A formal framework for inter-agents dialogue to reach an agreement about a representation[1]

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Abstract. We propose in this paper a framework for inter-agents dialogue to reach an agreement, which formalize a debate in which the divergent representations are discussed. For this purpose, we propose an argumentation-based representation framework which manages the conflicts between claims with different relevances for different audiences to compute their acceptance. Moreover, we propose a model for the reasoning of agents where they justify the claims to which they commit and take into account the claims of their interlocutors. This framework bounds a dialectics system in which agents play a dialogue to reach an agreement about a conflict of representation.

1 Introduction

A fundamental communication problem in open multiagent systems is caused by the heterogeneity of agents knowledge, in particular the discrepancy of the underlying ontologies. The approaches, such as standardization [6] and ontology alignment [4], are not suited due to the system openness. Since standardization requires that all parties involved reach a consensus on the ontology to use, it seems very unlikely that it will ever happen. On the other hand, ontology alignment is a technique that enables agents to keep their individual ontologies by making use of mappings. However, we do not know *a priori* which ontologies should be mapped within an open multiagent system. Conflicts of representation should not be avoid but resolved [1]. Contrary to [3], our work is not restricted to a protocol but also provide a model of reasoning and a model of agents.

Argumentation is a promising approach for reasonning with inconsistency information. In [14], Dung formalizes the argumentation reasonning with a framework made of abstract arguments with a contradiction relation to determine their acceptances. Classicaly, the extensions of this framework are built upon a background logic language [13, 7]. Therefore, arguments are not abstract entities but relations of consequence between a premise and a conclusion. Moreover, are introduced argumentative frameworks which assign strength to the arguments according to one (in [13]) or many priority relationships (in [12, 7]).

In this paper, we aim at using argumentative technics in order to provide a dialogical mechanism for the agents to reach an agreement on their representations. For this purpose, we extend DIAL [7], a formal framework for inter-agents dialogue based upon the argumentative technics. We propose here an argumentation-based representation framework, offering a way to compare definition with contradiction relation and to compute their acceptance. We propose a model of agent reasonning to put forward some definitions and take into account the definitions of their interlocutors. Finally, we bound here a dialectic system in which a protocol enables two agents to reach an agreement about their representations.

Paper overview. Section 2 introduces the example of dialogue that will illustrate our framework throught this paper. In section 3, we provide the syntax and the semantic of the description logic which is adopted in this paper. Section 4 presents the argumentation framework that manages interaction between conflicting representations. In accordance with this background, we describe in section 5 our agent model. In section 6, we define the formal area for agents debate. The section 7 presents the protocol used to reach an agreement.

2 Natural language

A dialogue is a coherent sequence of moves from an initial situation to reach the goal of participants [9]. For instance, the goal of dialogues consists in resolving a conflict about a representation. In the initial situation, two participants do not share the same definition of a concept, either because one participant ignore such a definition, or their own definitions are contradictory. Such cases appear quite often in dialogues and may cause serious communication problems. At the end of the dialogue, the participants must reach an agreement about the definition of this concept.

Before we start to formalize such dialogues, let us first discuss the following natural language dialogue example between a visitor and a guide in the Foire de Paris:

- visitor : Which kind of transport service can I use to go the Foire de Paris ?
- guide : The subway is a suitable transport service.
- visitor : Why the subway is a suitable transport service ?
- guide : The subway can transport you in the Hall C at the level 2.
- visitor : To my opinion, the service must transport me anywhere in Paris.
- guide : To my opinion, the service does not need to transport you anywhere in Paris but a taxi can.

In this dialogue, two participants share the concept “suitable transport service”. However, this dialogue reveals a conflict in the divergent definitions of this concept and resolve it. The guide considers that the definition of the visitor make authority and adjust her own representation to adopt this definition. Below we will assume the guide gives priority to the visitor’s concepts.

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3 Ontology and Description Logic

In this section, we provide the syntax and the semantics for the well-known $\mathcal{ALC}$ [8] which is adopted in the rest of the paper.

The data model of a knowledge base (KBase, for short) can be expressed by means of the Description Logic (DL, for short) which has a precise semantic and effective inference mechanisms. Moreover, most ontologies markup langagues (e.g. OWL) are partly founded on DL. Although, it can be assumed that annotations and conceptual models are expressed using the XML-based languages mentioned above. The syntax of the representation adopted here is taken from standard constructors proposed in the DL literature. This representation language is sufficiently expressive to support most of the principal constructors of any ontology markup language.

In $\mathcal{ALC}$, primitive concepts, denoted $C, D, \ldots$ are interpreted as unary predicates and primitive roles, denoted $R, S, \ldots$, as binary predicates. We call description a complex concepts which can be built using constructors. The syntax of $\mathcal{ALC}$ is defined by the following BNF definition: $C \rightarrow \top|\bot|C|\neg C|C \sqcup D|C \sqcap D|\exists R.C|\forall R.C$

The semantics is defined by an interpretation $\mathcal{I} = (\Delta^{\mathcal{I}}, \cdot^{\mathcal{I}})$, where $\Delta^{\mathcal{I}}$ is the non-empty domain of the interpretation and $\cdot^{\mathcal{I}}$ stands for the interpretation function. The semantics of the constructors are summarized in the figure 1.

Figure 1. Semantics of the $\mathcal{ALC}$ constructors

Name	Syntax	Semantics
top concept	$\top$	$\Delta^{\mathcal{I}}$
bottom concept	$\bot$	$\emptyset$
concept	C	$C^{\mathcal{I}} \subseteq \Delta^{\mathcal{I}}$
concept negation	$\neg C$	$\Delta^{\mathcal{I}} - C^{\mathcal{I}}$
concept conjunction	$C_1 \sqcap C_2$	$C_1^{\mathcal{I}} \cap C_2^{\mathcal{I}}$
concept disjunction	$C_1 \sqcup C_2$	$C_1^{\mathcal{I}} \cup C_2^{\mathcal{I}}$
existencial restriction	$\exists R.C$	$\{x \in \Delta^{\mathcal{I}}; \exists y \in \Delta^{\mathcal{I}}((x,y) \in R^{\mathcal{I}} \wedge y \in C^{\mathcal{I}})\}$
universal restriction	$\forall R.C$	$\{x \in \Delta^{\mathcal{I}}; \forall y \in \Delta^{\mathcal{I}}((x,y) \in R^{\mathcal{I}} \rightarrow y \in C^{\mathcal{I}})\}$

A KBase $\mathcal{K} = \langle \mathcal{T}, \mathcal{A} \rangle$ contains a T-box $\mathcal{T}$ and a A-box $\mathcal{A}$. The T-box includes a set of concept definition ($C \equiv D$) where C is the concept name and D is a description given in terms of the language constructors. The A-box contains extensional assertions on concepts and roles. For example, a (resp. (a,b)) is an instance of the concept C (resp. the role R) iff $a^{\mathcal{I}} \in C^{\mathcal{I}}$ (resp. $(a^{\mathcal{I}}, b^{\mathcal{I}}) \in R^{\mathcal{I}}$). We call **claims**, the set of concept definitions and assertions contained in the KBase. A notion of subsumption between concepts is given in terms of the interpretations.

Definition 1 (Subsumption)**.** *Let C and D be two concepts. C **subsumes** D (denoted $C \sqsupseteq D$) iff for every interpretation $\mathcal{I}$ its holds that $C^{\mathcal{I}} \supseteq D^{\mathcal{I}}$.*

Indeed, $C \equiv D$ amounts to $C \sqsupseteq D$ and $D \sqsupseteq C$. We allow that the KBase contains partial definitions, *i.e.* axioms based on subsumption ($C \sqsupseteq D$). Below we will use $\mathcal{ALC}$ in our argumentation-based representation framework.

4 Argumentation KBase

At first, we consider that agents share a common KBase. In order to manage the interactions between conflicting claims with different revelances, we introduce an argumentation KBase.

We present in this section a value-based argumentation KBase, *i.e.* an argumentation framework built around the underlying logic language $\mathcal{ALC}$, where the revelance of claims (concept definitions and assertions) depends on the audience. The KBase is a set of sentences in a common language, denoted $\mathcal{ALC}$, associated with a classical inference, denoted $\vdash$. In order to take into account of the variability of particular situations, we are concerned by a set of audiences (denoted $\mho_A = \{\mathrm{a}_1, \ldots, \mathrm{a}_n\}$), which adhere to different claims with a variable intensity.

The audiences share an argumentation KBase, *i.e.* a set of claims promoting values:

Definition 2. *Let $\mho_A = \{a_1, \ldots, a_n\}$ be a set of audiences. The **value-based argumentation KBase** $AK = \langle \mathcal{K}, V, promote \rangle$ is defined by a triple where:*

- *$\mathcal{K} = \langle \mathcal{T}, \mathcal{A} \rangle$ is a KBase, i.e. a finite set of claims in $\mathcal{ALC}$;*
- *V is a non-empty finite set of values $\{v_1, \ldots, v_t\}$;*
- *$promote : \mathcal{K} \rightarrow V$ maps from the claims to the values.*

We say that the claim ϕ relates to the value v if ϕ promotes v. For every $\phi \in \mathcal{K}$, $promote(\phi) \in V$.

To distinguish different audiences, values, both concrete and abstract, constitute starting points [10]. Values are arranged in hierarchies. For example, an audience will value both justice and utility but an argument may require a determination of strict preference between the two. Since audiences are individuated by their hierarchies of values, the values have different priorities for different audiences. Each audience a_i is associated with a **value-based argumentation KBase** which is a 4-tuple $\mathrm{AK}_i = \langle \mathcal{K}, V, \mathrm{promote}, \ll_i \rangle$ where:

- $\mathrm{AK} = \langle \mathcal{K}, V, \mathrm{promote} \rangle$ is a value-based argumentation KBase as previously defined;
- $\ll_i$ is the priority relation of the audience a_i, *i.e.* a strict complete ordering relation on V.

A priority relation is a transitive, irreflexive, asymmetric, and complete relation on V. It stratifies the KBase into finite non-overlapping sets. The priority level of a non-empty KBase $K \subseteq \mathcal{K}$ (written $\mathrm{level}_i(K)$) is the least important value promoted by one element in K. On one hand, a priority relation captures the value hierarchy of a particular audience. On the other hand, the KBase gathers claims (concept definitions and assertions) that are shared by audiences. Definitions, that are consequence relations between a premise and a conclusion, are built on this common KBase.

Definition 3. *Let K be a KBase in $\mathcal{ALC}$. A **definition** is couple $A = \langle \Phi, \phi \rangle$ where ϕ is a claim and $\Phi \subseteq K$ is a non-empty set of claims such as : Φ is consistent and minimal (for set inclusion); $\Phi \vdash \phi$. Φ is the premise of A, written $\Phi = premise(A)$. ϕ is the conclusion of A, denoted $\phi = conc(A)$.*

In other words, the premise is a set of claims from which the conclusion can be inferred. The definition A' is a **sub-definition** of A if the premise of A' is included in the premise of A. A' is a **trivial definition** if the premise of A' is a singleton. Since the KBase $\mathcal{K}$ can be inconsistent, the set of definitions (denoted $\mathcal{A}(\mathcal{K})$) will conflict.

Definition 4. *Let K be a KBase in $\mathcal{ALC}_{\mho}$ and $A = \langle \Phi, \phi \rangle, B = \langle \Psi, \psi \rangle \in \mathcal{A}(K)$ two definitions. A **attacks** B iff : $\exists \Phi_1 \subseteq \Phi, \Psi_2 \subseteq \Psi$ such as $\Phi_1 \vdash \chi$ and $\Psi_2 \vdash \neg \chi$.*

Because each audience is associated with a particular priority relation, audiences individually evaluate the revelance of definitions.

Definition 5. *Let $AK_i = \langle \mathcal{K}, V, promote, \ll_i \rangle$ be the value-based argumentation KBase of the audience a_i and $A = \langle \Phi, \phi \rangle \in$*

$\mathcal{A}(\mathcal{K})$ *a definition. According to* AK_i*, the* ***revelance of*** A *(written revelance*$_i(A)$*) is the least important value promoted by one claim in the premise.*

In other words, definitions revelance depends on the priority relation. Since audiences individually evaluate definitions revelance, an audience can ignore that a definition attacks another. According to an audience, a definition defeats another definition if they attack each other and the second definition is not more revelant than the first one:

Definition 6. *Let* $AK_i = \langle \mathcal{K}, V, promote, \ll_i \rangle$ *be the value-based argumentation KBase of the audience* a_i *and* $A = \langle \Phi, \phi \rangle$, $B = \langle \Psi, \psi \rangle \in \mathcal{A}(\mathcal{K})$ *two definitions.* A ***defeats*** B ***for the audience*** $\mathbf{a}_i$ *(written defeats*$_i(A, B)$*) iff* $\exists \Phi_1 \subseteq \Phi, \Psi_2 \subseteq \Psi$ *such as : i)* $\Phi_1 \vdash \chi$ *and* $\Psi_2 \vdash \neg\chi$*; ii)* $\neg(level_i(\Phi_1) \ll_i level_i(\Psi_2))$*. Similarly, we say that a set* S *of definitions defeats* B *if* B *is defeated by a definition in* S*.*

Considering each audience own viewpoint, we define the subjective acceptance notion:

Definition 7. *Let* $AK_i = \langle \mathcal{K}, V, promote, \ll_i \rangle$ *be the value-based argumentation KBase of the audience* a_i*. Let* $A \in \mathcal{A}(\mathcal{K})$ *be a definition and* $S \subseteq \mathcal{A}(\mathcal{K})$ *a set of definitions.* A ***is subjectively acceptable by the audience*** $\mathbf{a}_i$ ***with respect to S*** *iff* $\forall B \in \mathcal{A}(\mathcal{K})$ *defeats*$_i(B, A) \Rightarrow$ *defeats*$_i(S, B)$*.*

The following example illustrates our argumentation-based representation framework.

Example 1. *Let us consider two participants coming to the "Foire de Paris" and arguing about suitable transport service. Without loosing generality, we restrict the KBase to the T-box in this example. The value-based argumentation KBase of the audience* a_1 *(resp.* a_2*) is represented in the figure 2 (resp. figure 3). The audience is associated with a KBase, i.e. a set of claims. The different claims* $\phi_{11}, \ldots, \phi_7$ *relate to the different values* $v_1, \ldots, v_7$*. According to an audience, a value above another one in a table has priority over it. The five following definitions conflict:*
$A_1 = (\{\phi_{11}, \phi_3, \phi_{22}\}, Taxi(x))$*;*
$A_2 = (\{\phi_{11}, \phi_5, \phi_6\}, Taxi(x))$*;*
$B = (\{\phi_{11}, \phi_4, \phi_7, \phi_{12}\}, \neg Taxi(x))$*;*
$B' = (\{\phi_{11}, \phi_4, \phi_7\}, Subway(x))$*.*
B' *is a sub-definition of* B*.*
If we consider the value-based argumentation KBase of the audience a_1*,* A_1 *relevance is* v_3 *and* B' *is* v_4*. Therefore,* B *defeats* A_1 *but* A_1 *does not defeat* B*. If we consider thevalue-based argumentation KBase of the audience* a_2*,* A_1 *revelance is* v_3 *and* B' *is* v_7*. Therefore,* A_1 *defeats* B *but* B *does not defeat* A_1*. Whatever the audience is, the set* $\{A_1 A_2\}$ *is subjectively acceptable wrt* $\mathcal{A}(\mathcal{K})$*.*

Figure 2. The value-based argumentation KBase of the first participant

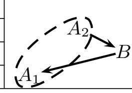
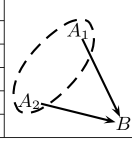
$\ll_1$	V	$\mathcal{K}$	
↑	$\mathbf{v_1}$	ϕ_{11} : Trans($\mathbf{x}$)	
		ϕ_{21} : Trans($\mathbf{x}$) $\sqsupseteq$ Subway($\mathbf{x}$) $\sqcup$ Taxi($\mathbf{x}$)	
	$\mathbf{v_2}$	ϕ_{12} : Taxi($\mathbf{x}$) $\sqcap$ Subway($\mathbf{x}$) $\equiv \bot$	
		ϕ_{22} : Trans($\mathbf{x}$) $\sqsupseteq$ Dest($\mathbf{x}$, inParis)	
	v_7	ϕ_7 : Trans(x) $\sqsupseteq$ Dest(x, level2hallc)	
	v_6	ϕ_6 : Trans(x) $\sqsupseteq$ Dest(x, versailles)	
	v_5	ϕ_5 : Dest(x, versailles) $\sqsupseteq$ Taxi(x)	
	v_4	ϕ_4 : Dest(x, level2hallc) $\sqsupseteq$ Subway(x)	
	v_3	ϕ_3 : Dest(x, inParis) $\sqsupseteq$ Taxi(x)	

Figure 3. The value-based argumentation KBase of the second participant

$\ll_2$	V	$\mathcal{K}$	
↑	$\mathbf{v_1}$	ϕ_{11} : Trans($\mathbf{x}$)	
		ϕ_{21} : Trans($\mathbf{x}$) $\sqsupseteq$ Taxi($\mathbf{x}$) $\sqcup$ Subway($\mathbf{x}$)	
	$\mathbf{v_2}$	ϕ_{12} : Taxi($\mathbf{x}$) $\sqcap$ Subway($\mathbf{x}$) $\equiv \bot$	
		ϕ_{22} : Trans($\mathbf{x}$) $\sqsupseteq$ Dest($\mathbf{x}$, inParis)	
	v_3	ϕ_3 : Dest(x, inParis) $\sqsupseteq$ Taxi(x)	
	v_4	ϕ_4 : Dest(x, level2hallc) $\sqsupseteq$ Subway(x)	
	v_5	ϕ_5 : Dest(x, versailles) $\sqsupseteq$ Taxi(x)	
	v_6	ϕ_6 : Trans(x) $\sqsupseteq$ Dest(x, versailles)	
	v_7	ϕ_7 : Trans(x) $\sqsupseteq$ Dest(x, level2hallc)	

We have defined here the mechanism to manage interactions between conflicting claims. In the next section, we present a model of agents which put forward claims and take into account other claims coming from their interlocutors.

5 Model of agents

In multi-agent setting it is natural to assume that all the agents do not use exactly the same ontology. Since agents representations (set of claims and priorities) can be common, complementary or contradictory, agents have to exchange hypotheses and argue. Our agents individually valuate the perceived commitments with respect to the estimated reputation of the agents from whom the information is obtained.

The agents, which have their own private representations, record their interlocutors commitments [5]. Moreover, agents individually valuate their interlocutors reputation. Therefore, an agent is in conformance with the following definition:

Definition 8. *The* ***agent*** $a_i \in \mho_A$ *is defined by a 6-tuple*
$a_i = \langle \mathcal{K}_i, V_i, \ll_i, promote_i, \cup_{j \neq i} CS^i_j, \prec_i \rangle$ *where:*

- $\mathcal{K}_i$ *is a personal KBase, i.e. a set of personal claims in* $\mathcal{ALC}$*;*
- V_i *is a set of personal values;*
- $promote_i : \mathcal{K}_i \rightarrow V_i$ *maps from the personal claims to the personal values;*
- $\ll_i$ *is the priority relation, i.e. a strict complete ordering relation on* V_i*;*
- CS^i_j *is a commitment store, i.e. a set of claims in* $\mathcal{ALC}_{\mho}$*.* $CS^i_j(t)$ *contains propositional commitments taken before or at time* t*, where agent* a_j *is the debtor and agent* a_i *the creditor;*
- $\prec_i$ *is the reputation relation, i.e. a strict complete ordering relation on* $\mho_A$*.*

The personal KBase are not necessarily disjoint. We call **common KBase** the set of claims explicitly shared by the agents: $\mathcal{K}_{\Omega_A} \subseteq \cap_{a_i \in \mho_A} \mathcal{K}_i$. Similarly, we call **common values** the values explicitly shared by the agents: $V_{\Omega_A} \subseteq \cap_{a_i \in \mho_A} V_i$. The common claims relate to the common values. For every $\phi \in \mathcal{K}_{\Omega_A}$, $\text{promote}_{\Omega_A}(\phi) = v \in V_{\Omega_A}$. The personal KBase can be complementary or contradictory. We call **joint KBase** the set of claims distributed in the system: $\mathcal{K}_{\mho_A} = \cup_{a_i \in \mho_A} \mathcal{K}_i$. The agent own claims relate to the agent own values. For every $\phi \in \mathcal{K}_i - \mathcal{K}_{\Omega_A}$, $\text{promote}_i(\phi) = v \in V_i - V_{\Omega_A}$.

We can distinguish two ways for an agent to valuate her interlocutors commitments: either in accordance with a global social order [11], or in accordance with a local perception of the interlocutor, called reputation. Obviously, this way is more flexible. Reputation is a social concept that links an agent to her interlocutors. It is also a leveled relation [2]. The individuated reputation relations, which are transitive, irreflexive, asymmetric, and complete relations on $\mho_A$, preserve these properties. $a_j \prec_i a_k$ denotes that an agent a_i trusts an agent a_k more than another agent a_j.In order to take into account the claims notified in the commitment stores, each agent is associated with the following extended KBase:

Definition 9. *The* ***extended KBase of the agent*** $\boldsymbol{a_i}$ *is the value-based argumentation KBase* $AK_i^* = \langle \mathcal{K}_i^*, V_i^*, promote_i^*, \ll_i^* \rangle$ *where:*

- $\mathcal{K}_i^* = \mathcal{K}_i \cup [\bigcup_{j \neq i} CS_j^i]$ *is the agent extended personal KBase composed of its personal KBase and the set of perceived commitments;*
- $V_i^* = V_i \cup [\bigcup_{j \neq i} \{v_j^i\}]$ *is the agent extended set of personal values composed of the set of personal values and the reputation values associated with her interlocutors;*
- $promote_i^* : \mathcal{K}_i^* \rightarrow V_i^*$ *is the extension of the function* $promote_i$ *which maps claims in the extended personal KBase to the extended set of personal values. On the one hand, personal claims relate to personal values. On the other hand, claims in the commitment store* CS_j^i *relate to the reputation value* v_j^i*;*
- $\ll_i^*$ *is the agent extended priority relation, i.e. an ordered relation on* V_i^*.

Since the debate is a collaborative social process, agents share common claims of prime importance. To reach the global goal of the multi-agent system, the common values have priority over the other values.

Let us consider a debate between two agents, a visitor and a guide in the "Foire de Paris". The guide considers that visitor's claims make authority and adjust her own representation to adopt these claims. By opposite, we will assume the visitor gives priority to the guide's claims. Therefore, there is an authority relation between the visitor and the guide. On one hand, a guide should consider that visitor's claims are more revelant than her own. Therefore, her interlocutor reputation values have priority over her personal values. If a_j is a visitor, the guide extended priority relation a_i is constrained as follows : $\forall v_\omega \in V_{\Omega_A} \forall v \in V_i - V_{\Omega_A}$ $(v \ll_i^* v_j^i \ll_i^* v_\omega)$. On the other hand, a visitor should consider that her own claims are more revelant than the guide ones. If a_j is a guide, the visitor extended priority relation a_i is constrained as follows: $\forall v_\omega \in V_{\Omega_A} \forall v \in V_i - V_{\Omega_A}$ $(v_j^i \ll_i^* v \ll_i^* v_\omega)$.

We can easily demonstrate that the extended priority relation is a strict complete ordering relation. The one-agent notion of conviction is then defined as follows:

Definition 10. *Let* $a_i \in \mho_A$ *be an agent associated with the extended KBase*
$AK_i^* = \langle \mathcal{K}_i^*, V_i^*, promote_i^*, \ll_i^* \rangle$ *and* $\phi \in \mathcal{ALC}$ *a claim. The* ***agent*** $\boldsymbol{a_i}$ ***is convinced by the claim*** ϕ *iff* ϕ *is the conclusion of an acceptable definition for the audience* a_i *with respect to* $\mathcal{A}(\mathcal{K}_i^*)$.

Agents utter messages to exchange their representations. The syntax of messages is in conformance with the common **communication language**, $\mathcal{CL}$. A message $M_k = \langle S_k, H_k, A_k \rangle \in \mathcal{CL}$ has an identifier M_k. It is uttered by a speaker (S_k = speaker(M_k)) and addressed to an hearer (H_k = hearer(M_k)). A_k = act(M_k) is the message speech act. It is composed of a locution and a content. The locution is one of the following: `question, propose, unknow, concede, counter-propose, challenge, withdraw`. The content, also called **hypothesis**, is a claim or a set of claims in $\mathcal{ALC}$.

Speech acts have an argumentative semantic, because commitments enrich the extended KBase of the creditors, and a public semantic, because commitments are justified by the extended KBase of the debtor.

For example, an agent can propose a hypothesis if he has a definition for it. The corresponding commitments stores are updated. More formaly, an agent a_i can propose to the agent a_j a hypothesis h at time t if a_i has a definition for it. The corresponding commitments stores are updated: for any agent a_k ($\neq a_i$) $\mathrm{CS}_i^k(t) = \mathrm{CS}_i^k(t-1) \cup \{h\}$.

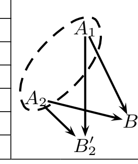
The argumentative and social semantic of the speech act `counter-propose` is equivalent with the proposition one. The rational condition for the proposition and the rational condition for the concession of the same hypothesis by the same agent distinguish themselves. Agents can propose hypotheses whether they are supported by a trivial definition or not. By contrast, an agent does not concede all the hypotheses he hears in spite of they are all supported by a trivial definition which are in the commitment stores.

The others speech acts (question(h), challenge(h), unknow(h), and withdraw(h)) are used to manage the sequence of moves (cf section 7). They have no particular effects on commitments stores, neither particular rational conditions of utterance. Since withdraw(h) speech act has no effect on commitments stores, we consider that commitments stores are cumulative [9].

The hypotheses which are received must be valuated. For this purpose, commitments will be individually considered in accordance with the speaker estimated reputation. The following example illustrates this principle.

Example 2. *If the agent* a_1 *utters the following message:* $M_1 = \langle a_1, a_2, propose(Subway(x)) \rangle$*, then the extended KBase of the agent* a_2 *is as represented in the table 4.*

Figure 4. The extended KBase of the agent a_2

$\ll_2^*$	V_2^*	$\mathcal{K}_2^*$	
	$\mathbf{v_1}$	ϕ_{11} : Trans$(\mathbf{x})$ ϕ_{21} : Trans $\sqsupseteq$ Taxi$(\mathbf{x}) \sqcup$ Subway$(\mathbf{x})$	
	$\mathbf{v_2}$	ϕ_{12} : Taxi $\sqcap$ Subway $\equiv \bot$ ϕ_{22} : Trans$(\mathbf{x}) \sqsupseteq$ Dest$(\mathbf{x}$, inParis$)$	
	v_3	ϕ_3 : Dest$(x$, inParis$) \sqsupseteq$ Taxi(x)	
	v_4	ϕ_4 : Dest$(x$, level2hallc$) \sqsupseteq$ Subway(x)	
	v_5	ϕ_5 : Dest$(x$, versailles$) \sqsupseteq$ Taxi(x)	
	v_6	ϕ_6 : Trans$(x) \sqsupseteq$ Dest$(x$, versailles$)$	
	v_7	ϕ_7 : Trans$(x) \sqsupseteq$ Dest$(x$, level2hallc$)$	
	v_1^2	$\{$Subway$(\mathrm{x})\} = \mathrm{CS}_1^2$	

We have presented here a model of agents who exchange hypotheses and argue. In the next section, we bound a formal area where debates take place.

6 Dialectic system

When a set of social and autonomous agents argue, they reply to each other in order to reach the interaction goal, *i.e.* an agreement about a claim. We bound a formal area, called dialectic system, which is inspired by [7] and adapted to this paper context.

During exchanges, speech acts are not isolated but they respond to each other. Moves syntax is in conformance with the common **moves language** : $\mathcal{ML}$. A move $\mathrm{move}_k = \langle M_k, R_k, P_k \rangle \in \mathcal{ML}$ has an identifier move_k. It contains a message M_k as defined before. Moves are messages with some attributes to control the sequence. R_k = reply(move_k) is the move identifier to which move_k responds.

A move (move_k) is either an initial move ($\text{reply}(\text{move}_k) = \text{nil}$) or a replying move ($\text{reply}(\text{move}_k) \neq \text{nil}$). $\text{P}_k = \text{protocol}(\text{move}_k)$ is the protocol name which is used.

A dialectic system is composed of two agents. In this formal area, two agents play moves to check an initial hypothesis, *i.e.* the topic.

Definition 11. *Let* $AK_{\Omega_A} = \langle \mathcal{K}_{\Omega_A}, V_{\Omega_A}, promote_{\Omega_A} \rangle$ *be a common value-based argumentation KBase and* ϕ_0 *a claim in* $\mathcal{ALC}$. *The* ***dialectics system*** *on the topic* ϕ_0 *is a quintuple* $DS_{\Omega_M}(\phi_0, AK_{\Omega_A}) = \langle N, H, T, protocol, Z, \rangle$ *where :*

- $N = \{init, part\} \subset \mho_A$ *is a set of two agents called players: the initiator and the partner;*
- $\Omega_M \subseteq \mathcal{ML}$ *is a set of well-formed moves;*
- H *is the set of histories, i.e. the sequences of well-formed moves s.t. the speaker of a move is determined at each stage by a turn-taking function and the moves agree with a protocol;*
- $T : H \rightarrow N$ *is the turn-taking function determining the speaker of a move. If* $|h| = 2n$ *then* $T(h) = init$ *else* $T(h) = part$*;*
- $protocol : H \rightarrow \Omega_M$ *is the function determining the moves which are allowed or not to expand an history;*
- Z *is the set of dialogue, i.e. terminal histories.*

In order to be well-formed, the initial move is a question about the topic from the initiator to the partner and a replying move from a player always references an earlier move uttered by the other player. In this way, backtracks are allowed. We call dialogue line the subsequence of moves where all backtracks are ignored. In order to avoid loops, hypothesis redundancy is forbidden within propositions belonging to the same dialogue line. Obviously, all moves should contain the same parameter protocol value.

We have bound here the area in which dialogues take place. We formalize in the next section a particular protocol to reach a representation agreement.

7 Protocol

When two agents have a dialogue, they collaborate to confront their representations. For this purpose, we propose in this section a protocol.

To be efficient, the protocol is a unique-response one where players can reply just once to the other player's moves. The protocol is a set of sequence rules (cf figure 5). Each rule specifies authorized replying moves. In this figure, speech acts resist or surrender to the previous one. For example, the "Propose/Counter-Propose" rule (written $\text{sr}_{P/C}$) specifies authorized moves replying to the previous propositions ($\text{propose}(\Phi)$). Contrary to resisting acts, surrendering acts close the debate. A concession ($\text{concede}(\Phi)$) surrenders to the previous proposition. A challenge ($\text{challenge}(\phi)$) and a counter-proposition ($\text{counter-propose}(\phi)$) resist to the previous proposition.

The figure 6 shows a debate in the extensive form game representation where nodes are game situations and edges are moves. For example, 2.3^{init} denotes a game situation where the exponent indicates that the initiator is the next move speaker. The exponent of game-over situations are boxes (*e.g.* $2.1^{\square}$, $3.2^{\square}$, and $4.2^{\square}$). For evident clarity reasons, the games that follows situations 2.2^{init}, 4.4^{init}, and 6.3^{init} are not represented. In order to confront her representation with a partner, an initiator begins a dialogue. If the partner has no representation of the topic, he pleads ignorance and closes the dialogue (cf game situation $2.1^{\square}$). If players have the same representation, the dialogue closes (cf game situation $3.2^{\square}$). Otherwise, the goal of the dialogue is to reach an agreement by verbal means. The following example illustrates such a dialogue.

Example 3. *Let us consider a dialogue between a visitor and a guide in the "Foire de Paris". In the initial situation, the value-based argumentation KBase of the visitor (resp. the guide) is represented in the figure 7 (resp. figure 8). Commitments stores are the results of moves sequence (cf figure 9).*

Figure 7. Extended argumentation KBase of the visitor

$\ll_1^*$	V_1^*	$\mathcal{K}_1^*$	
↑	$\mathbf{v_1}$	$\phi_{\mathbf{11}}$: Trans($\mathbf{x}$) $\phi_{\mathbf{21}}$: Trans $\sqsupseteq$ Taxi($\mathbf{x}$) $\sqcup$ Subway($\mathbf{x}$)	
	$\mathbf{v_2}$	$\phi_{\mathbf{12}}$: Taxi $\sqcap$ Subway $\equiv \bot$ $\phi_{\mathbf{22}}$: Trans($\mathbf{x}$) $\sqsupseteq$ Dest($\mathbf{x}$, inParis)	
	v_3	ϕ_3 : Dest(x, inParis) $\sqsupseteq$ Taxi(x)	$\mathcal{A}_1$
	v_2^1	$\emptyset = \text{CS}_2^1$	

Figure 8. Extended argumentation KBase of the guide

$\ll_2^*$	V_2^*	$\mathcal{K}_2^*$	
↑	$\mathbf{v_1}$	$\phi_{\mathbf{11}}$: Trans($\mathbf{x}$) $\phi_{\mathbf{21}}$: Trans $\sqsupseteq$ Taxi($\mathbf{x}$) $\sqcup$ Subway($\mathbf{x}$)	
	$\mathbf{v_2}$	$\phi_{\mathbf{12}}$: Taxi $\sqcap$ Subway $\equiv \bot$ $\phi_{\mathbf{22}}$: Trans($\mathbf{x}$) $\sqsupseteq$ Dest($\mathbf{x}$, inParis)	
	v_1^2	$\emptyset = \text{CS}_1^2$	
	v_4	ϕ_4 : Dest(x, level2hallc) $\sqsupseteq$ Subway(x)	
	v_7	ϕ_7 : Trans(x) $\sqsupseteq$ Dest(x, level2hallc)	$\mathcal{B}$

Figure 9. Dialogue to reach an agreement

$\mathcal{K}_1^* - \mathcal{K}_{\Omega_A}$		$\mathcal{K}_{\Omega_A}$ $\phi_{11}, \phi_{21}, \phi_{12}, \phi_{22}$	$\mathcal{K}_2^* - \mathcal{K}_{\Omega_A}$	
$\mathcal{K}_1$	CS_2^1	Game situation	CS_1^2	$\mathcal{K}_2$
ϕ_3	$\emptyset$	0	$\emptyset$	ϕ_4, ϕ_7
		$\rightarrow$ question(Trans(x)) $\rightarrow$		
ϕ_3	$\emptyset$	1	$\emptyset$	ϕ_4, ϕ_7
		$\leftarrow$ propose(Subway(x)) $\leftarrow$		
ϕ_3	Subway(x)	2	$\emptyset$	ϕ_4, ϕ_7
		$\rightarrow$ challenge(Subway(x)) $\rightarrow$		
ϕ_3	Subway(x)	3	$\emptyset$	ϕ_4, ϕ_7
		$\leftarrow$ propose($\phi_4, \phi_7, \phi_{11}$) $\leftarrow$		
ϕ_3	Subway(x), ϕ_4, ϕ_7	4	$\emptyset$	ϕ_4, ϕ_7
		$\rightarrow$ counter-propose($\phi_{11}, \phi_3, \phi_{22}$) $\rightarrow$		
ϕ_3	Subway(x), ϕ_4, ϕ_7	5	ϕ_3	ϕ_4, ϕ_7
		$\leftarrow$ concede(Taxi(x)) $\leftarrow$		

8 Conclusion

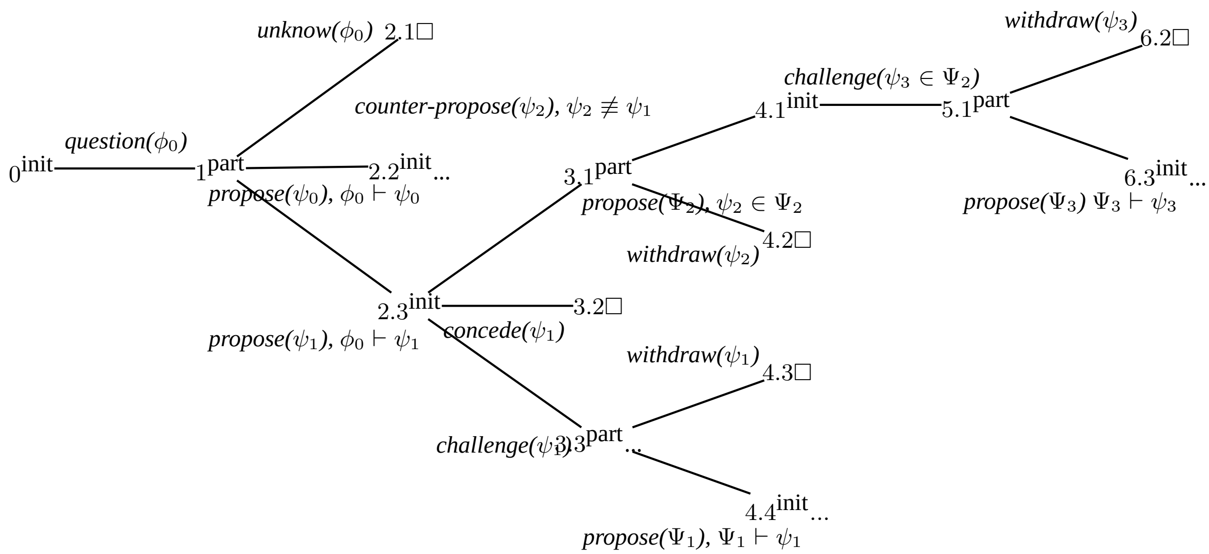
We have proposed in this paper a framework for inter-agents dialogue to reach an agreement, which formalize a debate in which the divergent representations are discussed. For this purpose, we have proposed an argumentation-based representation framework which manages the conflicts between claims with different relevances for different audiences to compute their acceptance. Moreover, we have proposed a model for the reasoning of agents where they justify the claims to which they commit and take into account the claims of their interlocutors. This framework bounds a dialectics system in which agents play a dialogue to reach an agreement about a conflict of representation.

Future works will investigate the applications of such dialogue for the services composition. For this purpose, we have to shift from our notion of propositional commitment to the notion of commitment in actions.

Figure 5. Set of speech acts and their potential answers.

Sequences rules	Speech acts	Resisting replies	Surrendering replies
$sr_{Q/A}$	question(ϕ)	propose(ϕ'), $\phi \vdash \phi'$	unknow(ϕ)
$sr_{P/C}$	propose(Φ)	challenge(ϕ), $\phi \in \Phi$ counter-propose(ϕ), $\phi \not\in \Phi$	concede(ϕ), $\Phi \vdash \phi$
$sr_{C/P}$	challenge(ϕ)	propose(Φ), $\Phi \vdash \phi$	withdraw(ϕ)
$sr_{Rec/P}$	counter-propose(Φ)	propose(Φ'), $\Phi \subseteq \Phi'$	withdraw(Φ)
sr_T	unknow(Φ)	$\emptyset$	$\emptyset$
	concede(Φ)	$\emptyset$	$\emptyset$
	withdraw(Φ)	$\emptyset$	$\emptyset$

Figure 6. Debate in an extensive form game representation



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