

Distinguishing Propositional and Action Commitment in Agent Communication

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Abstract

Our goal is to extend agent communication languages for persuasion dialogues. We distinguish action commitments from propositional commitments, because both limit future moves, but an action commitment is fulfilled when the hearer believes that the action is performed, whereas a propositional commitment is fulfilled only when the hearer concedes to the proposition – where concessions are the absence of a belief to the contrary, and prevent further challenges. Using a common model for both kind of commitments and a role-based semantics of agent communication languages, we show how propositional commitments are related to public beliefs and action commitments to public goals.

1 Introduction

There are two popular approaches to formalize persuasion dialogues. The first approach, as exemplified by Dung's [1995] abstract argumentation theory, formalizes argumentation as a reasoning model based on constructing arguments and determining potential conflicts between arguments. The argumentation theory determines the acceptable arguments. The second approach is based on dialectics and dialogue games [Hamblin, 1970; Walton and Krabbe, 1995]. An advantage of this approach to persuasion dialogues is that it is closer to natural argument than theories of abstract argumentation, because it defines the semantics of dialogue in terms of the semantics of individual speech acts rather than global semantics of argumentation dialogue.

To implement argumentation dialogues, it makes sense to connect to standards and infrastructures for agent communication languages like [FIPA, 2002]. The meaning of a speech act is reflected in the mental attitudes – beliefs and goals – of the agents involved. However, traditionally the semantics of agent communication languages presupposes that participants are cooperative and sincere, and can therefore not cover non-cooperative types of dialogue such as persuasion or negotiation. Moreover, the semantics are unverifiable in open multi agent systems, because the beliefs and goals of individual agents are not accessible [Wooldridge, 2000]. These problems can be overcome by formulating the semantics of speech

acts in terms of the *social commitments* of agents, instead of their individual beliefs and goals [Castelfranchi, 1995; Singh, 2000; Fornara and Colombetti, 2004]. Because this approach deviates from existing standards and logics, in previous papers we have reconciled social commitments with the FIPA approach, using a *role based semantics* [Boella *et al.*, 2005; 2005; 2006b; 2006a]. Here, the meaning of a speech act is expressed in terms of the beliefs and goals publicly attributed to the roles played by the participants.

Now consider the following two sentences:

- (1) *A* promises *B* to deliver the goods before Friday.
- (2) *A* informs *B* that Al Gore would have been a better president than Bush.

The first sentence commits agent *A* to the delivery of goods before Friday, and the second sentence commits agent *A* to defend the argument that Al Gore would have been a better president than Bush. We say that the first sentence leads to an *action commitment* and the second sentence leads to a *propositional commitment*. Researchers in the social commitment approach to agent communication [Castelfranchi, 1995; Singh, 2000; Fornara and Colombetti, 2004] focus on the former, because they are interested in task oriented dialogue and negotiation. Researchers in the argumentation tradition on the other hand [Hamblin, 1970; Walton and Krabbe, 1995], focus on the latter: “to assert a proposition may amount to becoming committed to subsequently defending the proposition, if one is challenged to do so by another speaker” [Walton and Krabbe, 1995]. Despite these differences, in a sense, a promise and an inform have the same effect: they create a commitment of the speaker, respectively an action commitment or a propositional commitment.

Usually the meaning of a speech act is defined in terms of the attitudes of the speaker, without any effects on the hearer. But according to Kibble [2005], the meaning of a speech act must also be defined in terms of the effects on the hearer. In particular, an assertion that goes unchallenged may count as a concession for the hearer. This corresponds to the ‘silence means consent’ principle, already studied by Mackenzie [1979]. Walton and Krabbe argue that in case of a concession, the hearer becomes weakly committed to the proposition: the hearer can no longer make the speaker defend the proposition by challenging him, albeit the hearer does not have to defend the proposition himself if challenged.

In this paper, we therefore extend the role-based ‘bridge’ between social commitments and a FIPA-like approach to agent communication [Boella *et al.*, 2005; 2005; 2006b; 2006a]. We model both action commitments and propositional commitments in terms of concessions. After an assertion the hearer can make a concession explicitly, or implicitly by not challenging the assertion. So we reinforce Kibble’s claim that speech acts also have an effect on the attitudes of the hearer. To show the feasibility of the semantics, we model persuasion dialogues inspired by the PPD_0 protocol of [Walton and Krabbe, 1995]. We illustrate the approach by a dialogue that involves a mixture of propositional and action commitments.

The paper is organized as follows. In Section 2 we discuss social commitment in agent communication languages. In Section 3 we use a role based semantics for the formal analysis. In Section 4 we translate the social commitment approach of [Fornara and Colombetti, 2004] into role-based semantics.

2 Commitments in agent communication

Traditionally, the semantics of agent communication languages (ACL), such as those proposed by [FIPA, 2002] (Foundation for Intelligent Physical Agents), is based on mental attitudes. The meaning of speech acts is defined in terms of the mental state of the BDI agent who issues them, by means of so called rational effects and feasibility preconditions. The rational effect is the mental state that the speaker intends to bring about in the hearer by issuing a speech act, and the feasibility preconditions encode the appropriate mental states for issuing a speech act. The main drawback of FIPA resides in the fact it refers to mental states, which cannot be verified, unless we assume that agents are sincere, or cooperative [Wooldridge, 2000]. So, this type of semantics is not appropriate in non-cooperative circumstances, like persuasion dialogues, argumentation or negotiation. By contrast, meaning should be public, as claimed by Walton and Krabbe [1995], Singh [2000], and Fornara and Colombetti [2004] amongst others.

The social commitment (SC) approach to agent communication, e.g., [Castelfranchi, 1995; Fornara and Colombetti, 2004; Bentahar *et al.*, 2004; Singh, 2000], constitutes an attempt to overcome the mentalistic assumption of FIPA. Speech acts are defined in terms of the social commitments publicly determined for speaker and the hearer, by virtue of what was said. According to [Fornara and Colombetti, 2004], commitment is “a social relationship between the speaker and the hearer”. The social commitment approach needs the notion of obligation to explain how the social dimension of a commitment can affect the behavior of an individual agent. While this approach is mostly appropriate in competitive environments, like negotiation, its advantages are less clear cut in cooperative ones, like information seeking dialogues, where the weaker notion of expectation is sufficient to model conformance. Moreover, the reference to obligations brings into communication semantics the orthogonal issue of obligation enforcement [Pasquier *et al.*, 2004; Boella *et al.*, 2005].

In [Boella *et al.*, 2005; 2006b] we discussed how a role-

based semantics can deal with both mentalistic approaches and SC ones. In [Boella *et al.*, 2006a] we provide a common semantics to these two approaches. The role-based semantics advances the idea that the meaning of communication can be described in terms of beliefs and goals, but that those beliefs and goals must be maintained in public. The solution is to attribute beliefs and goals to roles played by the participants in the dialogue, rather than referring to the participants’ private mental states. The roles’ beliefs and goals are public and are constructed by the introduction or removal of beliefs and goals by the speech acts. An advantage of the metaphorical use of ‘beliefs and goals of roles’ is that we can reuse insights and standards from the mentalistic approach to agent communication, such as the [FIPA, 2002] standards.

The term commitment has been used in different ways, in particular, propositional and action commitment.

A commitment in [Fornara and Colombetti, 2004] has *debtor* and *creditor*, i.e., respectively, the agent who has the commitment, and the agent to which the commitment is made. If we interpret it as the beneficiary, we have that the creditor is interested in the content of the commitment.

According to [Bentahar *et al.*, 2004], the difference between an action commitment and a propositional commitment lies only in the type of content, and both kinds of commitment are fulfilled (or violated) if the content is true (false) in the world, albeit the debtor cannot do anything to make a propositional commitment true, whereas he can perform the action object of a commitment. At a closer analysis the definition of fulfillment is not correct for action commitment. According to these authors, a commitment is fulfilled if (at the deadline time) its content is true in the world. This objectivistic solution is too weak: fulfillment does not only depend on what is true in the world, but also on what is believed by the creditor. Thus the creditor can still claim to be entitled to the commitment, until he is convinced and the evidence is shared by both agents.

Moreover, this view of fulfillment is not realistic for propositional commitment. For propositional commitments the problem is made worse by the fact that their content is not restricted to actions whose execution can be monitored in the world. Consider, e.g., a commitment towards the fact that Al Gore would have been a better president than Bush. There is no way to fulfill such a hypothetical commitment, unless one of the agents concedes on the basis of arguments. This is the general case in persuasion and argumentation, e.g., in a political debate or in a trial.

An alternative solution is to define that a propositional commitment is fulfilled when the creditor also becomes committed to the proposition. But this is too strong, since not all assertions and informs aim to make the hearer believe them, and viceversa, not all informs and assertions aim to satisfy a goal of the creditor to know information. For example, in information seeking, the creditor wants to have reliable information but, in a dispute, he wants to win. In general, and in contrast with action commitment, there is not always a creditor who has the goal to have some information. In our approach, a propositional commitment is fulfilled when the hearer concedes, and, thus, cannot challenge the proposition anymore. Other possible goals, like that the hearer must come

to believe the proposition, depend on particular types of dialogues and have their own fulfillment conditions. Our role-based semantics allows to associate different fulfillment conditions to the roles that belong to different dialogue games.

Concerning concessions, inspired by [Kibble, 2005], we argue that an assertion creates by default a concession of the hearer, which can be in contradiction with his beliefs, unless he challenges the assertion. When the hearer challenges the assertion, the contradiction is passed to the speaker, and forces a retraction of the speaker, if not challenged in turn; and so on, until one of them does not have any arguments left to put forward, and concedes or retracts explicitly.

Finally, considering the creation of a commitment as a result of an assertion, as SC does, is different from the traditional interpretation, which sees propositional commitments as a kind of action commitment to defend the proposition, see section 4 below. Instead, a commitment to defend, is typically created by the challenge.

3 Formal analysis in a role model

According to [Ferber *et al.*, 2003] interaction is defined only between the roles of a group: “The communication model within a group can be more easily described by an abstracted interaction scheme between roles”. In contrast, most approaches to the semantics of agent communication languages do not take into account the fact that communication takes place among roles. ‘Speakers’ and ‘addressees’ or ‘buyers’ and ‘sellers’ are often mentioned. The terms ‘buyer’ and ‘seller’ are role names, which only act as place holders, that can be filled in by any agent: the only function they serve is to bind individual agents to the speech acts in the protocol, and they are not associated with a state which changes during the conversation as a result of the performed speech acts.

Boella et al [2005] propose to use the notion of role as a basis for a semantics of agent communication languages. Speech acts can still be modelled as plan operators with pre-conditions and effects which can refer to beliefs, goals and intentions, as in FIPA, but the mental attitudes they refer to are not the private inaccessible ones of the agents. Rather, the beliefs, goals and intentions are attributed to a public image of the participants in the dialogue representing the role they play. Roles, as often claimed, are defined as descriptions of expected behavior and in agent theory, behavior is modelled by means of mental attitudes attributed to roles, following Dennett’s intentional stance.

The term role is used in this paper in the same sense as role instances, *qua* individuals, or role enacting agents [Dastani *et al.*, 2003]), rather than as role types. Obviously, role types can not have mental attitudes or send messages, but role enacting agents can.

The advantage of using roles is that it overcomes the unverifiability problem of mental attitudes approaches, since the role’s mental attitudes are publicly attributed by the rules of the dialogue game according to the moves performed. To play a role an agent is expected to act *as if* the beliefs and goals of the role were his own: he should adopt his role’s goals and carry them out according to his role’s beliefs. Moreover, when a speech act is performed, the role’s mental attitudes

must remain coherent. Thus we adopt [Pasquier and Chaib-draa, 2003]’s view that dialogue arises from the need to maintain coherence: “two agents communicate if an incoherence forces them to do so. [...] Conversation might be seen [...] as a generic procedure for attempting to reduce incoherence”. An agent engaged in the dialogue tries to avoid contradictions, not within his private mental states, but within the public image which his role constitutes. As long as an agent plays a dialogue game according to the constitutive rules, he cannot deny that what was said will be considered as a public display of his position. Consider the example of a liar, who once he starts lying, has to continue the dialogue consistently with what he said before, independently of his real beliefs.

Note that our model keeps apart the motivations for playing a role from the rules of the dialogue game. In this way separate the public character of dialogue from the private motivations of the agents involved in a dialogue. Agents can adopt the mental attitudes attributed to roles for reasons of cooperativity, or they can be publicly committed to their roles as in institutional contexts. If a role is played for cooperativity, requests are adopted without any obligations. Sincerity is not required in general, but an agent may still be sincere, at least he acts as expected from his role, for the fear of losing reputation. In contrast, in other contexts, expectations are fulfilled for the fear of a sanction.

We now define the basic elements of a dialogue game, whose constitutive rules regulate the exchange of speech acts between agents in roles.

Definition 1 (Dialogue Game) A dialogue game $\langle A, RN, PL, R, B, G, SA, CR \rangle$ is a tuple where:

- A is a set of agents in the interaction, e.g., x, y .
- RN is a set of role names, like r_1, r_2, \dots
- $PL : A \times RN \mapsto R$ is a role playing function, such that $i = PL(x, r_1)$ is an agent-in-a-role. We will write $i = x:r_1$ for $i = PL(x, r_1)$.
- R is a set of agents-in-roles, e.g., $i = x:r_1, j = y:r_2$.
- B and G are respectively the beliefs and goals of individual agents, or agents-in-roles.
- SA is a set of speech acts: *assert, request, etc.*
- CR are the constitutive rules of the dialogue game: they specify how speech acts affect the attitudes of the roles, and create institutional facts.

We define a simple formal language, inspired by FIPA’s [2002] specification language and by its axioms, extending [Boella *et al.*, 2006a]. In this way we keep the language simple and understandable for a large community, even if we inherit its limitations.

Definition 2 (Language) Given a set of propositions L and actions AA , define

$$q := p \mid \neg q \mid q \vee q \mid q \wedge q \mid q \rightarrow q \mid B(m, q) \mid G(n, q) \mid done(m, act) \mid send(x, y, sa(i, j, q)) \mid sa(i, j, q) \mid i = x:r_1,$$

where $p, q \in L$, $x, y \in A$, $i, j \in R$, $m, n \in A \cup R$, $r_1 \in RN$, $act \in AA$, and $sa \in SA$.

B and G represent the beliefs and goals. According to this definition also agents-in-roles can have beliefs and roles. For simplicity here we do not distinguish goals from intentions.

We add the following rationality constraints, mostly inspired by FIPA. For all agents-in-roles i, j :

- Each role has correct knowledge about its own mental states, in particular, its beliefs about its goals are correct. This corresponds to FIPA's [2002] schema $\varphi \leftrightarrow B_i\varphi$, whenever φ is governed by a mental attitude:

$$\begin{aligned} (B(i, G(i, p)) \rightarrow G(i, p)) \wedge \\ (B(i, \neg G(i, p)) \rightarrow \neg G(i, p)) \end{aligned} \quad (1)$$

$$\begin{aligned} (B(i, B(i, p)) \rightarrow B(i, p)) \wedge \\ (B(i, \neg B(i, p)) \rightarrow \neg B(i, p)) \end{aligned} \quad (2)$$

- Since the attitudes are public, each role has the complete knowledge about the other roles' beliefs and goals:

$$\begin{aligned} (B(j, p) \leftrightarrow B(i, B(j, p))) \wedge \\ (\neg B(j, p) \leftrightarrow B(i, \neg B(j, p))) \end{aligned} \quad (3)$$

$$\begin{aligned} (G(j, p) \leftrightarrow B(i, G(j, p))) \wedge \\ (\neg G(j, p) \leftrightarrow B(i, \neg G(j, p))) \end{aligned} \quad (4)$$

- Sending a message is a way to perform a speech act:

$$i = x:r_1 \wedge j = y:r_2 \wedge \text{send}(x, y, sa(i, j, p)) \rightarrow sa(i, j, p). \quad (5)$$

These axioms deserve some discussion. Axiom (5) is used to connect individual agents, that can access resources and send messages, with the public roles that they play. Based on the speech act sa , a number of pre- and postconditions can be inferred, as detailed below. Since messages on a certain channel are public, and the constitutive rules CR are public, all inferences on the basis of speech acts are public too. This motivates axiom (3) and (4). From left to right: if one can infer for example a concession $\neg B(i, \neg p)$ by axiom (18), all agents j can infer that: $B(j, \neg B(i, \neg p))$. From right to left: if some agent j believes a concession can be inferred, there is actually a concession.

Only those mental attitudes are publicly attributed to the role, which follow directly from the agent's communication or from commonly held beliefs about the attitudes of particular roles, e.g., a buyer in a negotiation is expected to prefer a lower price. All other mental attitudes are attributed to the agent itself. As a consequence, professional secrets like passwords, which are related to playing a role, should under this interpretation not be modeled as beliefs or goals of the role, but as beliefs and goals of the individual agent. This marks a difference with other approaches to roles, such as [Dastani *et al.*, 2003].

Note that in the role model it is not assumed that the role's mental attitudes correspond to the mental attitudes of their players. This assumption can be made only when an agent is sincere, and can be expressed as:

$$\begin{aligned} B(i, p) \wedge i = x:r \rightarrow B(x, p) \\ G(i, p) \wedge i = x:r \rightarrow G(x, p) \end{aligned} \quad (\text{sincerity})$$

4 From commitments to roles

In this section we translate the social semantics for agent communication languages of Fornara and Colombetti [2004] to the role-based semantics. We explicitly distinguish between propositional commitments and action commitments, and by introducing concessions, we show how the social commitment approach can also be made to work for persuasion and argumentation dialogues. This enterprise presupposes that the similarities between action commitment and propositional commitment are more than accidental. This needs some argument, because "...the word commitment and the corresponding verb commit are used in many different ways, and there is no reason to suspect that there is a common core meaning in all of them." [Walton and Krabbe, 1995, p 13].

Our general intuition is that through making a commitment, the number of future options becomes restricted. For action commitment, this can be explained by referring to the well-known slogan that "intention is choice with commitment" [Cohen and Levesque, 1990]. Having the stability provided by commitments, makes sense when re-planning is costly, and when certain resources must be reserved in advance, e.g. time slots in an agenda [Bratman, 1987]. The same holds for commitments made to other agents. For example, by agreeing to meet on Friday at noon, future options to do other things on Friday, become restricted. Analogously, conceding to an action of another agent means agreeing not to prevent him from doing the action by making other conflicting commitments. For example, a concession to do an action which needs a car, implies that the conceder will not use the car for other purposes. Thus, the relation between commitment and concession is similar to the one between obligation and permission.

If we view argumentation or persuasion as a kind of game in which players make moves, a propositional commitment can also be said to limit the future possible moves a player can make. In particular, whenever an agent, the *proponent*, makes an assertion, he or she is committed to uphold that proposition. This means that all moves which would enable the other player, the *opponent*, to force the proponent to retract the proposition, must be avoided. Thus, here too commitments restrict the set of future options.

Just like one needs a specific logic of practical reasoning to explain action commitment, we need a specific persuasion protocol to explain propositional commitment. In this paper, we will take a persuasion protocol inspired by [Walton and Krabbe, 1995, p.150,151], and elaborated by [Gaudou *et al.*, 2006, fig 2]. Although this protocol is simplified, we believe it is sufficient to illustrate the notion of propositional commitment. The protocol is depicted in Figure 1.

The idea behind the protocol corresponds to the following quote, which is often cited to relate propositional commitment to a kind of action commitment: "Suppose X asserts that P . Depending on context, X may then become committed to a number of things, for example, holding that P , defending that P (if challenged), not denying that P , giving evidence that P , arguing that P , proving or establishing that P and so on" [Walton and Krabbe, 1995, p23].

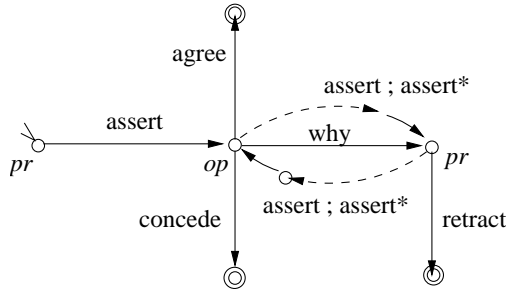


Figure 1: Persuasion Protocol

The protocol is defined as follows. For each instantiation of the protocol, there are participants in two roles: the *proponent* (*pr*), and the *opponent* (*op*). By definition, the proponent is the agent who makes the initial assertion. Proponent and opponent have different burden of proof. Note that the agent who is the opponent of some proposition p , may very well become the proponent of another proposition q later in the dialogue. For this reason, it is crucial that we have an explicit representation of roles.

Following an assertion by the proponent, the opponent can respond by a challenge like a *why*-question, which essentially requests the proponent to come up with some argument to support the assertion. The opponent may also agree with the asserted proposition, or concede the asserted proposition. Agreeing means not only relieving the proponent from the burden of proof, but also adopting the burden of proof towards third parties. Conceding means only that the opponent has given up the right to challenge the proposition, and has relieved the proponent of the burden of proof. Thus agreement implies concession. Alternatively, we can say that not challenging means a concession. In this way we capture [Kibble, 2005]’s idea that entitlement to a commitment comes by default after an assertion (see rule 18).

In response to a challenge, the proponent must give some argument in support of the proposition, which itself consists of one or more assertions, or retract the original assertion. Following the assertion in response to a challenge, the opponent may either concede the proposition, or challenge or concede any of the assertions made by the proponent during the argument in support.

A *why*-challenge does not add any new material. But an opponent can also challenge propositions by so called rebutting arguments, that provide an independent argument for the opposite assertion. Both these cases can be handled as assertions by the opponent, which trigger another instantiation of the same protocol, with a role reversal. So for rebutting arguments, the burden of proof lies with the rebutter.

The dialogue ends either when the proponent has run out of arguments to support his assertion; in this case she is forced to retract the proposition, or when the opponent has run out of challenges; in this case he is forced to concede. An agreement of the opponent, is essentially an assertion by the opponent. This end condition corresponds to WK’s win and loss rules of PPD₀ persuasion dialogues [Walton and Krabbe, 1995, p.152].

Before	speech act	After
--	<i>assert</i> (<i>pr</i> , <i>op</i> , <i>p</i>)	$B(\textit{pr}, p)$
$B(\textit{pr}, p)$	<i>why</i> (<i>op</i> , <i>pr</i> , <i>p</i>)	$\neg B(\textit{op}, p)$
$B(\textit{pr}, p)$	<i>concede</i> (<i>op</i> , <i>pr</i> , <i>p</i>)	$\neg B(\textit{op}, \neg p)$
$B(\textit{pr}, p)$	<i>agree</i> (<i>op</i> , <i>pr</i> , <i>p</i>)	$B(\textit{op}, p)$
$B(\textit{pr}, p), \neg B(\textit{op}, p)$	<i>retract</i> (<i>pr</i> , <i>op</i> , <i>p</i>)	$\neg B(\textit{pr}, p)$

Table 1: Updates of speech acts in Persuasion protocol

4.1 Translation

A commitment is set by a speech act, with a certain state. This state can be modified by actions of the participants to the speech or by events, like the execution of an action fulfilling the commitment. Thus, to model the SC approach in our role model we have to model the introduction of commitments and how their state is changed by subsequent speech acts. We use the following translation procedure. First, we map each commitment state to certain beliefs and goals of the roles. Second, according to the constitutive rules CR of the role model, a speech act directly changes those beliefs and goals in such a way to reflect the commitment introduction or change of state.

In our formalisation of the persuasion protocol, propositional commitments of the proponent are modelled as public beliefs. The open challenges are modelled as public absence of belief of the opponent. Note that in the following definition, the Before and After fields indicate what is added to the belief bases, as a result of the speech act. Thus they are update rules. They should not be confused with the FP and RE conditions of FIPA.

A commitment is conditional and can have different states: unset (i.e., to be confirmed), pending (i.e., confirmed, but its condition is not true), active (i.e., confirmed and its condition is true), fulfilled (i.e., its content is true), violated (i.e., the content is false even if the commitment was active), cancelled (e.g., the debtor does not want to be committed to the action). Propositional commitment is not distinguished from action commitment in [Fornara and Colombetti, 2004].

In this work, we represent conditionals in a simplified way: e.g., a conditional goal p of role i in case q is true: $B(i, q \rightarrow G(i, p))$. Conditional attitudes can be better accounted for in a conditional logic, like the Input/Output logic used in [Boella *et al.*, 2005]. Here, we stick to FIPA’s solution for the sake of clarity, while aware of its limitations.

4.2 Propositional Commitments

We first consider propositional commitments. In the translation, a concession PP is represented by the fact that the debtor does not believe that $\neg p$:

$$PP(i, j, p) \equiv \neg B(i, \neg p) \quad (6)$$

A propositional commitment PC is active when the debtor believes the proposition, while nothing is required to the creditor:

$$PC(\textit{active}, i, j, p) \equiv B(i, p) \quad (7)$$

A propositional commitment PC is fulfilled when the creditor concedes the proposition and cannot challenge it anymore:

$$PC(\textit{fulfilled}, i, j, p) \equiv \neg B(j, \neg p) \quad (8)$$

A propositional commitment PC is violated when the debtor's beliefs are in contradiction, due to the failure of defending some previous commitment.

$$PC(\text{violated}, i, j, p) \equiv \neg B(i, p) \wedge B(i, p) \quad (9)$$

Note that a proper treatment of this issue requires a detailed mechanism for dealing with temporal issues which is missing in the FIPA formal language we use.

It is not clear if a conditional propositional commitment is different from a propositional commitment about a conditional and what means for a propositional commitment to be unset or pending (note that in [Fornara and Colombetti, 2004] there is no way to create an unset or pending propositional commitment). Thus we do not define here these states, nor cancellation, which also requires to introduce time.

4.3 Action Commitment

Concerning action commitment, an unset action commitment corresponds to the conditional goal of the creditor (expressed as a belief, see (12)).

$$C(\text{unset}, i, j, \text{done}(i, \text{act})|q) \equiv B(i, q \rightarrow G(j, G(i, \text{done}(i, \text{act})))) \quad (10)$$

In the antecedent of the previous rule, the commitment condition q becomes a condition on the goal assumed by the creditor of the commitment. At this stage of the commitment life-cycle, no mental attitude is attributed to the debtor: he has not publicly assumed any actual goal, but has only been publicly requested to.

A commitment is pending when the debtor of the commitment conditionally wants to perform the action if the associated condition q is true, and the creditor has this as a belief.

$$C(\text{pending}, i, j, \text{done}(i, \text{act})|q) \equiv B(i, q \rightarrow G(j, G(i, \text{done}(i, \text{act})))) \wedge B(i, q \rightarrow G(i, \text{done}(i, \text{act}))) \wedge B(j, q \rightarrow G(i, \text{done}(i, \text{act}))) \quad (11)$$

A commitment is active when it is a goal of both debtor and creditor, and the pending condition is true:

$$C(\text{active}, i, j, \text{done}(j, \text{act})|\top) \equiv G(i, \text{done}(i, \text{act})) \wedge G(j, G(i, \text{done}(i, \text{act}))) \quad (12)$$

Note that to make a pending commitment active, it is sufficient that the condition q is believed to be true, since from

$$B(i, q \wedge q \rightarrow G(i, \text{done}(i, \text{act}))) \quad (13)$$

we can derive $G(i, \text{done}(i, \text{act}))$ with rule 1. Thus, the rules for commitment update listed in [Fornara and Colombetti, 2004]'s model are accounted for by the logical formalism.

Commitments are violated or fulfilled when they are goals of the creditor and the content of the commitment is respectively true or false according to the beliefs of the creditor (abstracting from time):

$$C(\text{fulfilled}, i, j, \text{done}(i, \text{act})|\top) \equiv B(j, \text{done}(i, \text{act})) \wedge G(j, \text{done}(i, \text{act})) \quad (14)$$

$$C(\text{violated}, i, j, \text{done}(i, \text{act})|\top) \equiv B(j, \neg \text{done}(i, \text{act})) \wedge G(j, \text{done}(i, \text{act})) \quad (15)$$

Since roles are public, fulfilment and violation are not dependent on what the agents subjectively believe about the truth of the commitment, but on roles' public beliefs.

A commitment is cancelled if the creditor does not want the goal to be achieved anymore, no matter if the debtor still wants it.

$$C(\text{cancelled}, i, j, \text{done}(i, \text{act})|q) \equiv \neg G(j, \text{done}(i, \text{act})) \quad (16)$$

4.4 Speech acts

Given the definition of the commitment state in terms of the mental states of the roles, we can provide the following translation of the speech acts semantics. Speech acts affect both the beliefs and goals of speaker and hearer and not only of the speaker. This represents the fact that in SC agents are publicly committed to the mental attitudes attributed by the constitutive rules to the roles they play. No cooperativity or sincerity assumptions are necessary, by contrast to FIPA.

An assertion introduces an active propositional commitment of the speaker and, if it is not challenged, it also introduces a concession of the hearer:

$$\text{assert}(i, j, p) \rightarrow B(i, p) \quad (17)$$

$$\text{assert}(i, j, p) \wedge \neg(\text{why}(j, i, p) \vee \neg \text{rebut-challenge}(j, i, p)) \rightarrow \neg B(j, \neg p) \quad (18)$$

Both implicit and explicit concessions are modelled as absence of the contrary belief. This is similar to weak commitment [Gaudou *et al.*, 2006, eq 17 p.128].

$$B(j, p) \wedge \text{concede}(i, j, p) \rightarrow \neg B(i, \neg p) \quad (19)$$

Agreement simply means that the hearer becomes committed too. So agreement implies concession.

$$B(j, p) \wedge \text{agree}(i, j, p) \rightarrow B(i, p) \quad (20)$$

Asserting an argument against p counts as a rebut-challenge. We simplify here for space reason the notion of argument:

$$B(j, p) \wedge \text{assert}(i, j, (q \rightarrow \neg p) \wedge q) \rightarrow \text{rebut-challenge}(i, j, p) \quad (21)$$

A why-challenge asks arguments to support the assertion. It indicates that the opponent is not yet convinced.

$$B(j, p) \wedge \text{why}(i, j, p) \rightarrow \neg B(i, p) \quad (22)$$

Putting forward an argument in support of the original assertion is a way to reply to a why challenge:

$$\neg B(j, p) \wedge \text{assert}(i, j, (q \rightarrow \neg p) \wedge q) \rightarrow \text{support}(i, j, p) \quad (23)$$

Not replying to a why challenge with a supporting argument, counts as a retraction:

$$\text{why}(i, j, p) \wedge \neg \text{support}(j, i, p) \rightarrow \neg B(j, p) \quad (24)$$

Replying to a rebut challenge with a counter argument is also compulsory, but because the rebut challenge is performed by means of a set of assertions, this is already accounted for by rule 18.

Once a concession has been introduced it prevents the agent from committing itself to the opposite proposition, since this would lead to a contradiction: $\neg B(i, \neg p) \wedge B(i, p)$. Thus he cannot make an assert of $\neg p$ nor challenge p , since a challenge is performed by informing about an argument for $\neg p$. Avoiding a contradiction explains also why an agent is lead to challenge an assert if he previously committed itself to the contrary.

		Proponent <i>a</i>	Opponent <i>b</i>	
A1	B	$B(a, open)$	$\neg(why(b, a, open) \vee rebut(b, a, open)) \rightarrow \neg B(b, \neg open)$	(7,17-18)
A2	G	$G(a, G(b, give-exam))$		(10,26)
B1		$\neg(why(a, b, (games \rightarrow \neg open) \wedge games) \vee$ $rebut(a, b, (games \rightarrow \neg open) \wedge games))$ $\rightarrow \neg B(a, open)$	$B(b, (games \rightarrow \neg open) \wedge games)$	(7,17-18,21)
	B	$B(a, open)$	$B(b, \neg open)$	(persistence)
	G	$G(a, G(b, give-exam))$		(persistence)
A3	B	$B(a, (exam \wedge games \rightarrow open) \wedge exam)$	$\neg(why(b, a, (exam \wedge games \rightarrow open) \wedge exam) \vee$ $rebut(b, a, (exam \wedge games \rightarrow open) \wedge exam))$ $\rightarrow \neg B(b, \neg open)$	(7,17-18)
		$B(a, open)$	$B(b, \neg open)$	(persistence)
	G	$G(a, G(b, give-exam))$		(persistence)
B2	B	$B(a, open)$	$B(b, open)$	(7,20)
B3	G	$G(a, G(b, give-exam))$	$G(b, give-exam)$	(11,12,27)
B4	B	$B(a, give-exam)$	$B(b, give-exam)$	(14)

Figure 2: The interpretation of the dialogue in Example 1

Now we turn to the speech acts that create action commitments, such as promise and request. A promise introduces a pending action commitment of the speaker:

$$\begin{aligned}
& promise(i, j, done(i, act), q) \rightarrow \\
& B(i, q \rightarrow G(j, G(i, done(i, act)))) \wedge \\
& B(i, q \rightarrow G(i, done(i, act))) \wedge \\
& B(j, q \rightarrow G(i, done(i, act)))
\end{aligned} \quad (25)$$

A request introduces an unset commitment with the hearer as debtor: the hearer should perform the requested action.

$$\begin{aligned}
& request(i, j, done(j, act), q) \rightarrow \\
& B(i, q \rightarrow G(i, G(j, done(j, act))))
\end{aligned} \quad (26)$$

Accept changes the state of an existing unset commitment, which appears as its precondition, to pending. Since we model an existing commitment as a configuration of belief and goals attributed to roles, the precondition is simply added to the antecedent of the condition to account for the presence in the dialogue roles of the mental attitudes which correspond to an unset belief.

$$\begin{aligned}
& (B(i, (q \rightarrow G(j, G(i, done(i, act)))))) \wedge \\
& accept(i, j, done(i, act), q) \rightarrow \\
& B(i, q \rightarrow G(i, done(i, act))) \wedge \\
& B(j, q \rightarrow G(i, done(i, act)))
\end{aligned} \quad (27)$$

The notion of promise needs some discussion. According to Guerini and Castelfranchi [2006] the definition above is too weak: a promise needs to be explicitly adopted. It is not enough that *j* has indicated to prefer *i* to do the action, and that *i* and *j* believe that *i* has a goal to do the action; what is missing is *j*'s belief, as a result of the acceptance, that *i* will eventually do it. Nevertheless, we think that the conditional nature of a promise, i.e., that it requires explicit acceptance, is well covered by the combination of rules (25) and (27). Rule (25) only covers an initiative to make a promise; the promise is only complete when accepted. See also the remark below (13). Moreover, these rules are not meant to define necessary and sufficient conditions for speech acts; instead, they indicate what inferences can be made on the basis of an apparent speech act event.

In Table 2 we show the interpretation of the following dialogue. For each turn, we report the beliefs and goals which are created and those which persist from the previous turn.

Example 1

- A1: Tomorrow the University is open. *assert(a, b, open)*
- A2: Can you give the exams for me? *request(a, b, give-exam)*
- B1: Isn't it closed for the Olympic games? *rebut-challenge(b, a, open)*
- A3: Not for exams. *assert(b, a, (games \rightarrow \neg open) \wedge games)*
- B2: I see. *rebut-challenge(a, b, (games \rightarrow \neg open) \wedge games)*
- B3: OK *assert(a, b, (exam \wedge games \rightarrow open) \wedge exam)*
- B4: [B gives the exam] *agree(b, a, open)*
- B4: [B gives the exam] *accept(b, a, give-exam)*
- B4: [B gives the exam] *give-exam*

5 Conclusions

In this paper we introduce the distinction between propositional and action commitment in agent communication languages. We do this by introducing the notion of concession in these languages, taking inspiration from Walton and Krabbe [1995] and Kibble [2005]. We map propositional commitments to the roles' beliefs, and action commitments to their goals. The constitutive rules of a dialogue game represent the effects that speech acts have on the roles' mental attitudes, and, thus, indirectly on commitments. Concessions are introduced as the absence of a belief to the contrary, and prevent further challenges. This is analogous to action commitments, which prevent future actions that require the same resources.

We illustrate the approach by modelling a particular persuasion protocol, inspired by Walton and Krabbe. This protocol allows the 'silence means consent' principle. Because under this principle concessions of the hearer can be made by default, i.e., by not challenging an assertion, we demonstrate that the semantics of speech acts should not only be expressed in terms of the effects on the attitudes of the speaker, but also on those of the hearer.

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