A Dynamic Epistemic Logic for Abstract Argumentation*
(extended abstract)

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Logic, understood as the study of correct reasoning, and Rhetorics, understood as the study of persuasive argumentation have been separated fields of research since, at least, Aristotle. This separation is present throughout the course of history, finding one of its most explicit expositions in the work of Toulmin [6], along with his criticism of formal logic for being incapable of modelling the key features of real-life argumentation. In order to fill this gap, several formalisms have been developed in the last decades, argumentation frameworks [2] (AFs, for short) being one of the most prominent. Making use of these new tools, logic, specially epistemic logics and their dynamic extensions, can recover an appealing role in the formal understanding of how persuasive argumentation unfolds.

Persuasive argumentation among individuals contains, leaving emotions aside, at least three fundamental components. First, agents involved in a persuasive dialogue have *goals* i.e. targeted changes of the opinions of their interlocutors. Second, those agents have *beliefs* (and sometimes knowledge) about the knowledge base of their interlocutors (i.e. which arguments they own). Third, agents use different *policies of information change* to reach their goals: speakers choose the information that they share in the different steps of a dialogue (*communication policies*) and hearers choose how to incorporate this information into their own knowledge bases (*updating policies*). The three ingredients are intertwined in persuasive dialogues. For example, if the main suspect of a crime is trying to convince the detective, during an interrogation, that she is innocent (*goal*), then she will use an alibi only if, according to her *beliefs*, the detective is not going to find an easy counterargument for it (*communication policy*).

Recent works have studied the relations between beliefs and argumentation by combining epistemic logic and abstract argumentation. They have done so by developing two different intuitions. The first one is that argumentation is an input for belief ([5] among others); hence different mechanisms for capturing argument-based belief are discussed. The second one is that belief is an input for argumentation and, therefore, a tool for epistemic reasoning about argumentation frameworks is needed (among others, [4]). Persuasion, however, has received few attention by these approaches. In this talk, we will present a dynamic epistemic logic for abstract argumentation, suitable for modelling the three relevant ingredients of persuasion mentioned above. Let us give some details about how each component is modelled.

From an abstract point of view, the content of a debate is representable by an AF: a pair (A, R) where A is a finite set of abstract arguments and $R \subseteq A \times A$ is an attack relation between them [2]. In this context, the **knowledge base** of an agent i is modelled as a subgraph (A_i, R_i) of (A, R), i.e. where $A_i \subseteq A$ and $R_i = R \cap (A_i \times A_i)$ – assuming that the understanding of the attack relation is shared, a natural assumption in many contexts and common in the literature. **Goals** of argumentation are modelled as intended changes in the justification status of an argument, with respect to a given AF. Given an AF (A, R) and its subgraphs, acceptable opinions

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can be represented through *argument labellings*: functions that identify subsets of arguments that meet certain requirements to be acceptable (usually called *solutions* or *extensions*). In [8], labelling semantics is used to define a notion of fine-grained *justification status* of an argument, establishing a position within an acceptance hierarchy for each argument. All these notions must be encoded in a logical language, in order to reason about them [1]. We do this by introducing three different sets of propositional variables $\mathcal{V} := \mathcal{A} \cup \mathcal{O} \cup \mathcal{I}$. $\mathcal{A}$ is used to talk about the attack relation, $\mathcal{O}$ is used to describe the set of arguments owned by each agent, and $\mathcal{I}$ is used to determine whether each argument belongs to each subset. To the best of our knowledge, this is the first encoding of fine-grained justification status in propositional logic.

Beliefs, and more generally epistemic attitudes, are modelled by defining multi-agent Kripke models $(W, \{\mathcal{R}_i\}_{i \in Ag}, V)$ where the elements of W are the possible configurations of a multi-agent debate, each described by a valuation on $\mathcal{V}$. The agents' uncertainty among these configurations is captured by the relation $\mathcal{R}_i$ and the standard language of epistemic logic suffices to describe its properties. This is the general idea of one of the logics presented in [4] where, moreover, a couple of reasonable constraints are imposed on valuations. In the actual setting, however, some technical problems arise. For instance, we would like the valuation of the elements of $\mathcal{I}$ to be uniform (i.e. $V(p) = W$ or $V(p) = \emptyset$ for each $p \in \mathcal{I}$), for the encoding mentioned above to make sense throughout all the model. Something analogous happens if we want to capture the mentioned assumption about sharing the attack relation. We skip this difficulty by showing that there is a strongly complete logic with respect to the restricted class of models, without the need of a global modality.

Policies of information change, and more generally dynamic phenomena, are modelled in our setting by a special application of action models with assignments [7]. The flexibility of action models allows us to express a wide range of policies. The price of this flexibility is well-known: doxastic models (where each accessibility relation is serial, transitive and euclidean), are not closed under action model execution. Moreover, we would also like all the constraints on the propositional valuations, including those presented in [4], to be maintained after action model execution. Both problems are solved as follows. First, we show that executing any of the actions needed for our discussion of persuasion do preserve doxastic accessibility relations. Second, we give a set of conditions for action models that are sufficient for the constraints on valuations to be preserved after executing them. In the last part of the presentation, we will present a complete axiomatisation for the dynamic extension via reduction axioms.

To sum up, the resulting logical framework is enough to give a formal analysis of persuasion capturing its three ingredients: *goals* (as targeted changes of the justification status of certain argument for the interlocutor), *epistemic attitudes* (as usual in epistemic logic) and *policies of information change* (as certain (combination of) action models). By means of this, it is possible to show, via modelling, the rationale behind a number of communication strategies that are commony used in persuasive argumentation. There is, however, work to be done yet. From the different open problems, we highlight the question of how to construct a meaningful classification of all the definable policies of information change.

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