes sense for both agents involved in the debate. We are also interested in the generalization of this framework to include more than two dialoguing agents and to consider different forms of argument relations, others than binary conflict (some arguments are introduced in a dialogue to strenght previous ones, or to provide topic alternatives, resign positions, etc). The framework must allow the modelization of more complex, mixed dialogues, where questions, assertions, retractions and out-of-debate explanations may ocurr. Some of this goals are partially solved in previous papers [6, 7, 8].

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[4] When the same preference criterion is used by both agents, this situation is called a *fallacy*.