Dialogues with conflict resolution: goals and effects

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Abstract

The aim of the paper is to propose the semi-formal model of dialogues with conflict resolution. We focus on the specification for goals and effects of this type of dialogue. Our proposal is based upon the popular and influential model by D. Walton. We show that this model, even though referring directly to conflict resolution, does not allow to express its important properties. The paper proposes the model's modification and extension, which enables describing various characteristics related to the goals of conflict resolution. Moreover, we combine formal and linguistic concepts to define different kinds of effects achieved in this type of dialogues.

1 Introduction

The paper proposes the semi-formal model of dialogues with conflict resolution (CR). The model is to serve as a heuristic tool for the study of dialogues aiming at conflict resolution. The properties of the heuristic tool are rooted in both interpersonal dialogues and multi-agent systems (MAS).

The paper is organized into Section 2 and Section 3. In Section 2, drawing on the influential model established by D. Walton, we discuss the possible goals of dialogues with conflict resolution. Considerations in Section 2 serve also as underpinnings of our claim that Walton's model should be extended to enhance its applicability. In Section 3, relying on the heuristic power of the model we have proposed in Section 2, we focus on the degrees of reaching the initial goal of CR.

Although Walton's typology of dialogues takes into account the dialogue with conflict resolution, it omits its significant properties and aspects. More specifically, it does not allow for the distinction of the two types of strategies for achieving conflict resolution: egoistic and collaborative. While the first strategy enables an agent to strive for his/her individual goal, the second one emphasizes the superiority of the collaborative CR. The importance of the individual standpoints for agents is significantly diminished in the second case.

Our contribution to the existing models of dialogues is the proposal of clearly defined properties of CR. The first part of the model specifies the goals of dialogues with conflict resolution taking into account the pre-planned goals of system and agents. The second part of the model determines the types of the effects which can be achieved through a dialogue with the pre-planned conflict resolution. The effects are understood as degrees of achieving conflict resolution. The model uses both formal (e.g. dialogue systems) and linguistic (e.g. topical relevance) concepts.

2 Goals of dialogues with conflict resolution

In this section, we explore what goals the dialogues with conflict resolution have. We limit our considerations to the initial goal of a dialogue, i.e. the goal related to the intention of initiating the dialogue. We start our consideration with the model proposed by Walton (Section 2.1) and then propose its extension which allows to enhance expressivity and applicability of this model (Section 2.2).

2.1 Limitations of Walton's model

Walton's model was originally presented in (Walton, 1989) and further developed in (Walton, 1995; Walton and Krabbe, 1995). Walton's work is broadly studied in linguistics and selectively discussed in social psychology, while Walton & Krabbe's work is widely applied in the formal dialogue systems and MAS.

In this model, the persuasion dialogue (also called critical discussion originally introduced by

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(van Eemeren and Grootendorst, 1984)) is the only type of dialogue that is meant to be related to conflict resolution. There are other types of dialogues that have something in common with conflict, however, their goal is not to resolve it. Negotiation aims for conflict settlement, and eristics aims for reaching a (provisional) accommodation. The other types of dialogues do not refer to conflict at all (Walton and Krabbe, 1995, 80-81).

Walton specifies the dialogues by means of three properties: initial situation, main goal and participant's aims. The initial situation of the persuasion is a conflict of opinion. The main goal is to resolve this conflict by verbal means. The aim of each participant is to persuade the other party to take over its point of view (see Table 1).

initial state	**main goal**	**agent's goal**
conflicting points of view	resolution of conflict	persuade the other(s)

Table 1. The properties of persuasion dialogue from (Walton and Krabbe, 1995).

This model relates the persuasion dialogue to the issue of conflict resolution. However, it has some serious limitations if we want to analyze this issue in a more detailed manner. Below, we discuss three of those limitations.

Limitation 1: conflict's object. The first criticism refers to the types of conflicts identified in Walton's model. It distinguishes only two types of conflict - with respect to opinion (the conflict specific for persuasion) and interest (the conflict specific for negotiation). Since the goal of negotiation is not to resolve the conflict, the only dialogues with conflict resolution considered in this model are dialogues that aim for agreeing on opinions (i.e. resolving the conflict of opinion).

On the other hand, in the literature related to applications of dialogues allowing for conflict resolution, many other objects of conflict are distinguished and studied. Besides conflict between opinions (see (Prakken, 2006) for an overview), conflicts concern e.g. attitudes (Pasquier et al., 2006), actions (Bench-Capon et al., 2005), behavior (Sierra et al., 1997), intentions (Dignum et al., 2001), plans (Tang and Parsons, 2005), preferences (Sycara, 1990) or permissions for gaining access to information (Perrussel et al., 2007). The model restricted to conflict of opinion has, thus, a strong limitation in expressivity and applicability.

Limitation 2: the meaning of "main goal". The next limitation refers to the ambiguity of the notion "main goal". It is not clear if the main goal means: (1) that resolution of conflict is the basic, but still *individual* aim of an agent, while his secondary aim is to persuade the other agent, or (2) it means the goal of the *system* of all participants (i.e. the joint goal of agents as a group).

Throughout the paper, we use the word "system of agents" to denote the group of individuals (human or artificial). That is, a system may be a group of people (e.g. a council of doctors or a council of war), as well as a multi-agent system.

It seems that in Walton's model meaning (1) is assumed:[1]

> We must distinguish between the primary or main goal of a type of dialogue and the aims of the participants (...). Thus, the primary goal of negotiation could be characterized as "making a deal." By entering into negotiations the parties implicitly subscribe to this overall purpose. But, besides, each party pursues, within the dialogue, the particular aim of getting the best out of it for oneself (Walton and Krabbe, 1995, 67).

A negative consequence of this interpretation is discussed in Section 2.2 (see Proposition 1).

Limitation 3: the scope of persuasion's goal. The last criticism refers to the relation between the main goal and participants' aims. Assume the first meaning of the main goal described above (i.e., the main goal means a primary, individual goal). Two interpretations of the relation between the main goal and the participant's goal are possible: (1) the narrow one: the persuasion dialogue has to fulfill *both* of those goals, and (2) the broad one: the persuasion has to fulfill *at least one* of them.

Both of the interpretations generate some problems. If interpretation (1) is assumed, then collective methods of conflict resolution are inexpressible in Walton's model (i.e when agents aim to resolve a conflict and they do not care about their individual victories). From the point of view of its important applications such as MAS, it is a strong limitation. The multi-agents systems have some tasks to perform (e.g. to control the temperature in a building). A conflict among agents may be an

[1] Consider the goals of persuasion in analogy to negotiation.

obstacle in accomplishing those tasks: "Finding ways for agents to reach agreements in multiagent systems is an area of active research" (Parsons and Sklar, 2005, 297). Typically, in MAS persuasion represented by Walton's model is used as a tool for conflict resolution. As a result, the collective method for conflict resolution is entirely excluded from the studies. Since in the narrow interpretation an agent has to fulfill both of the goals, then he is restricted to adopt an egoistic strategy. This makes impossible to express the cooperative methods of conflict resolution which from the viewpoint of MAS should be equally (or maybe even more) desirable.

On the other hand, if interpretation (2) is assumed, then both of these methods of conflict resolution (egoistic and collective) are describable in Walton's model, however, they are undistinguishable. If the word "persuasion dialogue" denotes both of these strategies, then some additional subclasses of persuasion should be introduced to refer to a particular type of strategy.

In (Walton and Krabbe, 1995, 66), the authors indicate that their aim is not to propose the exhaustive typology of dialogues. However, the scope of applicability of this typology (e.g. in MAS) narrows down the functionality of the models which originate from the distinction. Therefore, despite its pioneering and important advances in the formal dialectics, Walton's model needs to be modified and extended such that limitations 1-3 could be avoided.

2.2 Extension of Walton's model

In this section, we propose the extension of Walton's (1989) model. Let $Agt = \{1, \ldots, n\}$ be a set of names of *agents*. Our model is built upon and uses the standard notions from the formal systems of persuasion dialogue (see e.g. (Prakken, 2006)), in particular the model proposed in (Prakken, 2005).[2] Let L_t be a *topic language* (a logical language including e.g. $p, \neg p$), and L_c be a *communication language* (a set of locutions including e.g. $claim\ p$, $why\ p$). Each agent maintains a list of utterances, called the *commitment store*. Intuitively, commitments are what an agent publicly declares as his beliefs, attitudes, intentions, plans, etc. A set of an agent i's commitments at a stage d of a dialogue is denoted by $C_d(i)$ (for $i \in Agt$). For example, if i makes a move $claim\ p$ at a dialogue stage d, then p is placed in his commitment store, i.e. $p \in C_d(i)$.

We introduce some simplifications for the clarity of presentation. First, we limit our considerations to a system of agents S which consists of two players in a dialogue, i.e. $S = \{i, j\} \subseteq Agt$. We use a symbol $\bar{i}$ to denote an agent i's adversary. It means that when $i \in prop(t)$ (i is a proponent for t), then $\bar{i} \in opp(t)$ ($\bar{i}$ is an opponent against t). Moreover, we assume that a conflict refers to one object (one belief, one attitude, etc.). This assumption corresponds to a single type of dialogue (van Eemeren and Grootendorst, 1984, 80).

Conflict. First we specify the notion of conflict. The conflict in relation to t is denoted by $\{t, \bar{t}\}$ ($\bar{t}$ denotes opposing standpoint to t). A topic t may refer to different objects, e.g. opinions, attitudes, actions, intentions, preferences, and so on. Moreover, for simplicity we do not consider "neutral" commitments, i.e. we assume that there is not such t that $t \notin C_d(i)$ and $\bar{t} \notin C_d(i)$. Consequently, $\{t, \bar{t}\}$ means that one of agents is committed to t, while his opponent is committed to $\bar{t}$, i.e. $t \in C_d(i)$ and $\bar{t} \in C_d(\bar{i})$.

Let $S = \{i, j\} \subseteq Agt$ be a system of agents, and $t \in L_t$ be a topic of disagreement between agents. We say that after a dialogue d a conflict $\{t, \bar{t}\}$ is resolved, when either both agents are committed to t, or both are committed to $\bar{t}$:

Definition 1 After execution of dialogue d, *conflict* $\{t, \bar{t}\}$ between agents in S *is resolved*, when exactly one of the following conditions holds: (1) $t \in C_d(i)$ and $t \in C_d(\bar{i})$, or (2) $\bar{t} \in C_d(i)$ and $\bar{t} \in C_d(\bar{i})$.

Observe that in this definition the disjunction is exclusive, i.e. it holds only if exactly one of the elements that it connects is true (either first one is true and second - false, or the opposite way).

Conflict resolution for system of agents. Now we can specify the class of dialogues in which the conflict resolution is the goal of the whole *system of agents*. We use the notion "conflict resolution" instead of "dialogue with conflict resolution", if there is no danger for confusion.

Definition 2 Dialogue d is *conflict resolution* for S in relation to t (denoted by $d \in \mathsf{CR}_{S,t}$), when

[2] In the paper, a detailed formal specification for a dialogue system is not needed; for the full details the reader is referred to the references.

the goal of S is to resolve conflict $\{t, \bar{t}\}$ between agents in S after execution of d.

We assume that a system's goal is a joint purpose of all agents in the system. For example, in MAS this goal may be a result of a need to accomplish a task by a system (e.g. to control the temperature in a building). Since a conflict is an obstacle for a system's joint performance, its goal will be to resolve this conflict. Observe that humans may be in some sense unaware of their joint purpose. Imagine that Bob and Ann have a walk in the mountains. They approach the crossroad. Ann thinks that they should go left, and Bob claims they should go right. They may be extremely competitive and willing to persuade the other party to take the path each of them have chosen, however, still their joint goal as a group is to move further and eventually come back home safely.

Conflict resolution for individuals. From the point of view of the system's members, the very same goal (of conflict resolution) may be accomplished in different manners. An agent may adopt one of the following individual strategies of fulfilling the system's goal: persuasive (egoistic), collaborative or passive.

The agent has a persuasive goal if he is interested only in such an outcome of a dialogue in which his standpoint wins. That is, if in conflict $\{t, \bar{t}\}$ an agent i is committed to t, then i executes persuasion when his goal is to make $\bar{i}$ be committed to t.

Definition 3 Conflict resolution d is *persuasion for agent* $i \in S$ in relation to t (denoted by $d \in \mathsf{CR}_{S,t}^{Per_i}$), when the goal of i is that after execution of d, it holds: $t \in C_d(i)$ and $t \in C_d(\bar{i})$.

The second strategy that an agent may adopt to achieve a system's goal is collaborative. Intuitively, the agent has a collaborative goal if he is interested in such an outcome of a dialogue in which any party wins. That is, i is collaborative when his goal is to reach an agreement regardless of whether both agents will be committed to t or both will be committed to $\bar{t}$:

Definition 4 Conflict resolution d is *collaborative dialogue for agent* $i \in S$ in relation to t (denoted by $d \in \mathsf{CR}_{S,t}^{Col_i}$), when the goal of i is to resolve conflict $\{t, \bar{t}\}$ between agents in S after execution of d.

Such dialogues are specific for cooperative systems, while persuasion is typical for adversarial domains. When doctors disagree and discuss what method of treatment to apply in a particular case, then they may adopt collaborative strategy of conflict resolution. On the other hand, when an insurance agent and a client disagree and discuss the type of insurance the client should buy, then the agent (typically) adopts egoistic strategy.

The goals of persuasion dialogues such as informativeness and the increase in understanding through the performance of maieutic function (Walton, 1995, 102-103) are specific for collaborative rather than for persuasive $\mathsf{CR}_{S,t}$ (see (Felton et al., 2009) for experimental results). Still, they are not the intended goals of $\mathsf{CR}_{S,t}$ but constitute some "extra" value.

Observe that persuasive and collaborative goals are not two mutually-exclusive strategies, but rather the prototypical forms representing the extremes of an intention continuum. While in MAS agents can be designed to behave according to given definitions, then in natural contexts humans may adopt strategies located somewhere between those two extremes (a person may be more or less persuasive, or collaborative).

The last individual "strategy" in conflict resolution is passive. Intuitively, the agent is passive in d, if he has no goal. He only reacts to the moves executed by his adversary. In other words, such an agent is an opponent against t, but not a proponent for $\bar{t}$ (i.e., $i \in opp(t)$, but $i \notin prop(\bar{t})$). This type of goal can be described as follows: "the other participant has a role of raising critical questions that cast doubt on that thesis" (Walton, 1995, 100).

Definition 5 Conflict resolution d is *passive dialogue for agent* $i \in S$ in relation to t (denoted by $d \in \mathsf{CR}_{S,t}^{\emptyset_i}$), when i has no goal of executing d.

Note that in $d \in \mathsf{CR}_{S,t}$, at least one agent cannot be passive.

Subclasses of conflict resolution. In the formal language of dialogue systems, no symbol representing a goal is specified. To account for our considerations, we introduce a preliminary version of its specification. Let $G_{i,t}(d)$ be a set of i's goals in a dialogue $d \in \mathsf{CR}_{S,t}$. We can distinguish the following types of system's conflict resolution:

- if ($G_{i,t}(d) = \{Per\}$ or $G_{i,t}(d) = \{Col\}$)[3], and $G_{\bar{i},t}(d) = \emptyset$, then d is asymmetric $\mathsf{CR}_{S,t}$ (which corresponds to simple dialogue derived from (van Eemeren and Grootendorst, 1984, 80));
- if ($G_{i,t}(d) = \{Per\}$ and $G_{\bar{i},t}(d) = \{Per\}$), or ($G_{i,t}(d) = \{Col\}$ and $G_{\bar{i},t}(d) = \{Col\}$), then d is symmetric $\mathsf{CR}_{S,t}$ (which corresponds to compound dialogue derived from (van Eemeren and Grootendorst, 1984, 80));
- if $G_{i,t}(d) = \{Per\}$ and $G_{\bar{i},t}(d) = \{Col\}$, then d is mixed $\mathsf{CR}_{S,t}$.

Recall that we discussed a problem with interpretation of "main goal" in Walton's model (Section 2.1). We argued that the goals of persuasion (plausibly) mean both resolving a conflict and persuading the other agent (see Limitation 3). Moreover, those goals seemed to be individual aims of the dialogue's participant (see Limitation 2). If this is the case, then an agent has two individual goals, i.e. $\{Per\} \subseteq G_{i,t}(d)$ and $\{Col\} \subseteq G_{i,t}(d)$. Then, Walton's persuasion would be a multi-goal dialogue. However, it can be easily shown that the multi-goal d reduces to the single-goal d of persuasive conflict resolution (for a given agent):

Proposition 1 Let $i \in S \subseteq Agt$ and $t \in L_t$. If $d \in \mathsf{CR}_{S,t}$ and $\{Per\} \subseteq G_{i,t}(d)$ and $\{Col\} \subseteq G_{i,t}(d)$, then $G_{i,t}(d) = \{Per\}$.

To prove the proposition formally, we would need to introduce more precise specifications. For example, we would have to decide how we want to understand goals (e.g. as formulas (Budzynska et al., 2009), or as states (Tokarz, 1985; Tang and Parsons, 2005)). However, such a level of formalization is outside the scope of this paper. Instead, we will give the intuitions for such a proof. Say that an agent's goal in a dialogue is understood as a set of states which could be reached after the dialogue. Then, the goal Per is a set of states where the following condition is satisfied: $t \in C_d(i)$ and $t \in C_d(\bar{i})$. Further, the goal Col is a set of states where the exclusive disjunction of the two conditions is satisfied: ($t \in C_d(i)$ and $t \in C_d(\bar{i})$) or ($\bar{t} \in C_d(i)$ and $\bar{t} \in C_d(\bar{i})$). If $\{Per\} \subseteq G_{i,t}(d)$ and $\{Col\} \subseteq G_{i,t}(d)$, then a goal set of states $G_{i,t}(d)$ have to be an intersection of two of the sets described above. Since the condition for Per is the first element of the exclusive disjunction for Col, then only this element will be true. It means that $G_{i,t}(d)$ is reduced to the set $\{Per\}$.

Consequently, in Walton's model the main goal of conflict resolution is an (unintended) result of an individual persuasive goal adopted by an agent, rather than an additional (primary, main) goal of this agent. Moreover, a collaborative conflict resolution cannot be defined within Walton's model. The solution that we propose in the paper is to extend this model with the separation of system's goal from agents' goals, and the distinction between different individual strategies of reaching system's goal.

To conclude, the extension of Walton's model generates five subclasses of the dialogues with conflict resolution for a system of agents:

$$\mathsf{CR}_{S,t} = (\mathsf{CR}_{S,t}^{Per_i} \cap \mathsf{CR}_{S,t}^{\emptyset_{\bar{i}}}) \cup (\mathsf{CR}_{S,t}^{Per_i} \cap \mathsf{CR}_{S,t}^{Per_{\bar{i}}}) \cup (\mathsf{CR}_{S,t}^{Col_i} \cap \mathsf{CR}_{S,t}^{\emptyset_{\bar{i}}}) \cup (\mathsf{CR}_{S,t}^{Col_i} \cap \mathsf{CR}_{S,t}^{Col_{\bar{i}}}) \cup (\mathsf{CR}_{S,t}^{Per_i} \cap \mathsf{CR}_{S,t}^{Col_{\bar{i}}}).$$

The first subclass of conflict resolution is asymmetric persuasive $\mathsf{CR}_{S,t}$, the second one - symmetric persuasive $\mathsf{CR}_{S,t}$, the third - asymmetric collaborative $\mathsf{CR}_{S,t}$, the forth - symmetric collaborative $\mathsf{CR}_{S,t}$, and the last one - mixed $\mathsf{CR}_{S,t}$. Observe that Walton's model allows to express and explore only two first subclasses.

3 Effects of conflict resolution

This section determines the types of the effects which can be achieved through a dialogue with the pre-planned conflict resolution. Four degrees of accomplishing conflict resolution are distinguished and exemplified: fully unsuccessful dialogue (Section 3.1), partially successful dialogue (Section 3.2), fully successful dialogue (Section 3.1) and over-successful dialogue (Section 3.4).

3.1 Unsuccessful vs. successful dialogue

Recall that $C_d(i)$ means agent i's commitment store at the stage of dialogue d. Following our specification for the goals in dialogues with conflict resolution, unsuccessful and successful $\mathsf{CR}_{S,t}$ may be defined. Let $S = \{i, j\} \subseteq Agt$ and $t \in L_t$.

Definition 6 Conflict resolution $d \in \mathsf{CR}_{S,t}$ is (fully) *unsuccessful for system* S in relation to t, when conflict $\{t, \bar{t}\}$ between agents in S is not resolved after execution of d.

[3] For simplicity, we do not introduce the precise specification for goals. Intuitively, $G_{i,t}(d) = \{Per\}$ means that i has persuasive goal in d with respect to t.

Since in Definition 1 the disjunction was exclusive, $\mathsf{CR}_{S,t}$ is fully unsuccessful for S in two cases: (1) if $t \in C_d(i)$, and $\bar{t} \in C_d(\bar{i})$, or (2) if $\bar{t} \in C_d(i)$, and $t \in C_d(\bar{i})$.

Definition 7 Dialogue $\mathsf{CR}^{Per_i}_{S,t}$ is (fully) *unsuccessful persuasion for agent* i in relation to t, when after execution of d, it holds: $\bar{t} \in C_d(i)$ or $\bar{t} \in C_d(\bar{i})$.

That is, a persuasive conflict resolution is fully unsuccessful for i in three cases: (1) if $t \in C_d(i)$ and $\bar{t} \in C_d(\bar{i})$, or (2) if $\bar{t} \in C_d(i)$ and $t \in C_d(\bar{i})$, or (3) if $\bar{t} \in C_d(i)$ and $\bar{t} \in C_d(\bar{i})$. In the cases (1) and (2), an agent i is unsuccessful, since the goal of the system is not accomplished. Thus, even though in (2) i managed to make $\bar{i}$ be committed to i's initial standpoint t, he failed to resolve the conflict. In case (3), even though the conflict is resolved, i is unsuccessful, since he failed to make $\bar{i}$ be committed to t.

Definition 8 Dialogue $\mathsf{CR}^{Col_i}_{S,t}$ is (fully) *unsuccessful collaborative dialogue for agent* i in relation to t, when conflict $\{t, \bar{t}\}$ between agents in S is not resolved after execution of d.

A passive conflict resolution for an agent i cannot be successful or unsuccessful for i, since a set of i's goals is empty. In other words, there is no goal to achieve for this agent in a given dialogue.

The definitions of successful dialogues are analogical to Definitions 6-8:

Definition 9 Conflict resolution $d \in \mathsf{CR}_{S,t}$ is (fully) *successful for system* S in relation to t, when conflict $\{t, \bar{t}\}$ between agents in S is resolved after execution of d.

Definition 10 Persuasion $\mathsf{CR}^{Per_i}_{S,t}$ is (fully) *successful for agent* i in relation to t, when after execution of d, it holds: $t \in C_d(i)$ and $t \in C_d(\bar{i})$.

Interestingly, when $d \in \mathsf{CR}^{Per_i}_{S,t}$ accomplishes individual goal of i, then d accomplishes a system's goal. Observe that the relationship in the opposite direction does not hold. That is, if a system's goal is accomplished, the persuasive goal of i does not have to be fulfilled, since $\bar{i}$ could be successful.

Definition 11 Collaborative dialogue $\mathsf{CR}^{Col_i}_{S,t}$ is (fully) *successful for agent* i in relation to t, when conflict $\{t, \bar{t}\}$ between agents in S is resolved after execution of d.

Clearly, if i accomplishes a collaborative goal, then he will accomplish the goal of a system. In this case, the relationship in the opposite direction does hold.

3.2 Fully unsuccessful vs. partly successful conflict resolution

In formal approach, it is not possible to differentiate partially successful $\mathsf{CR}_{S,t}$ from the fully unsuccessful $\mathsf{CR}_{S,t}$. Therefore, a need arises to define partially successful dialogues in pragmatic terms, using both Cartesian and non-Cartesian approach. Non-Cartesian approach relies on ratio-empirical pragmatics which allows for gradualistic reasoning and non-discreteness (Walton, 1995, 158)(Kopytko, 2002). Cartesian approach, as (Kopytko, 2002, 523) indicates, refers to 'discreteness/categoriality of pragmatic phenomena'. To define partially successful dialogues we need not only discrete terminology (such as 'move', 'goal', 'agent'), but also non-discrete procedures and concepts (such as 'gradual reasoning', 'topical relevance'). Consider the following examples (where i_1 means a first move in a dialogue performed by agent i):

(d^1) Bob_1: Let's go to the cinema today.
Ann_2: No.

(d^{1a}) Bob_3: But Avatar is playing at the Odeon.
Ann_4: OK, but we'll go tomorrow. I have no time today.

(d^{1b}) Bob_3: So let's go to the theatre.
Ann_4: OK, let's go.

Dialogue d^{1a} and dialogue d^{1b} are possible continuations of dialogue d^1. They are sequential procedures in which partial conflict resolution can be described in terms of the non-Cartesian approach. At the last stage of d^{1a} and d^{1b}, Ann is not committed to statement expressed in move Bob_1. At this point, it is essential to distinguish between the goal of the system of conflict resolution and the topic (t) of the conversation. In each case, topic t relates to the positive attitude to going to the cinema today while the goal of the system is a conflict resolution on topic t. The effectiveness of the achievement of conflict resolution is different in each case. In d^1 Ann rejects topic t and thus conflict resolution is

not achieved. In d^{1a} and d^{1b}, however, the partial accomplishment of conflict resolution occurs due to the agreement with statement in move Bob_3. It is evident in d^{1a} and d^{1b} that the moves refer to a set of topics $T_{i,t}$ which specify the area of i's interest of conflict resolution with respect to t. The commitment of agent i to one of the possible topics from the set $T_{i,t}$ (e.g. positive attitude to going to the cinema tomorrow not today) in his last turn manifests topical relevance and partial accomplishment of conflict resolution.

In dialogue d^{1b}, Bob divides his conflict resolution into submoves. As the achievement of conflict resolution is gradually strived for, in $move_3$ Bob attempts to remain within the set of topic $T_{Bob,t}$. Although topic t is rejected by Ann in $move_2$, Bob in the statement in move Bob_3 still tries to get some benefit for himself and be relevant. Ann treats the positive attitude to going to the theatre (move Bob_3) as an allowable alternative within the set of topics $T_{Bob,t}$. Only if both move Bob_1 and move Bob_3 were acclaimed by Ann, the whole conflict in d^{1b} would be successfully resolved. The accomplishment of part of i's conflict resolution occurs since only the statement in $move_3$ is accepted. Treating conflict resolution as related to a set of topics $T_{i,t}$ points to non-discreteness of the process of achieving conflict resolution.

3.3 Over-successful dialogue

Similarly, in formal approach there is no way to express over-successful dialogue. We have to take into account that the topics in $T_{i,t}$ differ in the degree of acceptance and degree of importance for agent i. If conflict resolution is achieved due to topical relevance and agent i is not only completely satisfied with the last move of agent $\bar{i}$ but also attributes the high degree of importance to it, then we can talk about over-successful conflict resolution.

We propose to draw the distinction between radial topics and prototype topics. The distinction is motivated by the Lakoff's categorization of concepts into prototypical and radial ones (Lakoff, 1987). In the approach we advocate, prototypical and radial categories should not exclusively relate to single concepts, but also to topics (opinions, attitudes, actions, intentions, preferences, etc.). Prototype topics manifest essential, stereotypical and salient examples of topic t. Radial topics are indirectly concerned with the prototype topics. It means that depending on the context they can relate to the prototype topics or not. This can be expressed by the formula $T_{i,t} = TP_{i,t} \cup TR_{i,t}$ in which $T_{i,t}$ is the set of topics relevant to t, $TP_{i,t}$ are the prototype topics relevant t and $TR_{i,t}$ are the radial topics indirectly relevant to t. If the last move of Ann manifests both prototype relevance ($TP_{i,t}$) and radial relevance ($TR_{i,t}$) and the radial relevance has a high degree of importance for agent i, then we can talk about over-successful $\mathsf{CR}_{S,t}$. Consider dialogue d^2:

(d^2) Bob_1: Let's go to the cinema today.
Ann_2: Why?
Bob_3: Avatar is playing at the Odeon.
Ann_4: OK and I'll invite you for dinner afterwards.
Bob_5: OK.

In d^2, $move_4$ of Ann manifest both $TP_{i,t}$ (the positive attitude to going to the cinema to see Avatar today) and $TR_{i,t}$ (the positive attitude to going for dinner afterwards). Since $TR_{i,t}$ has a high degree of importance and acceptance for agent i we can observe over-successful $\mathsf{CR}_{S,t}$.

4 Conclusions

Dialogues with conflict resolution play an important role in different contexts. In MAS, the most important issue is the realization of system's tasks. A $\mathsf{CR}_{S,t}$ dialogue enables to resolve a disagreement on t, which enhances a cooperative accomplishment of S's tasks. The minor issue is how the resolution of a conflict is achieved - either in an egoistic or a collaborative way. The conflict resolution is also important in educational setting, since the collaborative goal of performing a dialogue supports teaching students of knowledge construction through argumentation in science classrooms (Felton et al., 2009).

From this point of view, constraining a model to the subclass of dialogues that aim to resolve a conflict in an egoistic manner is a serious limitation. In Proposition 1, we show that the main (individual) goal of resolving the conflict is reducible to the secondary individual goal of persuading the other party. As a result, in Walton's model there is no reason to consider the property of the main goal defined in such a way, since it does not provide any additional information to the dialogue's specification beyond that information which is provided by the property of the persuasive individ-

ual goal. Thus, it is not clear in what sense Walton talks about the "collective goal" (contrasting it with the "individual goals") or the cooperativeness as a property of persuasion dialogue (Walton, 1995, 101).

In the paper, we propose the extensions that allow to specify dialogues in which the superior goal is to resolve a conflict. In our model, this goal may be achieved by individuals in different manners. First, an agent may be persuasive, i.e. he may be interested only in such a resolution in which his standpoint wins. An agent may also choose the collaborative goal, i.e. he may aim at any outcome which brings a resolution of conflict (no matter if his or the opponent's standpoint wins). Finally, an agent may be passive and only react to the other party's dialogue moves. Depending on the type of the individual goal, different strategy will be adopted by an agent. It means that we may need to specify a distinct formal dialogue system for each of the five subclasses of conflict resolution. The model proposed in this paper does not suffer from the problem discussed in Proposition 1, since we differentiate the goal of the system of agents from the goals of its members, instead of distinguishing two types of individual goals as assumed in Walton's model.

We also specify the four different types of effects in $\mathsf{CR}_{S,t}$. The dialogue may be fully successful (or unsuccessful), when a given goal (of a system, persuasive or collaborative) is fulfilled (or not fulfilled, respectively). Moreover, we explore such an effect when a goal is not achieved, however, an agent still "benefits" to a certain degree, as well as the effect when an agent achieves more that he initially intended. To identify the partially successful and over-successful dialogues, we use the linguistic concepts of topical relevance and gradualistic reasoning.

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