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Speech Acts and Burden of Proof in Computational Models of Deliberation Dialogue

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We argue that burden of proof (BoP) of the kind present in persuasion does not apply to deliberation. We analyze existing computational models showing that in deliberation agents may answer a critique but there is no violation of the protocol if they choose not to. We propose a norm-governed dialogue where BoP in persuasion is modeled as an obligation to respond, and permissions capture the different types of constraint observed in deliberation.

KEYWORDS: burden of proof, deliberation dialogue, dialogue protocol, multiagent systems, norms

1. INTRODUCTION

Recent work on deliberation dialogue in AI raised awareness of the need to develop formal models that capture the richness of deliberations that typically occur in human dialogue (Walton et al., 2014). Existing models of dialogue in multiagent systems use argumentation schemes, argument frameworks and formal dialogue structures to analyze and evaluate argumentation in deliberation, where the goal of the dialogue is to enable the participants to make an intelligent choice on what to do in a given set of circumstances. Existing research has generally focused on the problem of what to say; i.e. what speech acts can be performed or what critical questions can be advanced when making a proposal. An open problem is that of determining why certain speech acts should be performed and what the implications are for the participants.

In the formal deliberation system of Kok et al. (2011), when the speaker makes a proposal the hearer is required at its next move to either

reject the proposal or to challenge it by asking the why-question *"Why propose P?"*. In reply to this question, the hearer is obliged to give an argument supporting P. A similar requirement is considered in a persuasion dialogue, where there is a burden to defend an assertion that is questioned by the other party. In the argumentation literature, this requirement is called the burden of proof. However, there is an issue about whether making a proposal in a deliberation dialogue carries with it a burden of proof (Gordon et al., 2007), which suggests that the obligation on the hearer to support P may not be realistic in human deliberation dialogue. This problem is taken up in this paper where we analyze the problem of burden of proof in deliberation dialogue.

According to the account of the speech act of making a proposal of Kauffeld (1998), a proposal must present a statement of resolve that expresses a determination or conclusion that the speaker has reached. Kauffeld holds that the speaker makes a proposal with the intention of answering objections against it, and therefore incurs a burden of proof to defend the proposal. But it has been argued that making a proposal in a deliberation dialogue is different from making a claim in a persuasion dialogue, which does incur a burden of proof (Gordon et al., 2007). In persuasion dialogue, the participant that holds the burden of proof must answer to critiques to the claim because of the need to satisfy this burden. In contrast, recently Walton (2014) shows that there is no comparable burden of proof attached to the speech act of making a proposal in a deliberation dialogue. In deliberation, the goal is for the group of agents to arrive collectively at a decision on what to do. If the proposing agent fails to defend a proposal by immediately presenting an argument in support of the proposal, it should not have to retract the proposal. The problem is to understand the reasons for which the respondent has a problem with the proposal. Accordingly, the speech act protocol needs to allow participants to postpone answers to critiques to the proposal, to account for other proposals or explanations of circumstances. However, in existing dialogue protocols for multiagent deliberation that are often derived from persuasion dialogue games (McBurney et al., 2007; Kok et al., 2011; Medellin-Gasque et al., 2011; Walton et al., 2014), this flexibility is not permitted, and failing to answer to a critique would require a proposal to be withdrawn.

The absence of burden of proof in deliberation leads to a quest for a different model of protocols that considers what constraints arise between participants when a speech act is moved. In this paper, we propose a formal model of norms used to define protocol rules for deliberative dialogue. In multiagent systems, norms describe the ideal behavior of the agents in a society (Kollingbaum and Norman, 2004). We explore the use of norms to define what speech acts an agent is obliged or permitted to perform, and which are prohibited. Our dialogue protocol

is said to be *norm-governed* as the norms regulate when an agent is allowed to make a move in the dialogue.

The core idea of norm-governed dialogues is the association of the burden of proof to an obligation for the agents to defend a claim. In persuasion, an obligation after an opponent's critique requires a proponent to defend or to withdraw the claim. Failing to do so leads to a violation that forces the parties to terminate the dialogue. Here, we argue that in deliberative dialogue such an obligation must be substituted with a permission to answer a critique, where agents may reply with a supportive argument for a proposed action or may exchange explanations, but they are not obliged to. Therefore, there is no violation of the protocol if they choose not to put forward a counterargument.

In this paper, we analyze the problem of burden of proof in deliberation. We survey recent work on formal models of deliberation dialogue in AI in Section 2. We discuss how the rules for performing speech acts need to be reconfigured to account for the absence of burden of proof in deliberation (Section 3). We then present the characteristics of our norm-governed deliberation dialogues in Section 4. Our deliberative protocol permits some degree of flexibility in providing justifications for proposals that were not formally allowed for in previous models.

2. COMPUTATIONAL MODELS OF DELIBERATION DIALOGUE

In this section, we briefly survey recent work on computational models of deliberation dialogue. We show that the configuration of these speech act protocols raises issues about the burden of proof.

Models of deliberation dialogue proposed so far in the AI literature consider a group of agents, with each member pursuing its own goals. At the same time, there is the overall goal of the deliberation dialogue itself: the agents have to decide what course of action to take in a particular set of circumstances requiring a choice between alternative courses of actions (Medellin-Gasque et al., 2011). To achieve their collective goal, the agents have to collaborate with each other. At the same time, each will have its own interests or plans and proposals from different agents may conflict with each other. Agents may even disagree about what the circumstances of the decision are that constrain the choices. The best way forward is for the agents to present arguments, to critically examine the arguments put forward by others, and to collect evidence drawn from the circumstances of the case to produce other arguments that support or attack the arguments previously put forward.

Current formal argumentation systems developed in AI use argument mapping tools that can be applied to modeling the structure of arguments. This structure may be represented using argumentation

schemes, or using defeasible *modus ponens* (Walton, 1995) as rules of inferences in computational argumentation systems. Here we have chosen the Carneades Argumentation System (CAS) to make an argument map of the sequence of reasoning in the examples below (Gordon et al., 2007). In this system, the ultimate conclusion of the sequence of argumentation is shown at the left of the page and the arguments supporting or attacking it are displayed as a tree structure leading to the ultimate conclusion, which is the root of the tree. A pro argument is shown with the plus sign in its node, a con argument is shown with a minus sign.

In this paper we will use Example 1 presented in Toniolo et al. (2012) where the deliberation process sees two agents involved in the operations for responding to a natural disaster.

> (1) Two agents x, a local authority, and y, a humanitarian organization, are concerned with the repair of the water supply in a location that has suffered catastrophic damage. Agent x proposes to stop the water supply to the location in question. Agent y argues that there is a need for water in that location to run a field hospital, which is required to aid disaster victims. Agent x proposes that the supply of water to the location must be stopped because the water is contaminated. Agent x argues that supplying water to the location is not safe because x has scheduled the use of excavators during that time. To solve the problem, x and y should modify their individual plans. Such changes are constrained by the goals of agents x and y, the circumstances of the case (or by what is known of them), and by values such as public safety.

There are several important features of the argumentation in this example. First, the speech act of making a proposal is centrally important. Second, arguments are used to support or attack proposals. The features can be shown using an argument map. The pro argument used to support *x*'s proposal is shown at the top of Figure 1, while the con argument attacking it is shown at the bottom.

In the disaster example the two parties have conflicting proposals. In this case, agents must continue the dialogue to see whether some compromise can be made. Perhaps the field hospital could be located in a different area or the excavations could be carried out at a different time. The best way for the deliberation to move ahead is for the two parties to engage in a collaborative discussion in which they inform each other of their goals and means that could be devised in order to enable fulfillment of both their goals.

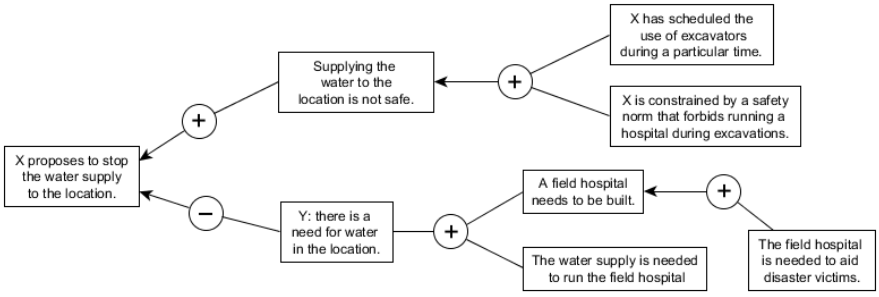

Figure 1 – Argumentation map of the disaster example

Speech acts in deliberation models

The first model of deliberation dialogue developed in the AI literature was the McBurney, Hitchcock and Parsons (MHP) model, which identified eight stages in a deliberation dialogue (McBurney et al., 2007).

1. *Opening Stage*: the collective goal of the dialogue is an issue or 'governing question' that applies to the whole dialogue. The issue is to decide what to do in a given set of circumstances.
2. *Inform Stage*: there is a discussion of goals, any constraints on the actions being considered, and any external facts relevant to the discussion.
3. *Propose Stage*: proposals are put forward by any of the parties.
4. *Consider Stage*: comments are made on the proposals that have been brought forward, and arguments for and against proposals are considered.
5. *Revise Stage*: the goals, the actions that have been proposed, and the relevant facts may be revised.
6. *Recommend Stage*: participants recommend a particular action which others can accept or reject.
7. *Confirm Stage*: participants together confirm their acceptance of one selected option.
8. *Close Stage*: participants arrive at a good decision on what to do.

In a dialogue model, the speakers have to take turns making their proposals and commenting on alternative proposals. A *communication protocol* is a set of rules agents use to communicate with each other by determining which part of the conversation comes at which point in the exchange and the permissible speech acts that can be made at each move. There are several kinds of distinctive speech acts recognized in the MHP model of deliberation dialogue. These include speech acts for making a proposal, asserting a statement, stating a preference for an action, asking

the other party to justify an assertion, saying whether a proposal should be accepted or rejected, retracting a previous assertion, and withdrawing from the dialogue. Permitted speech acts are represented in Figure 2 using a simplified finite state machine diagrams. More complex diagrams may report the subject of speech acts. Here, we only represent the type of speech acts (outgoing edges) that can be used to reply to speech acts previously performed (incoming edges).

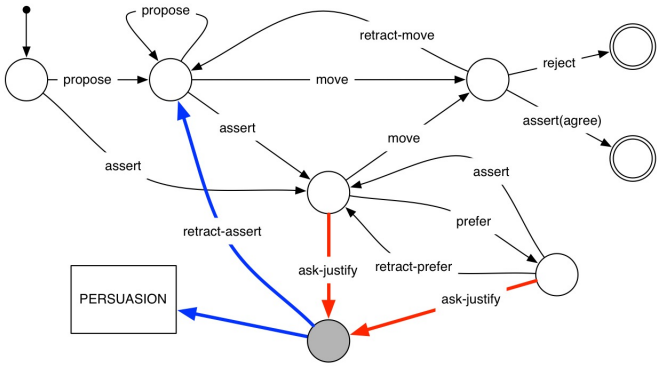

Figure 2 – Speech acts of the MHP model

In this research we argue that the speech acts employed as moves between the agents in a deliberation dialogue need to be refined. In the MHP model, when the speaker puts forward a proposal the hearer is required, in its next move, to either reject the proposal or to challenge it by asking *"Why propose P?"*. In reply to this question, the hearer is then obliged to give an argument supporting P. This is due to the burden of proof which is assigned to the participant who makes a suggestion, even after critiques by other participants. The consequence of this BoP allocation is explicitly represented via the protocol rules that regulate the dialogue. In the MHP dialogue, the use of the act *ask-justify* challenges previous statements and at the next turn, requires agents to: either shift to a persuasion dialogue to persuade the opponents that it is worth considering the current action proposal; or retract the statement that was challenged, weakening the support for the proposed action or removing that action from the commitment store. Therefore, we can observe that agents have an obligation to defend their proposal or it is likely that the proposal will be dropped.

Many approaches to deliberative dialogue for collaborative agents consider extensions to the MHP model of dialogue for interaction between agents to decide upon the best action (e.g., Kok et al., 2011) or plan (e.g., Medellin-Gasque et al., 2011) to perform.

The aim of the argumentation-based dialogue in Medellin-Gasque et al.'s work is to evaluate plans according to preferences among values

based on the argumentation scheme for practical reasoning where challenges follow critical questions (CQs). The proposal is a partial plan corresponding to a path of actions for achieving intermediate goals; those must be agreed upon before continuing to the next part of the plan.

The dialogue protocol uses speech acts defined via preconditions and effects, and dialogue phases inspired by the MHP protocol. The use of both acts *challenge(CQ)* and *question(CQ)* correspond to asking for a justification. The protocol is, however, more restrictive than the MHP protocol: the answer to challenges must defend the proposal or the proposal itself is retracted. A representation of the speech acts is shown in Figure 3.

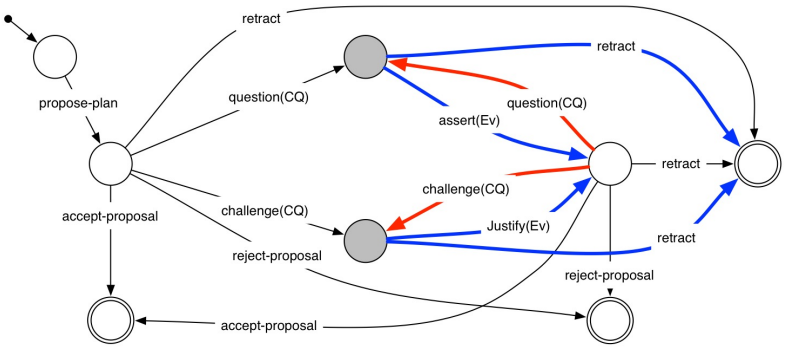

Figure 3 – Speech acts of Medellin-Gasque et al. (2011)

In the approach of Kok et al. (2011) a team of agents aims to choose the best action to achieve a goal. The protocol is based upon the protocol for persuasion of Prakken (2006) and inherits its characteristics of responses to challenges. When one of the *why* questions is asked to proponents, they must reply with *argue* or retract the proposal. If *why* is asked to opponents, they must argue or accept the proposal. Toniolo et al. (2012) developed a further model of deliberation dialogue based upon the protocol of Kok et al. (2011) by using the argumentation scheme for practical reasoning to help agents carry out a collective task by identifying conflicts between their plans. The plans of individual agents are interdependent, driven by different objectives and social constraints, leading to asymmetric knowledge of how the state of the world is modified by individual agents. The use of practical reasoning leads agents to form better collaborative plans to move forward in the deliberation sequence. The speech acts permitted are shown in Figure 4 and 5.

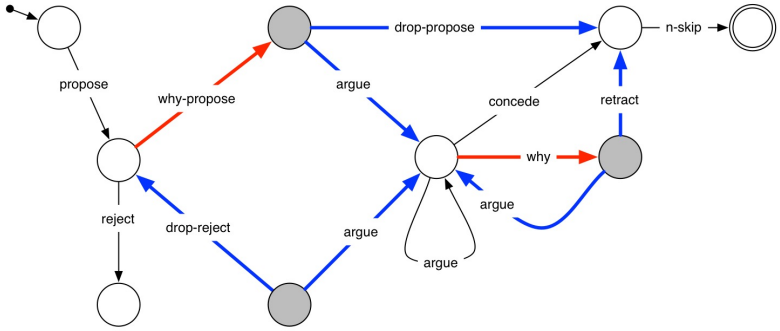

Figure 4 – Speech acts of Kok et al. (2011)

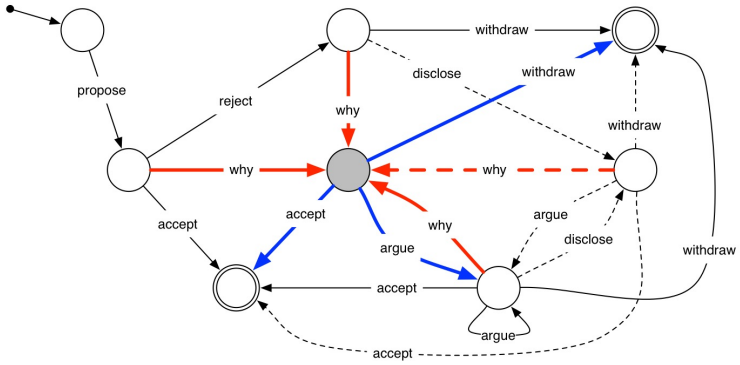

Figure 5 – Speech acts of Toniolo et al. (2012) – Dotted lines represent the Walton et al. (2014) extension

Walton et al. (2014) argued that a computational model of deliberation useful for dynamic multiagent systems is best based on a natural concept of deliberation, meaning that it should share certain important features with real examples of natural language deliberation. One important feature of natural deliberation is that it needs to remain open to collecting new information and considering arguments as long as this procedure continues to be fruitful, but at the same time it needs to be closed off once the circumstances require, arriving at a timely decision on what to do. An open knowledge model was designed to capture the capability of a deliberating agent to update its practical reasoning based on information regarding the circumstances of the practical problem acquired as the dialogue proceeds. This feature enhances the adaptability of a plan in relation to circumstances that may be rapidly changing. This way of setting up speech acts in deliberation protocols was followed in Walton et al. (2014). The additional moves in the protocol are represented with dotted lines in Figure 5.

In existing frameworks, the burden of proof is held by the participants that propose an action in the dialogue, and this guides the type of answers that are allowed after challenging a statement. For example, we have observed that to a question "*Why?*", the proponent must answer with a defending argument, or withdraw the proposal or an argument for this. This approach is derived from persuasion dialogue, but the problem is that it raises issues about burden of proof in deliberation. This problem is taken up by the present paper.

3. BURDEN OF PROOF IN DELIBERATION DIALOGUE

In this section we analyze the problem of burden of proof in deliberation dialogue, and introduce the reconfiguration of existing dialogue protocols in AI to model this problem.

The participants in a deliberation dialogue take turns making moves during the argumentation stage. These include the speech act of making a proposal, retracting a proposal, making an assertion, retracting an assertion, putting forward an argument, defending a goal, and attacking a goal.

In a persuasion dialogue, there is a burden to defend an assertion that is questioned by the other party. This means that if the proponent fails to defend the assertion it has made, it must immediately retract that assertion. This notion of burden of proof, albeit important, is a slippery one that is hard to define (Walton, 2014). One needs to begin by drawing a distinction between global and local burdens of proof. A global burden of proof is set at the opening stage of a dialogue. Once set in place, it applies through the whole argumentation stage. At the closing stage it is used to determine the outcome of the dialogue. The local burden of proof in a dialogue applies to speech acts made in moves during the argumentation stage. For example, in a persuasion dialogue the global burden of proof, called the burden of persuasion in law, is set by law at the opening stage of a trial. But requirements to supply evidence stemming from this global burden of proof are brought into place during the pro-contra argumentation by both sides during the trial. If one participant makes an assertion of proposition P during the argumentation stage, and the other party challenges that assertion, it can be assumed that there is a burden on the party who made the claim to provide evidential support for it. In law this is called the evidential burden, as contrasted to the global burden of proof set at the opening stage (Walton, 2014).

There is no comparable burden of proof attached to the speech act of making a proposal in a deliberation dialogue. First, the goal of the deliberation dialogue is not to resolve a conflict of opinions by putting forward pro and con arguments on both sides. Instead the goal set at the

opening stage is for the group of agents to arrive collectively at a decision on what to do. Suppose an agent puts forward a proposal in a deliberation dialogue and another agent questions it. If the proposing agent fails to defend its proposal by immediately presenting an argument in support of the proposal, the proposal does not need to be retracted. When a proposal is put forward by an agent it is assumed that this proposal is part of a feasible plan of action that this agent has thought about. The problem is that another agent in the dialogue might have a different plan. If so, this other agent can object to the proposal put forward by the first agent. But an appropriate response to the objection is that the plans are interdependent and need to be integrated, as indicated in the disaster response example.

In Walton et al. (2014) it was argued that feasibility can be determined by the increase in the number of conflicts resolved between the two plans. A speech act protocol must enable the timely asking of questions about another party's plan in a deliberation without this questioning being perceived as an attack of the kind one might have in a persuasion dialogue where fulfillment of burden of proof for an assertion is immediately demanded and required. There needs to be room for a discussion in which one party can ask the other about its plans and goals without being perceived to be pressing an argumentative attack against them. While deliberation can have its adversarial aspects, the speech act protocols need to be set up in such a way that an agent may ask constructively about the plans and goals of another agent, and offer an explanation about its own plans and goals. A framework is needed within which an agent can explain its plans and goals, as well as its knowledge of the present circumstances, to another agent who has put forward a different proposal as a means for answering the governing question.

A brief caution also needs to be inserted here. Another important aspect that is often overlooked is that there can be shifts to other types of dialogue, for example a shift from a deliberation dialogue to a persuasion dialogue or to an information-seeking dialogue (Walton and Krabbe, 1995). There are burdens of proof in these two latter types of dialogue, but if one is unaware of the shift, it may seem that the burden of proof resides in the deliberation dialogue itself.

The ambiguity of the asking of a why question in a deliberation dialogue was already acknowledged in Walton et al. (2014) when it was noted that when an agent asks a why question it is asking the question *"Why do you want to perform this action?"*. When the other agent poses con arguments it can do so by explaining some circumstances, using the speech act (Arg_{sup}). This speech act could be described as a counterargument but it has the function of explaining circumstances. The capability to allow for explanation to be embedded in arguments (Bex and Walton, 2011) is very important in deliberation because an agent

may need to take the initiative to exchange new information about the circumstances at any point in the dialogue. Accordingly, the speech act protocol needs to be set up to allow that an appropriate response can be either an argument, an introduction of new information about the circumstances, or an explanation of, say, an agent's plans or goals. Tolerance has to be made for the permitting of such speech acts at any point in a deliberation dialogue. For these reasons, a narrow framing of the burden of proof in the way that is characteristic of persuasion dialogue is inappropriate in deliberation dialogue.

Deliberation protocols with no BoP

To set up a speech act protocol that conforms to the approach described above, we see the sequence as proceeding along these general lines. When an agent puts forward a proposal, arguments supporting or attacking it are naturally advanced, leading to pro and con argumentation in which many arguments support or attack other arguments connected into a network of argumentation. But suppose an agent fails to defend its proposal in the face of an attack against it by another agent. This will mean that the proposing agent will lose ground for support of its proposal by the other participants in the deliberation or unless somehow during the subsequent dialogue some moves are made that overcome the deficiency in the proposal that has been pointed out, unless the proposal is modified to meet the objection. However, the protocol should be that if an agent fails to defend a proposal it has brought forward, the dialogue should move on to other considerations. For example, agents may need to modify their plans to take into account new information acquired during the dialogue. The dialogue terminates when an agreement is found on how to move forward with a practical reasoning sequence needed to solve the problem set at the opening stage. Even an undefended proposal may in the end be adopted if no other alternatives exist that are any better are found, or if new information has come to light during the dialogue that strongly supports the undefended proposal or shows that it is not really open to an objection that was earlier posed.

For these reasons we define a range of reactions by a hearer agent when a speaker agent puts forward a proposal in a deliberation dialogue. The responding agent can, of course, accept or reject the proposal, but this does not matter very much at this stage. The reason is that after the proposal is discussed and explained there will be a point just before the closing stage where agreements or disagreements with the proposal can be voiced. Often a vote is taken, for example. What matters at this earlier point where the proposal has just been introduced is whether the respondent has a problem with the proposal. There can be a range of such problems. One of the leading ones is that the respondent might have a

different plan of action, and therefore might want to question the proposal with regard to differences between different plans of action. Another problem is that the respondent might not understand the proposal, because understanding it presupposes knowledge of the complex plan that the proposer has in mind. The proposer in this case needs to explain the plan in a way that responds to the questioner's problem. Another problem is that the respondent, even though it is generally agreeable with the proposal, might think that it needs to be modified in certain respects before it will work. Another option is for the responding agent to present a different proposal. The sequence of dialogue may then take the route of exploring the differences between the two proposals.

The protocol for speech acts in a deliberation dialogue should be flexible enough to admit all these options, even if the participants failed to support the proposals at some point in the dialogue. The aim is to direct the dialogue down a sequence of argumentation in which various proposals are articulated and refined, leading either to some general agreement on a compromise proposal, or at least the formulation of a set of clear proposals so that the participants are well-informed enough that they can have good grounds to either agree with or disagree with any particular proposal. Simply to say that there is a burden of proof to either prove or refute a proposal at the next point in the dialogue where the respondent has to reply to it, would restrict these possibilities.

In conclusion, although it seems like a very controversial thesis to uphold, there is no burden of proof in a deliberation dialogue. There is only a burden of responding appropriately to a proposal by answering it with a range of replies that moves the deliberation dialogue forward. We refer to this as the *burden of responding constructively (BrC)* and in the next section, we will define a norm-governed protocol that accounts for the BrC and the absence of BoP in deliberation.

4. NORM-GOVERNED DIALOGUES

In multiagent systems, norms describe the ideal behavior of the agents in a society (Kollingbaum and Norman, 2004; Gasparini et al., 2015). Norms generally represent permissions, obligations and prohibitions. In this research, we exploit this diversity of constraints to model the requirements in responding to challenges during dialogue imposed by the burden of proof. We claim that the burden of proof in deliberation in existing research corresponds to an obligation to respond to a challenge. Such a burden, however, does not exist in deliberation. In contrast, agents are permitted to respond to challenges, but answers to such challenges can be postponed or omitted. For simplicity, we refer to a deliberative dialogue with burden of proof as a BoP dialogue and to our proposed

dialogue with burden of responding constructively as a BrC dialogue. In this section, we define a norm-governed dialogue in a multiagent environment based on the protocol of Walton et al. (2014).

Following Walton and Krabbe (1995), the elements of a communication protocol include: *locution rules* (i.e., moves possible); *structural rules* (i.e., moves allowed); *commitment rules* (i.e., players' commitments); and *termination rules*. The novelty of a norm-governed dialogue lies in the introduction of norms to define structural rules and termination rules.

4.1 Locution rules

In our dialogue, a speech act is $perf(\vartheta)$, where $perf$ is a performative and ϑ is a subject defined among plans of agents. Plans are formed by goals, states of the world and actions, expressed via sentences ℓ_i in a logic language L_t as defined in Toniolo et al. (2012). The dialogue is among a set of agents $Agt = \{x, y, z, \dots\}$ and proposals are actions $\mathcal{A} = \{A_k, A_l, \dots\}$. Arguments $Args$, defined with sentences ℓ_i, are built as argumentation schemes from negative consequences (Walton, 1995), stating that an action A_k should not be brought about because it conflicts with other goals or actions. We refer to instances of this type of argument as Arg_{def}. Information about circumstances and explanations for proposed actions can be exchanged by offering support to previously stated claims via supporting arguments Arg_{sup}.

The speech acts that we consider are:

- $propose(A_k)$: agent proposes an action;
- $reject(A_k)$: agent rejects the proposal;
- $accept(A_k)$: agent accepts the proposal;
- $withdraw(A_k)$: agent withdraws the proposal;
- $why(\ell_i)$: agent asks a question *"why?"* to challenge an argument $\ell_i \in Arg_{def}/Arg_{sup}$ or an action $\ell_i = A_k/\neg A_k$;
- $argue(Arg_{def})$: agent presents an attacking argument against a sentence ℓ_i where $\neg\ell_i \in Arg_{def}$;
- $disclose(Arg_{sup})$: agent presents a supporting argument for a sentence ℓ_i where $\ell_i \in Arg_{sup}$.

A dialogue d is formed by a sequence of moves m_i, executed in a turn-taking fashion, where no repetitions are allowed. Each move is identified by the player of the move in Agt, and a speech act $perf(\vartheta)$.

4.2 Structural rules

Structural rules state when agents are allowed to speak and what they are permitted to say. In a norm-governed dialogue, these rules are

represented with norms using the CÒIR language (Gasparini et al., 2015). Norms in CÒIR are defined as obligations, permissions or prohibitions to achieve certain states. In our formalism these are dialogue states. Norms are activated according to a condition over previously achieved states. Each norm expires in a new dialogue state. Let DKB represent a knowledge base of a dialogue state.

Definition 1. *A norm n_i is defined as a tuple:*

$$\langle idn_i, mod_i, act_i, goal_i \rangle$$

where: idn_i a unique identifier; mod_i is chosen among $\{O, P, F\}$ where P is a permission, O an obligation and F a prohibition ($\neg P \equiv F$); act_i is the activation condition that, when matched in DKB, causes a norm to activate; and $goal_i$ is the state to be achieved or avoided.

Conditions act_i and $goal_i$ are formulated in terms of predicates `q(?v)` with variables represented as `?v`, and constants as `c`. Note that a prohibition corresponds to the absence of permission. The following elements mark certain properties of the dialogue:

- `agent(?agt)`: an agent in Agt;
- `prop(?agt,?act)`: a proponent `?agt` $\in Agt$ of `?act` $\in \mathcal{A}$;
- `spoke(?agt)`: a player `?agt` has spoken;
- `done(?perf,?subj,?agt)`: m_i has been moved by agent `?agt` containing a speech act $perf(\vartheta)$ composed by `?perf`$= perf$ and `?subj` $= \vartheta$
- `others(?agtx)`: a function that returns a group of agents `?agty` $\in Agt$ excluding `?agtx`;
- `memberOf(?agt,?group)`: an agent `?agt` $\in Agt$ member of a group `?group` $\subseteq Agt$.

In norm-governed dialogues, norm compliance is tested at each dialogue state. Following Gasparini et al. (2015), we use a Kripke structure DKS to represent the possible evolutions of the world as a directed graph with states as nodes. A sequence of moves in a dialogue is a path in the graph where arcs correspond to moves, represented as $\rho_h = s_0 \rightarrow^{m_1} s_1 \rightarrow^{m_2} \ldots \rightarrow^{m_h} s_h$. Intuitively, DKS represents a formalism for the graphs of Section 2. We refer to a formula entailed by the structure as a formula that is evaluated to true in a particular state, $(DKS, s) \vDash \varphi$. The knowledge base DKB in a state s is the set of propositions entailed by DKS such that $q \in DKB(s)$ if and only if $(DKS, s) \vDash q$. Further, we assume that at each transition $s_i \rightarrow^{m_{i+1}} s_{i+1}$, `spoke(agt)` and `done(perf,subj,agt)` hold in s_{i+1}. After a move $propose(A_k)$, a predicate `prop(agt,Ak)` holds and the move $withdraw(A_k)$ removes

`prop(agt,Ak)`. This maintains a record of the active proposals during a dialogue.

In order to evaluate norm-compliance, we match the activation condition act_i of each norm n_i against $DKB(s')$ in a state s'. If it holds, we refer to the instantiated condition as $act_i(\theta_j)$ where $(DKS, s') \vDash act_i(\theta_j)$. The instantiated goal of the norm $goal_i(\theta_j)$ is tested against the next state s'' to determine the norm-compliance of move m'', where $s' \rightarrow^{m''} s''$.

Consider a path ρ_h for dialogue d_h. We define a *norm store* $NS(s)$ for gathering active norms and an evaluation function $\mathcal{V}(s)$ to label violations for each state $s \in \rho_h$.

Definition 2. *The norm store $NS(s)$ is defined for a dialogue state $s \in \rho_h$ as a set of tuples $\langle mod_i, goal_i(\theta_j)\rangle$ of a norm n_i activated in state s.*

$NS(s)$ is updated at each transition, and emptied when a new transition is executed in path ρ_h.

Definition 3. *An evaluation function $\mathcal{V}(s): S \rightarrow$ {`compliant`, `non-compliant`} labels each dialogue state $s \in \rho_h$. Given $s' \rightarrow^{m''} s''$, state s'' is* `non-compliant` *when:*

- *A forbidden goal is achieved: $(DKS, s'') \vDash goal_i(\theta_j)$ and $\langle F, goal_i(\theta_j)\rangle \in NS(s')$,*
- *An obliged goal is not achieved: $\langle O, goal_i(\theta_j)\rangle \in NS(s')$ and $(DKS, s'') \nvDash goal_i(\theta_j)$, or*
- *None of the goals is permitted: $\nexists goal_i(\theta_j)$ s.t. $\langle P, goal_i(\theta_j)\rangle \in NS(s')$ and $(DKS, s'') \vDash goal_i(\theta_j)$.*

Otherwise, s'' is `compliant`*.*

The norms that model the protocol of Walton et al. (2014) as a norm-governed dialogue with BoP are:

1. Norms to regulate turn-taking $N_T = \{n_{t1}\}$: The last agent who spoke is forbidden to speak.
2. Norms N_P to define what an agent is permitted to say:
   - n_{p1}: A proposal is always permitted.
   - n_{p2}, n_{p3}: Every agent, except the proponent, is permitted to reject or accept a proposal.
   - n_{p4}: Only the proponent is permitted to withdraw the proposal.
   - n_{p5}: Every agent is permitted to disclose information after a proposal has been moved.

- n_{p6}, n_{p7}: A why or argue move (both with the intent to challenge a statement) is permitted after accept, propose, disclose, argue, reject and why.

3. Norms N_O that impose obligations on agents to respond in a certain way:
   - n_{o1}: Agents are obliged to move reject, why or accept after *propose*.
   - n_{o2}: Agents are obliged to move disclose, why or withdraw after *reject*.
   - n_{o3}: Any response to *withdraw* is forbidden.
   - n_{o4}: Any response to *accept* is forbidden.
   - n_{o5}: Agents are obliged to move argue, why, withdraw or accept after *disclose*.
   - n_{o6}: Agents are obliged to move why, argue, disclose, withdraw or accept after *argue*.
   - n_{o7}: Agents are obliged to move argue, withdraw or accept after *why*.

These norms are formalized in Figure 6.

Observation 1. *The structural rules of a norm-governed protocol for deliberation dialogue with BoP are formed by* $N_{BoP} = N_T \cup N_P \cup N_O$. *The obligations* n_{o6} *and* n_{o7} *impose a burden of proof on the proponent requiring it to immediately respond to a challenge.*

Here, we argue for the need of a protocol that accounts for the absence of burden of proof in deliberation — BrC. This is represented by a new set of obligations $N_O{}'$ that includes $n_{o1}, n_{o2}, n_{o3}, n_{o4}, n_{o5}$, but excludes n_{o6} and n_{o7} as they are responsible for imposing the burden of proof. We also remove n_{o3} permitting agents to continue the dialogue after withdrawing a proposal.

Observation 2. *The structural rules of a norm-governed protocol for deliberation dialogue with BrC are formed by* $N_{BrC} = N_T \cup N_P \cup N_O{}'$ *that include obligations for propose, reject, accept and disclose. Replies to argue and why challenges are permitted but not obliged.*

N_T:
$n_{t1} = \langle idn_{t2}, F, act_{t2} = \texttt{agent(?agtx)} \wedge \texttt{spoke(?agtx)}, goal_{t2} = \texttt{spoke(?agtx)} \rangle$

N_P:
$n_{p1} = \langle idn_{p1}, P, act_{p1} = \texttt{true}, goal_{p1} = \texttt{done(propose,?actk,?agtx)} \rangle$
$n_{p2} = \langle idn_{p2}, P, act_{p2} = \texttt{IN\{agent(?agtx)} \wedge \texttt{prop(?agtx,?actk)\}FILTER NOT EXISTS}$
$\texttt{\{prop(?agty,?actk)\}}, goal_{p2} = \texttt{done(reject,?actk,?agtx)} \rangle$
$n_{p3} = \langle idn_{p3}, P, act_{p3} = \texttt{IN\{agent(?agtx)} \wedge \texttt{prop(?agtx,?actk)\}FILTER NOT EXISTS}$
$\texttt{\{prop(?agty,?actk)\}}, goal_{p3} = \texttt{done(accept,?actk,?agtx)} \rangle$
$n_{p4} = \langle idn_{p4}, P, act_{p4} = \texttt{prop(?agtx,?actk)}, goal_{p4} = \texttt{done(withdraw,?actk,?agtx)} \rangle$
$n_{p5} = \langle idn_{p5}, P, act_{p5} = \texttt{prop(?agtx,?actk)}, goal_{p5} = \texttt{done(disclose,?subj,?agty)} \rangle$
$n_{p6} = \langle idn_{p6}, P, act_{p6} = \texttt{done(propose,?subj,?agtx)} \vee \texttt{done(disclose,?subj,?agtx)} \vee$
$\texttt{done(argue,?subj,?agtx)} \vee \texttt{done(reject,?subj,?agtx)} \vee \texttt{done(why,?subj,?agtx)} \vee$
$\texttt{done(accept,?subj,?agtx)}, goal_{p6} = \texttt{done(why,?subl,?agty)} \rangle$
$n_{p7} = \langle idn_{p7}, P, act_{p7} = \texttt{done(propose,?subj,?agtx)} \vee \texttt{done(disclose,?subj,?agtx)} \vee$
$\texttt{done(argue,?subj,?agtx)} \vee \texttt{done(reject,?subj,?agtx)} \vee \texttt{done(why,?subj,?agtx)} \vee$
$\texttt{done(accept,?subj,?agtx)}, goal_{p7} = \texttt{done(argue,?subl,?agty)} \rangle$

N_O:
$n_{o1} = \langle idn_{o1}, O, act_{o1} = \texttt{done(propose,?subl,?agtx)}, goal_{o1} = \texttt{EXISTS\{memberOf(?agty,}$
$\texttt{others(?agtx))} \wedge \texttt{[done(reject,?subj,?agty)} \vee \texttt{done(why,?subj,?agty)} \vee$
$\texttt{done(accept,?subj,?agty)]\}} \rangle$
$n_{o2} = \langle idn_{o2}, O, act_{o2} = \texttt{done(reject,?subl,?agtx)}, goal_{o2} = \texttt{EXISTS\{memberOf(?agty,}$
$\texttt{others(?agtx))} \wedge \texttt{[done(disclose,?subj,?agty)} \vee \texttt{done(why,?subj,?agty)} \vee$
$\texttt{done(withdraw,?subj,?agty)]\}} \rangle$
$n_{o3} = \langle idn_{o3}, F, act_{o3} = \texttt{done(withdraw,?subl,?agtx)}, goal_{o3} = \texttt{done(?perf,?subj,?agty)} \rangle$
$n_{o4} = \langle idn_{o4}, F, act_{o4} = \texttt{done(accept,?subl,?agtx)}, goal_{o4} = \texttt{done(?perf,?subj,?agty)} \rangle$
$n_{o5} = \langle idn_{o5}, O, act_{o5} = \texttt{done(disclose,?subl,?agtx)}, goal_{o5} = \texttt{EXISTS\{memberOf(?agty,}$
$\texttt{others(?agtx))} \wedge \texttt{[done(argue,?subj,?agty)} \vee \texttt{done(why,?subj,?agty)} \vee$
$\texttt{done(withdraw,?subj,?agty)} \vee \texttt{done(accept,?subj,?agty)]\}} \rangle$
$n_{o6} = \langle idn_{o6}, O, act_{o6} = \texttt{done(argue,?subl,?agtx)}, goal_{o6} = \texttt{EXISTS\{memberOf(?agty,}$
$\texttt{others(?agtx))} \wedge \texttt{[done(argue,?subj,?agty)} \vee \texttt{done(withdraw,?subj,?agty)} \vee$
$\texttt{done(accept,?subj,?agty)} \vee \texttt{done(disclose,?subj,?agty)} \vee \texttt{done(why,?subj,?agty)]\}} \rangle$
$n_{o7} = \langle idn_{o7}, O, act_{o7} = \texttt{done(why,?subl,?agtx)}, goal_{o7} = \texttt{EXISTS\{memberOf(?agty,}$
$\texttt{others(?agtx))} \wedge \texttt{[done(argue,?subj,?agty)} \vee \texttt{done(withdraw,?subj,?agty)} \vee$
$\texttt{done(accept,?subj,?agty)]\}} \rangle$

Figure 6 – Norms for a norm-governed dialogue

4.3 Termination rules

A dialogue d terminates if: no further possible state exists after a last state s_h or agents enter an illegal state of the dialogue such that $\mathcal{V}(s_h) =$`non-compliant`. In the case of deliberation with BoP, the agents must reply to a speech act argue, or why with a counterargument, otherwise s_h is a non-compliant state that leads to an early termination of the dialogue. In a BrC dialogue, these obligations are removed and this early termination is avoided.

4.4 Norm-governed BoP and BrC dialogues: an example

Let us expand Example 1 to consider norm stores for BoP and BrC norm-governed dialogues in Example 2.

(2) Agent x proposes action A_1: stop the water supply (move m_1). This is rejected by y (m_2). Agent x explains that the water is contaminated (m_3) but y is not satisfied with this explanation and asks for further reasons with $why(A_1)$ in a move m_4. The dialogue path is $\rho_4 = s_0 \rightarrow^{m_1} s_1 \rightarrow^{m_2} s_2 \rightarrow^{m_3} s_3 \rightarrow^{m_4} s_4$. The norm stores for BoP and BrC at state s_4 are:

– DKB:

$(DKS, s_4) \vDash$ `prop(x,A1)∧spoke(y)∧done(why,A1,x)`

– Deliberation BrC:

$NS_{BrC}(s_4) = \{\langle P,$`done(propose,?actk,x)`$\rangle,$
$\langle P,$`done(withdraw,A1,x)`$\rangle, \langle P,$`spoke(x)`$\rangle,$
$\langle P,$`done(disclose,?subj,x)`$\rangle, \langle F,$`spoke(y)`$\rangle,$
$\langle P,$`done(why,?subj,x)`$\rangle, \langle P,$`done(argue,?subj,x)`$\rangle\}$

– Deliberation BoP:

$NS_{BoP}(s_4) = NS_{BrC}(s_4) \cup \{$
$\langle O,$`memberOf(x,others(y))∧[done(argue,?subj,x)`
`∨done(withdraw,?subj,x)]`$\rangle\}$

In a BoP dialogue, a move after s_4 must adhere to the obligation of replying to why with an argument. For example, x may say that the location is not safe as there are other interventions scheduled. The other option is for x to withdraw A_1 otherwise there is a violation of the protocol. We may observe that $why(.)$ in a BoP dialogue corresponds to $ask\text{-}justify(.)$ in a MHP dialogue. Counterarguments should be immediately moved, otherwise A_1 must be retracted.

In a BrC dialogue, the speech act argue is permitted, but additional options (as those listed in Section 3) are also permitted as per instantiations of N_P. For example, agent x may propose to postpone blocking off the water supply. Agent x may ask why to understand the reasons why agent y is reluctant to agree with the proposal. Agent x may disclose a part of its plan stating that there will be free access to water cisterns. In this way, agent x prevents y committing to refuse the proposal. Therefore, we can see that our new model of dialogue permits agents to postpone or omit answers to a challenge.

5. CONCLUSION

The focus of this research is to improve and enrich existing autonomous systems in the light of new findings on the theory of natural deliberation. Recently, Walton (2014) argued that there is no burden of proof in deliberation. In this paper, we showed that in AI even the most influential protocols for deliberation inherited the characteristics of burden of proof from persuasion dialogues. We proposed to overcome this problem by employing norms to define protocol rules. In norm-governed dialogues with BoP, the proponent is obliged to argue against a challenge. In

dialogues without BoP, the proponent is simply permitted to do so. This allows time for the participants to consider different proposals.

Other features of computational models of deliberative dialogue may be affected by the absence of BoP; e.g., how to decide which action to adopt, as agents may be committed to an action that has no support. The shifts to other dialogues with BoP should be modeled to ensure that the BoP requirements are reinstated. Norm-governed protocols may also, permit the definition of other dialogue features; e.g., the "right" to make a move. This involves a permission for an agent to move a speech act, while all the other agents would be prohibited to prevent the agent to speak.

We believe that the research proposed in this paper may give useful insights on how develop AI systems that more adequately capture the richness of natural deliberation.

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