

Justifying Underlying Desires for Argument-based Reconciliation

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Abstract. Not focusing on stakeholders' original desires, but on their underlying desires helps agents to reconcile practical conflicts. This paper proposes a logical formalization of an argument-based reasoning for justifying both underlying desires and means for realizing them. Based on the idea that an underlying desire can be obtained by abstracting an original desire, we give a problem setting for desire abstraction in terms of sufficiency and consistency using practical syllogisms. We introduce two kinds of defeasible inference rules, called positive and negative practical abductive syllogisms, as counterparts of the practical syllogisms and show their correctness in terms of sufficiency and consistency. We give three kinds of argumentation systems structured with practical abductive syllogisms or/and practical syllogisms and show that the argumentation systems can simply handle Kowalski and Toni's reconciliatory scenario for committee member selection and our reconciliatory scenario for business transfer.

Keywords: argument-based reasoning, practical reasoning, deliberation, reconciliation, defeasible inference rules

Introduction

Practical reasoning comprises two parts; deliberation and means-ends reasoning. Deliberation decides what state of affairs we want to achieve, and the means-ends reasoning decides how we want to achieve these states of affairs [1]. In actual practical reasoning, stakeholders often confront with the situations in which the means for realizing one's desires prevent those of the other. One possible way to resolve the conflict is to choose one of them by argument or preferences. On the other hand, a more attractive way is to reconcile the conflict by not only determining means for realizing either all or parts of the given desires but also determining means for realizing their underlying desires behind the given ones.

However, little attention has been paid to how to find underlying desires behind given desires, how to realize the underlying desires and how to handle both in a unified way as argument-based reasoning. Much work has been done

for argument-based formalizations of persuasion, negotiation, practical reasoning, and so on. From the viewpoint of reconciliation, in [2–5], the authors give mechanisms to select or combine a part of given goals or proposals using Dung’s acceptability semantics [6] or dialogical status assignment [7] in order to address their individual problems on negotiation. However, determining agent’s underlying desires behind the given goals or proposals, or revising them is outside the scope of these literatures. In [8–10], the authors give mechanisms for generating knowledge-dependent and context-dependent desires in practical reasoning. The mechanisms use deductive reasoning or default reasoning for deriving desires from given knowledge and desires. They, however, do not address the situations in which there are no means for realizing the given desires nor desires derived from the sum of the desires and knowledge using these reasoning. In [11], the authors give defeasible inference rules transferring a modal operator representing desires from the given desires to the means for realizing those desires. The argumentation framework structured with these inference rules determines the best way to achieve the given desires. It, however, also do not focus on inferences about underlying desires behind the given desires. In [12], the authors maintain the importance of the mechanisms for generating some abstract goals for reconciliation. Although they show guidelines for reconciliatory solutions to their thoughtful story, however, they do not give a formal and general method for finding underlying desires in accordance with well known scheme of practical reasoning [20].

In this paper, we provide an argument-based formalization of justifying means for underlying desires of given desires. Aiming to define underlying desires, we give a problem setting for desire abstraction in terms of sufficiency and consistency and introduce two defeasible inference rules, called positive and negative practical abductive syllogisms, as counterparts of positive and negative practical syllogisms given in [11]. These two rules intuitively states that it would be desirable to an agent if it is caused by realizing what the agent wants, and it would be undesirable to the agent if it is caused by not realizing what the agent wants. We give three kinds of argumentation systems, called practical abductive argumentation systems, practical argumentation systems and reconciliatory argumentation systems. We show that practical abductive argumentation systems can justify arguments whose conclusions satisfy sufficiency and consistency and the latter two are useful for handling reconciliatory solutions shown in two realistic scenarios: one is of committee member selection shown by Kowalski and Toni [12] and the other is of business transfer posed in this paper.

The paper is organized as follows. After showing logical preliminaries in Section 1, we give sufficiency and consistency conditions as a problem setting of desire abstraction and introduce two kinds of defeasible inference rules for practical reasoning. In Section 3, we give practical abductive argumentation systems and show their correctness in terms of sufficiency and consistency. In Section 4, we give practical argumentation systems and reconciliatory argumentation systems. In Section 5, we show the ability of our proposal by applying to committee member selection posed by Kowalski and Toni and business transfer posed by

this paper. Section 6 describes related work and discussions and Section 7 shows conclusions and future work.

1 Logical Preliminaries

We assume a modal propositional language with a single desire operator D that cannot be nesting. An assumed logic is type KD satisfying that if $D\varphi$ is true then $\neg D\neg\varphi$ is true. A knowledge representing language \mathcal{L} is a union of the modal propositional language, denoted by \mathcal{L}_0 , and the set, denoted by \mathcal{L}_1 , of defaults constructed on \mathcal{L}_0 . Defaults have the form “ $\varphi \Rightarrow \psi$ ” where φ is a conjunction of atomic propositions in \mathcal{L}_0 and ψ is an atomic proposition in \mathcal{L}_0 . Informally, “ $\varphi \Rightarrow \psi$ ” has the meaning that “If φ is the case then ψ is typically the case.” \mathcal{L}_0 is decided into two subsets; one is a set of controllable formulae and the other is a set of uncontrollable formulae. Intuitively, a controllable formula represents a state, including an action, agents can realize, e.g., “The book is on the desk” or “I read the book,” while an uncontrollable formula represents a states agents cannot change, e.g., “He is thirty years old.” Note that strict distinction is beyond the scope of this paper. We assume that D operates only on controllable formulae. Agent’s knowledge is a default theory $T = (F, \mathcal{D})$ where $F \subseteq \mathcal{L}_0$ is a consistent set without modal operator D and $\mathcal{D} \subseteq \mathcal{L}_1$ is a set of the defaults, and agent’s desire is a set $\mathcal{G} \subseteq \mathcal{L}_0$ where each element of \mathcal{G} is an atomic propositions with operator D .

An inference rule without an exception is called a strict inference rule, while an inference rule with an exception is called a defeasible inference rule. We use symbol “ \rightsquigarrow ” to represent any defeasible inference rules. Defeasible modus ponens is a defeasible inference rule defined as follows.

$$- \text{DMP} : \phi, \phi \Rightarrow \psi \rightsquigarrow \psi$$

In [11], the authors introduce two defeasible inference rules for practical reasoning called positive practical syllogism, PPS , and negative practical syllogism, NPS . Let a and p be controllable formulae and r be uncontrollable formula. The rules have the following forms.

$$\begin{aligned} - \text{PPS} &: a \wedge r \Rightarrow p, Dp, r \rightsquigarrow Da \\ - \text{NPS} &: a \wedge r \Rightarrow \neg p, Dp, r \rightsquigarrow \neg Da \end{aligned}$$

Informally, if an agent who desires p and believes r also believes that realizing a in a circumstance r realizes p , then this is a reason for desiring a , while if the agent believes that realizing a in a circumstance r instead realizes $\neg p$, then this is a reason not to desire a [11]. PPS transfers modal operator D from a certain formula to its possible means, while NPS negatively transfers the operator to its possible means. In this paper, we make a minor revision to NPS without losing intuition and use the following defeasible inference rule NPS' instead of NPS .

$$- \text{NPS}' : a \wedge r \Rightarrow \neg p, Dp, r \rightsquigarrow D\neg a$$

NPS' is more aggressive than NPS in the sense that it derives more than $\neg Da$ because if $D\neg a$ is true then $\neg Da$ is true. Moreover, we often use simplifications “ $a \Rightarrow p, Dp \rightsquigarrow Da$ ” and “ $a \Rightarrow \neg p, Dp \rightsquigarrow \neg Da$ ” of PPS and NPS' , respectively. We use the following notation for representing that proposition x is derived from a set B of formulae using only PPS or NPS' only once, where PS is an abbreviation of “practical syllogisms.”

$$B \vdash_{PS} x$$

Dung’s acceptability semantics is defined on an abstract argumentation framework. An abstract argumentation framework is defined as a tuple of a set of arguments without any internal structures and a binary relation, called attack relation, on the set of arguments. The following is the summary of definitions of Dung’s grounded semantics [6].

- An *argumentation framework* is a pair $AF = \langle AR, Attacks \rangle$, where AR is a set of arguments, and $Attacks$ is a binary relation on AR , i.e., $Attacks \subseteq AR \times AR$.
- A set $S \subseteq AR$ of arguments is *conflict-free* if there are no arguments $A, B \in S$ such that A attacks B , i.e. $(A, B) \in Attacks$.
- An argument $A \in AR$ is *acceptable* with respect to a set $S \subseteq AR$ of arguments iff, for all arguments in $B \in AR$, if B attacks A then there is an argument $C \in S$ such that C attacks B .
- A characteristic function $F_{AF} : Pow(AR) \rightarrow Pow(AR)$ is defined as follows.

$$F_{AF}(S) = \{A \mid A \text{ is acceptable with respect to } S\}$$

- The *grounded extension* of an argumentation framework AF is the least fixed point of F_{AF}

An argument A is *justified* in abstract argumentation framework AF , denoted by $A \in Jargs(AF)$, iff it is in the grounded extension of AF and is *overruled* in AF , denoted by $A \in Oargs(AF)$, iff it is not in the grounded extension of AF .

2 Defeasible Inference Rules for Desires Abstraction

2.1 Problem Settings for Desire Abstraction

This subsection aims to give a formal problem setting of desire abstraction. Our idea behind desire abstraction is that as is the case that rational actions or proposals have their objects, original desires also have their objects, i.e., underlying desires, and the underlying desires are within effects caused by realizing the original desires. What we want is to hypothetically identify underlying desires from possible effects of original desires.

Formally, what we want is a set $\mathcal{H} \subseteq \mathcal{L}_0$ of atomic propositions with modal operator D , called hypotheses, that explains why a given desire is desirable in terms of its effects, but does not explain why a given desire is undesirable in terms of its effects. The prior conditions for desire abstraction consists of prior insufficiency and prior consistency.

Prior insufficiency: $\forall Dx \in \mathcal{G}(\mathcal{F} \cup \mathcal{D} \not\vdash_{PPS} Dx)$

Prior consistency: $\forall Dx \in \mathcal{G}(\mathcal{F} \cup \mathcal{D} \not\vdash_{PPS} D\neg x)$

Prior insufficiency states that no given desire can be explained by present knowledge $\mathcal{F} \cup \mathcal{D}$ using PPS nor NPS' . Prior consistency states that no given desire can be negated by the present knowledge in terms of PPS nor NPS' .

The posterior conditions for desire abstraction consists of posterior sufficiency and posterior consistency.

Posterior sufficiency: $\forall Dx \in \mathcal{G}(\mathcal{F} \cup \mathcal{D} \cup \mathcal{H} \vdash_{PPS} Dx)$

Posterior consistency: $\forall Dx \in \mathcal{G}(\mathcal{F} \cup \mathcal{D} \cup \mathcal{H} \not\vdash_{PPS} D\neg x)$

Posterior sufficiency states that once we assume \mathcal{H} , every given desire can be explained in terms of PPS or NPS' . In other words, \mathcal{H} is an explanation of why a given desire is desirable. This is similar to a hypothesis of abduction that gives an explanation of why a fact is the case. Posterior consistency states that even if we assume \mathcal{H} , no given desire can be negated in terms of PPS nor NPS' . In other words, \mathcal{H} gives no explanation of why a give desire is undesirable. Now, we can summarize the problem setting of desire abstraction as follows.

Given: A knowledge $T = (\mathcal{F}, \mathcal{D})$ and a desire $\mathcal{G} \subseteq \mathcal{L}_0$ satisfying prior insufficiency and prior consistency.

Find: Hypotheses $\mathcal{H} \subseteq \mathcal{L}_0$ satisfying posterior sufficiency and posterior consistency.

2.2 Practical Abductive Syllogisms

In this subsection, we introduce two defeasible inference rules for deriving abstract desires that satisfy posterior sufficiency and posterior consistency. An inference rule approach is motivated by our observation that introducing defeasible inference rules allows us to instantiate Dung's abstract argumentation frameworks that provides fundamental principles for conflict resolution. As shown in Section 4, we will extend desire abstraction from complete knowledge to incomplete knowledge defined by a default theory, where desire abstraction should go hand-in-hand with conflict resolutions. Dung's abstract argumentation frameworks give us a unified way to handle desire abstraction within conflict resolutions.

The two defeasible inference rules, called a positive practical abductive inference rule $PPAS$ and a negative practical abductive inference rule $NPAS$, are defined as follows.

Definition 1 (Practical abductive syllogisms). *Let $a, p \in \mathcal{L}_0$ be controllable formulae and $r \in \mathcal{L}_0$ be an uncontrollable formula. A positive practical abductive syllogism, denoted by $PPAS$, and a negative practical abductive syllogism, denoted by $NPAS$, have the following forms, respectively.*

- $PPAS : a \wedge r \Rightarrow p, Da, r \rightsquigarrow Dp$
- $NPAS : \neg a \wedge r \Rightarrow p, Da, r \rightsquigarrow D\neg p$

PPAS intuitively states that p would be desirable if a is desirable in circumstance r and if a is realized in circumstance r then generally p is realized. On the other hand, *NPAS* intuitively states that p would be undesirable, or precisely it is desirable that p is not realized, if a is desirable in circumstance r and if a is not realized in circumstance r then generally p is realized. For simplicity, we abbreviate *PPAS* and *NPAS* as *PAS*, practical abductive syllogism, when we do not need to distinguish them. We say that p is an *abstraction* of a when an application of *PAS* derives Dp using Da .

Proposition 1. *Let $T = (\mathcal{F}, \mathcal{D})$ be a knowledge and \mathcal{G} be a desire that satisfy prior insufficiency. A set $\mathcal{H} \subseteq \mathcal{L}_0$ satisfies posterior sufficiency iff, for all $Dg \in \mathcal{G}$, there is $Dh \in \mathcal{H}$ such that $\mathcal{F} \cup \mathcal{D} \cup \{Dg\} \vdash_{PAS} Dh$.*

Proof. \mathcal{H} satisfies posterior sufficiency iff, for all $Dg \in \mathcal{G}$, there is $Dh \in \mathcal{H}$ such that $\mathcal{F} \cup \mathcal{D} \cup \{Dh\} \vdash_{PS} Dg$. This is true iff, for all $Dg \in \mathcal{G}$, there is $Dh \in \mathcal{H}$ such that $\mathcal{F} \cup \mathcal{D} \cup \{Dg\} \vdash_{PAS} Dh$. \square

Proposition 1 allows us to translate the problem of finding candidates satisfying posterior sufficiency into the problem of abstracting g using *PAS*, for all $Dg \in \mathcal{G}$.

Proposition 2. *Let $T = (\mathcal{F}, \mathcal{D})$ be a knowledge and \mathcal{G} be a desire that satisfy prior insufficiency. A set $\mathcal{H} \subseteq \mathcal{L}_0$ satisfies posterior consistency iff, for all $Dg \in \mathcal{G}$ and $Dh \in \mathcal{H}$, $\mathcal{F} \cup \mathcal{D} \cup \{Dg\} \not\vdash_{PAS} D\neg h$.*

Proof. \mathcal{H} satisfies posterior consistency iff, for all $Dg \in \mathcal{G}$ and $Dh \in \mathcal{H}$, $\mathcal{F} \cup \mathcal{D} \cup \{Dh\} \not\vdash_{PS} D\neg g$. This is true iff, for all $Dg \in \mathcal{G}$ and $Dh \in \mathcal{H}$, $\mathcal{F} \cup \mathcal{D} \cup \{D\neg h\} \not\vdash_{PS} Dg$. This is true iff, for all $Dg \in \mathcal{G}$ and $Dh \in \mathcal{H}$, $\mathcal{F} \cup \mathcal{D} \cup \{Dg\} \not\vdash_{PAS} D\neg h$. \square

Proposition 2 allows us to translate the problem of finding candidates not satisfying posterior consistency into the problem of abstracting g using *PAS*, for all $Dg \in \mathcal{G}$.

3 Justifying Underlying Desire

3.1 Successful Desire Abstraction by An Argument Interaction

The previous section introduced two defeasible inference rules, *PPAS* and *NPAS*. This section aims to give the mechanism to justify the hypotheses by argument-based reasoning. The following examples show how arguments structured with *PAS* interact each other to justify hypotheses satisfying posterior sufficiency and posterior consistency.

Example 1 (Posterior sufficiency of $\{D\beta_1\}$). An officer A of a product manufacturer desires to employ a certain staff ($D\alpha_1$). A believes that all members of the staff are capable (γ_1) and also that if the employment is realized in the situation where the members are capable, then A 's company promotes technological advancement ($\alpha_1 \wedge \gamma_1 \Rightarrow \beta_1$). *PPAS* defeasibly concludes that A desires to promote technological advancement ($D\beta_1$).

Example 2 (Posterior sufficiency of $\{D\beta_2\}$). An officer A of a product manufacturer desires to employ a certain staff ($D\alpha_1$). A believes that all members of the staff are capable (γ_1), and also that if the employment is realized in the situation where the members are capable, then A 's company increases total expenditure ($\alpha_1 \wedge \gamma_1 \Rightarrow \beta_2$). *PPAS* defeasibly concludes that A desires to increase total expenditure ($D\beta_2$).

The argument in Example 1 shows posterior sufficiency of $\{D\beta_1\}$ and the argument in Example 2 shows posterior sufficiency of $\{D\beta_2\}$. Obviously, we can notice that β_1 is a desirable main effect and β_2 is an undesirable side effect caused by employing the staff. Namely, *PPAS* is defeasible in the sense that it derives false conclusions even when the premises are true. *NPAS*, however, has a role of preventing such unintentional side effects to be justified, in the following way.

Example 3 (Posterior inconsistency of $\{D\beta_2\}$). A desires to reduce the cost ($D\alpha_2$). A believes that a resource price is as-is (γ_2) and also that if A fails to reduce a cost in the situation that a resource price is as-is, then A 's company increases total expenditure ($\neg\alpha_2 \wedge \gamma_2 \Rightarrow \beta_2$). *NPAS* defeasibly concludes that A desires not to increase total expenditure ($D\neg\beta_2$).

The argument in Example 3 shows posterior inconsistency of $\{D\beta_2\}$. Although no argument attacks the argument in Example 1, the argument in Example 3 attacks the argument in Example 2. In other words, arguments concluding posterior inconsistency prevents arguments concluding posterior sufficiency from justified.

3.2 Argumentation System for Desire Abstraction

These intuitive analysis in the previous subsection is formally handled in argumentation systems defined in this subsection. Arguments are constructed from knowledge $T = (\mathcal{F}, \mathcal{D})$ and desire \mathcal{G} . Each argument is assumed to have a tree structures where each leaf is in $\mathcal{F} \cup \mathcal{D} \cup \mathcal{G}$ and a set of edges connecting some node and its all children is an inference rule deriving the node from its all children. A conclusion, denoted by $\text{conc}(A)$ of an argument A is the root of A . An argument A is defeasible if it has a defeasible inference rule and strict if it has only strict inference rules. An argument A is a sub-argument of an argument B iff it is a subtree of B . A notion of attacks is defined as a binary relation on a set of arguments.

Definition 2 (Attacks). *Let A and B be arguments. A attacks B iff there is a sub-argument B' of B such that B' is defeasible and $\{\text{conc}(A), \text{conc}(B')\} \vdash \perp$.*

A *practical abductive argument* is defined as follows.

Definition 3 (Practical abductive arguments). *Let A be an argument and $Dg \in \mathcal{L}_0$. A is a practical abductive argument for Dg iff*

- Every node, except the root and leaves, is derived from its all children by a valid inference on first order logic.
- A 's root is derived from its all children using PAS .
- A child of the root is Dg .

A practical abductive argument is defeasible since PAS is defeasible.

Definition 4 (Practical abductive argumentation systems). A practical abductive argumentation system is a tuple $\langle AR, Attacks \rangle$ where AR be a set of practical abductive arguments and $Attacks$ be a binary relation on AR such that $(A, B) \in Attacks$ iff A attacks B .

We show correctness of the argumentation systems in terms of sufficiency and consistency.

Theorem 1. Let AS be a practical abductive argumentation system. A set of conclusions of justified arguments in AS satisfies posterior sufficiency and posterior consistency iff, for all $Dg \in \mathcal{G}$, there is an argument a in AS such that a is a practical abductive argument for Dg and a is justified in AS .

Proof. Both prior insufficiency and prior consistency are the cases because \mathcal{F} does not include modal operator D . Obviously, posterior sufficiency is the case iff there are practical abductive arguments for all $Dg \in \mathcal{G}$ and posterior consistency is the case iff all of the arguments are justified, i.e., no argument can show inconsistency. \square

Theorem 1 gives us the way to find hypotheses satisfying posterior sufficiency and posterior consistency by instantiations of Dung's abstract argumentation frameworks evaluated by Dung's semantics.

4 Justifying Means for Abstracted Desires

This section gives argumentation systems combining desire abstraction and means-ends reasoning. Moreover, we extend the assumed language from first-order theory to default theory, which allows us to desire abstraction and means-ends reasoning in incomplete information.

Definition 5 (Practical arguments). Let A be an argument and $Dg \in \mathcal{L}_0$. A is a practical argument for Dg iff it is Dg or it satisfies all the following conditions.

- A 's root is derived from its all children using PS .
- The subtree with root $D\varphi$ is a practical argument for Dg where $D\varphi$ is a child of A 's root.
- The subtrees with roots $\psi \wedge r \Rightarrow \varphi$ and r are both valid arguments with respect to default logic where they are both children of A 's root.

Definition 6 (Reconciliatory arguments). Let A be an argument and $Dg \in \mathcal{L}_0$. A is a reconciliatory argument for Dg iff it is a practical abductive argument for Dg or it satisfies all the following conditions.

- A 's root is derived from its all children using PS.
- The subtree with root $D\varphi$ is a reconciliatory argument for Dg where $D\varphi$ is a child of A 's root.
- The subtrees with roots $\psi \wedge r \Rightarrow \varphi$ and r are both valid arguments with respect to default logic where they are both children of A 's root.

Example 4 (A reconciliatory argument). Figure 1 is a reconciliatory argument for Da represented as a style of proof-tree. The argument is structured using positive practical syllogism on top and positive practical abductive syllogism on bottom. Db can be seen as a possible candidate for an abstracted desire of Da and Dc can be seen as a possible solution for the abstracted desire.

$$A : \frac{c \wedge s \Rightarrow b \quad \frac{a \wedge r \Rightarrow b \quad Da \quad r}{Db}}{Dc} \quad s$$

Fig. 1. A reconciliatory argument represented by a proof-tree

Definition 7 (Practical argumentation systems). A practical argumentation system is a tuple $\langle AR, Attacks \rangle$ where AR be a set of arguments except reconciliatory arguments and $Attacks \subseteq AR^2$ be a binary relation on AR such that $(A, B) \in Attacks$ iff A attacks B .

Definition 8 (Reconciliatory argumentation systems). A reconciliatory argumentation system is a tuple $\langle AR, Attacks \rangle$ where AR be a set of arguments except practical arguments and $Attacks \subseteq AR^2$ be a binary relation on AR such that $(A, B) \in Attacks$ iff A attacks B .

5 Two Persuasive Applications

We show usefulness of our argumentation systems by showing their ability to handle two realistic reconciliatory scenarios. Note that this section aims to show the ability of our argumentation systems to reconcile conflict independently from argumentation or dialogue protocols nor arguing agent's strategies. This section assumes that agents aim to reach an agreement even if they concede their original desires. Moreover, they are assumed to prefer to solutions obtained by abstracting desires rather than just choose compatible parts of their original ones.

We assume a default theory $T = (\mathcal{F}_1 \cup \mathcal{F}_2, \mathcal{D}_1 \cup \mathcal{D}_2)$ and desires $\mathcal{G}_1, \mathcal{G}_2$ where $(\mathcal{F}_i, \mathcal{D}_i)$ represents i 's default theory, i.e., knowledge, and \mathcal{G}_i represents i 's desire, for $i = 1, 2$.

5.1 A Solution for Committee Member Selection

Kowalski and Toni give a thoughtful scenario indicating the importance of desire abstraction in reconciliation. Although a solution using argument-based reasoning is expected, a simple but sufficient formal solution has not yet been found. This section gives a solution for the problem by showing how our argument-based reasoning handles the problem. The following is the scenario described in [12]:

In a recent head-of-sections committee meeting in our Department, we discussed the composition of a new resources committee. Two conflicting arguments were put forward. The Director of Administration argued that, in the interests of efficiency, the members of the new committee should consist of himself and the other principal administrative officers of the Department. The Director of Research argued, in opposition to him, that, in the interests of democracy, the committee should also contain members elected by the Department. During the course of the discussion it became clear that the two sides were focussing on different assumptions about the purpose of the new committee: the Director of Administration on its purely administrative function, and the Director of Research on its presumed policy making nature. These two assumptions could be viewed as conflicting solutions to the more general goals of deciding, on the one hand, which group should make policy about resources. By focussing on the more general goals, it was possible to identify a new solution which was acceptable to both parties: the resources committee will administer resources, whereas the head-of-sections committee will make policy about resources. In the interests of efficiency, the members of the resources committee will consist of administrative officers only. In the interests of democracy, the head-of-sections committee will represent the views and interests of the various Department sections on matters concerning policy about the allocation of resources.

We assume the following default theory and desires where “*R-cmtr*” denotes the resource committee, “*H-cmtr*” denotes the head-of-sections committee, “*R*” denotes resources and “*P*” denotes policies.

$$\begin{aligned} \mathcal{F} &= \{ \text{administers}(R\text{-cmtr}, R), \text{makes}(R\text{-cmtr}, P), \text{democratic}(H\text{-cmtr}) \} \\ \mathcal{D} &= \{ \text{election}(X) \Rightarrow \neg \text{efficient}(X)(= r_1), \text{election}(X) \Rightarrow \text{democratic}(X)(= r_2), \\ &\quad \text{administers}(X, Y) \wedge \text{efficient}(X) \Rightarrow \text{lean}(Y)(= r_3), \\ &\quad \text{makes}(X, Y) \wedge \text{democratic}(X) \Rightarrow \text{fair}(Y)(= r_4) \} \\ \mathcal{G}_1 &= \{ D(\text{efficient}(R\text{-cmtr})) \} \\ \mathcal{G}_2 &= \{ D(\text{democratic}(R\text{-cmtr})) \} \end{aligned}$$

Figure 2 represents practical arguments constructed from the above default theory and desires where defaults are substantiated with appropriate constants.

$$\begin{aligned}
 A_1 : & \frac{D(\text{efficient}(R\text{-cmtr})) \quad \text{election}(R\text{-cmtr}) \Rightarrow \neg\text{efficient}(R\text{-cmtr})}{D(\neg\text{election}(R\text{-cmtr}))} \\
 A_2 : & \frac{D(\text{democratic}(R\text{-cmtr})) \quad \text{election}(R\text{-cmtr}) \Rightarrow \text{democratic}(R\text{-cmtr})}{D(\text{election}(R\text{-cmtr}))}
 \end{aligned}$$

Fig. 2. Practical arguments

We can see that no argument is justified in the following practical argumentation system.

$$\langle \{A_1, A_2\}, \{(A_1, A_2), (A_2, A_1)\} \rangle$$

Figure 3 represents practical abductive arguments constructed from the same default theory and desires, where r_1^* , r_3^* , r_4^* and r_4^+ are defined as follows.

$$\begin{aligned}
 r_1^* &= \text{election}(R\text{-cmtr}) \Rightarrow \neg\text{efficient}(R\text{-cmtr}) \\
 r_3^* &= \text{administers}(R\text{-cmtr}, R) \wedge \text{efficient}(R\text{-cmtr}) \Rightarrow \text{lean}(R) \\
 r_4^* &= \text{makes}(R\text{-cmtr}, P) \wedge \text{democratic}(R\text{-cmtr}) \Rightarrow \text{fair}(P) \\
 r_4^+ &= \text{makes}(H\text{-cmtr}, P) \wedge \text{democratic}(H\text{-cmtr}) \Rightarrow \text{fair}(P)
 \end{aligned}$$

We can see that A_3 and A_4 can both be justified in the following reconciliatory argumentation system.

$$\langle \{A_3, A_4\}, \emptyset \rangle$$

$$\begin{aligned}
 & \frac{D(\text{efficient}(R\text{-cmtr})) \quad \text{administers}(R\text{-cmtr}, R) \quad r_3^*}{D(\text{lean}(R))} \quad \frac{\text{administers}(R\text{-cmtr}, R) \quad r_3^*}{D(\text{efficient}(R\text{-cmtr}))} \quad r_1^* \\
 & \frac{\text{administers}(R\text{-cmtr}, R) \quad r_3^*}{D(\text{lean}(R))} \quad \frac{\text{administers}(R\text{-cmtr}, R) \quad r_3^*}{D(\text{efficient}(R\text{-cmtr}))} \quad r_1^* \\
 A_3 : & \frac{\frac{\frac{D(\text{efficient}(R\text{-cmtr})) \quad \text{administers}(R\text{-cmtr}, R) \quad r_3^*}{D(\text{lean}(R))} \quad \frac{\text{administers}(R\text{-cmtr}, R) \quad r_3^*}{D(\text{efficient}(R\text{-cmtr}))} \quad r_1^*}{D(\text{lean}(R))} \quad \frac{\text{administers}(R\text{-cmtr}, R) \quad r_3^*}{D(\text{efficient}(R\text{-cmtr}))} \quad r_1^*}{D(\neg\text{election}(R\text{-cmtr}))} \\
 A_4 : & \frac{D(\text{democratic}(R\text{-cmtr})) \quad \text{makes}(R\text{-cmtr}, P) \quad r_4^*}{D(\text{fair}(P))} \quad \frac{\text{democratic}(H\text{-cmtr}) \quad r_4^+}{D(\text{makes}(H\text{-cmtr}, P))}
 \end{aligned}$$

Fig. 3. Reconciliatory arguments

5.2 A Solution for Business Transfer

Consider the following scenario of a solution for a problem of business transfer. An officer A of product manufacturer deliberates with an officer B of parts

manufacturer about the acquisition of some department X of the parts manufacturer. They argue about solutions realizing their original desires. A wants B to transfer all members of X as a means to realize her desire to employ the staff. By contrast, B does not want to transfer all members because it prevents his desire to reallocate the staff. There is no another means to realize both A 's and B 's desires. So, B starts to look for reconciliatory solutions. After some consideration, B conceives that A actually wants to promote technological advancement by the transition. B seeks the possible means to promote technological advancement and finds a solution that B devolves an intellectual property right to A . A does not complain about his solution and the deliberation successfully arrives at the contract signing stage.

We assume the following default theory and desires where uncontrollable formulae of practical syllogisms and practical abductive syllogisms are abbreviated for simplicity: $T = (\emptyset, \{e \Rightarrow b, g \Rightarrow a, g \Rightarrow \neg d, \neg b \Rightarrow h, a \Rightarrow h, a \Rightarrow j, k \Rightarrow j\})$, $G_1 = \{Da, Db\}$ and $G_2 = \{Dd\}$. Each formula has the following meaning: “ A employs the staff from B . ($= a$),” “ A reduces the cost. ($= b$),” “ B reallocates the staff. ($= d$),” “ B accepts the warranty against defects. ($= e$),” “ B transfers all members of the department to A . ($= g$),” “ A 's company increases the total expenditure. ($= h$),” “ A 's company promotes the technological advancement. ($= j$),” and “ B devolves an intellectual property right to A . ($= k$).”

$$A_1 : \frac{Da \quad g \Rightarrow a}{Dg} \quad A_2 : \frac{Db \quad e \Rightarrow b}{De} \quad A_3 : \frac{Dd \quad g \Rightarrow \neg d}{D\neg g}$$

Fig. 4. Practical arguments

Only A_2 is justified in the following practical argumentation system.

$$\langle \{A_1, A_2, A_3\}, \{(A_1, A_3), (A_3, A_1)\} \rangle$$

Figure 4 represents all practical arguments, i.e., A_1 , A_2 and A_3 , constructed from T , \mathcal{G}_1 and \mathcal{G}_2 . On the other hand, only A_6 and A_8 are justified in the following reconciliatory argumentation system.

$$\langle \{A_i \mid 4 \leq i \leq 9\}, \{(A_8, A_4), (A_7, A_5), (A_7, A_9), (A_9, A_7)\} \rangle$$

where A_9 is a sub-argument of A_5 whose conclusion is Dh . Figure 5 represents practical arguments, i.e., A_1 , A_2 and A_3 , constructed from T , \mathcal{G}_1 and \mathcal{G}_2 .

6 Related Work and Discussions

In [11], the authors addressed the question: what is the best way to achieve given desires? They proposed a logical formalization of an argument-based justification for actions. In contrast, we addressed the question: what is an abstract desire of

$$\begin{array}{l}
A_4 : \frac{\frac{Da \quad a \Rightarrow h}{Dh} \quad a \Rightarrow h}{Da} \quad \frac{g \Rightarrow a}{Dg} \quad \frac{d \Rightarrow \neg g}{D-d} \\
A_5 : \frac{\frac{Da \quad a \Rightarrow h}{Dh} \quad \frac{\neg b \Rightarrow h}{D-b}}{D-e} \quad e \Rightarrow b \\
A_6 : \frac{Da \quad a \Rightarrow j}{Dj} \quad \frac{k \Rightarrow j}{Dk} \\
A_7 : \frac{Db \quad \neg b \Rightarrow h}{D\neg h} \\
A_8 : Dd
\end{array}$$

Fig. 5. Reconciliatory arguments and arguments attacking them

given desires and what is a way to achieve the abstract desire? We proposed a logical formalization of an argument-based justification for desire abstraction. We think that practical abductive syllogisms are counterparts of practical syllogisms in practical reasoning as the relationships between abduction and deduction in epistemic reasoning, and that they are essential in reconciliation by showing two persuasive examples.

In [20], the authors organized various sorts of cogent reasoning in our daily life as argumentation schemes where each scheme consists of premises, conclusions, and critical questions written in natural language. Practical syllogisms are kinds of practical inference according to Walton's classification. On the other hand, on classification is given for practical abductive syllogisms in Walton's theory although they are essential to find reconciliatory solutions.

From a standpoint of negotiation, Fisher and Ury urge that determining the stakeholders' interests helps to achieve reconciliatory solutions in negotiation [17]. Negotiation theory shows that positions are what negotiators say they want and interests are the needs of concerns that underlie positions [18]. Although argument-based negotiation is outside of scope of this paper, we think that our proposal is useful for identifying latent interests by effectively using original positions. In fact, although many of argument-based negotiation handle reasoning to identify desires or goals that depend on context [2–5, 8–10, 19], no one attempt to seek latent desires behind original positions. In our opinion, not only agent's knowledge, but agent's desire can be incomplete.

The technical contribution of this paper is to propose practical abductive syllogisms, *PPAA* and *NPAS* as a counterpart of abduction and deduction in epistemic reasoning, and argumentation systems structured with these inference rules. Moreover, another contribution is to show usefulness of the argumentation systems by showing two persuasive examples. The argumentation systems justify means for abstracted desires of given desires as an interaction of arguments, i.e., argument-based reasoning.

7 Conclusions and Future Work

This paper proposed a logical formalization of an argument-based justification for abstract desires of given desires. We gave a problem setting for desire ab-

straction in terms of sufficiency and consistency and introduced two defeasible inference rules, called positive and negative practical abductive syllogisms. Practical abductive arguments hypothetically derive possible desirable effects caused by realizing the given desires and possible undesirable effects caused by not realizing the given desires. We showed that these two rules and practical abductive argumentation systems structured with the rules are correct with respect to sufficiency and consistency. We gave practical argumentation systems and reconciliatory argumentation systems and showed that the argumentation systems can simply handle reconciliatory scenarios of committee member selection posed by Kowalski and Toni, and of business transfer posed in this paper.

We will apply the practical abductive syllogisms not only to practical reasoning or deliberation, but also negotiation because they are useful for promoting goals of negotiation, i.e., finding reasonable settlement through, e.g., compromise. Moreover, we will address the problems of agent's strategies showing how to an agent strategically abstracts another agent's desires, and argument protocols showing when to an agent puts forward reconciliatory solutions.

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