Ontology Alignment Argumentation with Mutual Dependency Between Arguments and Mappings

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Abstract — **For a successful communication, autonomous entities (e.g. agents, web services, peers) must reconcile vocabulary used in their ontologies. The result is a set of mappings between ontology entities. Since each party might have its own perspective about what are the best mappings, conflicts will arise. Toward a mapping consensus building between information exchanging parties, this paper proposes an approach based on a formal argumentation framework, whose existing ontology matching algorithms generate the mappings, which are further interpreted into semantic arguments employed during the argumentation. The proposal models a mutual dependency between the mappings and arguments, which goes beyond the state of the art in argumentation-based ontology alignment negotiation, better reflecting the requirements of the task.**

I. INTRODUCTION

Ontologies are artifacts that provide a shared vocabulary and its meaning about a domain of interest that can be conveyed between people and application systems [1]. Because ontologies are targeted and fitted to describe the structure and the semantics of information, they play a key role in many application scenarios, such as the Semantic Web [1], Knowledge Management and e-commerce [2], information integration [3], peer-to-peer systems [4] and also in inter-agent communication [5], [6]. Autonomous entities (from now on referred as agents) embedded in open and dynamic environments such as the Web and its extension, the Semantic Web [1], can express beliefs and actions and communicate them by means of ontologies. Due to the nature of such environments different parties (i.e. people and agents) adopt different ontologies for their descriptions, which make heterogeneity problems arise between communication partners. Therefore, interoperability relies on the ability to reconcile ontologies with different terminologies, different modelling structure and different formats and languages with a partially overlapping domain. Typically, this reconciliation relies on establishing a set of correspondences (i.e. an alignment) between agents' ontologies which are further exploited to interpret or translate exchanged messages. In literature this reconciliation problem is usually called *Ontology Matching*. Research initiatives in ontology matching have developed many algorithms and systems able to generate (semi-) automatic correspondences between two different but overlapping ontologies [7]. Considering those systems trustable and independent, agents could agree on applying one of the many systems that exist to generate an alignment. Independent of which algorithm is used, the result is a set of mapping elements (also referred to as matches or correspondences), where each match is a 4-tuple: $\langle e, e', R, n \rangle$ where e and e' are source and target ontology entities (respectively), R is a relation (e.g. equivalence, more general) and n is a confidence value, typically in the [0-1] range. State-of-the-art matching systems [8] rely on the combination of several (basic) techniques (e.g. string-based, language-based, structure-based) which express a set of preferences related with (i) the selection of those techniques and (ii) the way they are combined and/or aggregated. Thus, different systems might have contradictory and inconsistent perspectives about candidate correspondences. Additionally, autonomous agents pursuing their own goals might have different preferences and interests due, for instance, to the subjective nature of ontologies, the context and the alignment requirements. Moreover, since agents are online in an open environment and they have no prior knowledge of the existence of other agents, the decision to accept (or to reject) these correspondences must be done at run-time. So, the agents' acceptability of correspondences proposed by one single and independent system is not guaranteed.

This paper presents our approach to overcome these problems by employing an argumentation-based framework that allows agents to reach a consensus about the correspondences that must be part of the alignment that will enable them to communicate and mutually understand each other. For that, agents will exchange arguments in order to persuade the other agent to change its initial position, i.e. to accept a correspondence instead of rejecting it and vice-versa.

The rest of this paper is organized as follows: the next section introduces background concepts about argumentation frameworks. Section III describes our proposal, which is complemented in section IV with an example. Section V compares the proposed approach with the related work. Finally, section VI draws conclusions and comments on future work.

II. ARGUMENTATION FRAMEWORK

While several argumentation frameworks [9] exist, many of them are based on the Dung's argumentation framework, also referred as classical argumentation framework [10].

A. *Classical Argumentation Framework*

Dung defines an argumentation framework as follows.

Definition 1. An Argumentation Framework is a pair $AF = \langle A, R_{att} \rangle$, where A is a set of arguments and R_{att} is a binary relation on A such that $R_{att} \subseteq A \times A$. A pair $\langle x, y \rangle \in R_{att} : x, y \in A$ means that "argument x attacks argument y" and might be represented as $attack(x, y)$. A set of arguments S attacks an argument y if y is attacked by an argument in S.

An argumentation framework may be represented by a directed graph whose nodes are arguments and edges represent the attack relation. In Dung's work an attack always succeed (i.e. defeats the attacked arguments). This notion produces the following definitions:

Definition 2. An argument $a \in A$ is *acceptable* with respect to set of arguments $S(acceptable(a, S))$ if $(\forall x)(x \in A)\ \&\ (attacks(x, a)) \longrightarrow (\exists y)(y \in S)\ \&\ attacks(y, x)$.

Definition 3. A set S of arguments is *conflict-free* if $\neg(\exists x)(\exists y)((x \in S) \& (y \in S) \& attacks(x, y))$.

Definition 4. A *conflict-free* set S of arguments is *admissible* if $(\forall x)(x \in S) \longrightarrow acceptable(x, S)$.

Definition 5. A set of arguments S is a *preferred extension* if it is maximal (with respect to set inclusion) *admissible* set of A.

A *preferred extension* represents a consistent position within an AF, which is defensible against all attacks and cannot be further extended without introducing a conflict. Yet, multiple *preferred extensions* can exist in an AF due to the presence of cycles of *even* length in the graph. In addition, one can have the notion of *sceptical* arguments which are those that are present in all preferred extensions and the notion of *credulous* arguments which are those that are present in at least one preferred extension. So, when multiple *preferred extensions* exist, adopting one implies the establishment of some *preferences* over arguments.

This argumentation framework assumes that an argument A supports B if A attacks and therefore defeats an argument C that attacks argument B. Thus, it only explicitly represents the negative interaction (i.e. attack), while the positive interaction (i.e. defence/support) of an argument A to another argument B is implicitly represented by the attack of A to C (Fig. 1).

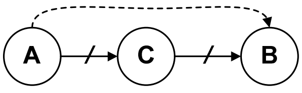

Fig. 1 The attack and the implicit support relation in AF

So, the AF modelling approach adopts a parsimonious strategy, which is neither complete nor the correct modelling of argumentation [11].

B. Bipolar Argumentation Framework

The BAF [12] extends the AF to explicitly represent the support relation between arguments which is assumed to be independent of the attack relation (or defeat, since an attack always succeeds in an AF). In that sense, bipolarity refers to the existence of two independent kinds of information which have a diametrically opposed nature and which represent repellent forces [12]. For example, an argument can be seen as a set of premises and a conclusion, where the set of premises entails the conclusion according to some logical inference schema [12]. Thus, an argument C confirming a premise of an argument A is supporting A, while an argument B opposing to a premise of A is attacking A. Thus, no direct relation exists between B and C (Fig. 2).

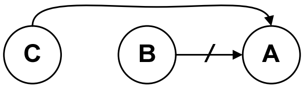

Fig. 2 The attack and the explicit support relation in BAF

Definition 6. A BAF is a 3-tuple: $BAF = \langle A, R_{att}, R_{sup} \rangle$ where A, R_{att} means the same as in the AF and R_{sup} is a binary relation on A such that $R_{sup} \subseteq A \times A$. A pair $\langle x, y \rangle \in R_{sup} : x, y \in A$ means that "argument x supports argument y" and might be represented as $support(x, y)$. A generic relation between two arguments x and y is represented as follows: xRy where $x, y \in A$ and R is the relation between them, i.e. *defeat* or *support*.

The BAF can still be represented by a direct graph, with two kinds of edges, one for the attack relation and another one for the support relation. Moreover, it is assumed that bipolar interaction graph is acyclic.

Definition 7. A *supported defeat* for an argument y is a sequence $a_1R_1a_2 \ldots a_{n-2}R_{n-1}a_n$ with $n \geq 3$ and $a_n = y$, such that $\forall i = 1 \ldots n-2, R_i = support$ and $R_{n-1} = defeat$.

Definition 8. An *indirect defeat* for an argument y is a sequence $a_1R_1a_2 \ldots a_{n-2}R_{n-1}a_n$ with $n \geq 3$ and $a_n = y$, such that $\forall i = 2 \ldots n-1, R_i = support$ and $R_1 = defeat$.

Definition 9. Let $S \subseteq A$, let $x \in A$. *S set-defeats x iif there exist a supported defeat or an indirect defeat for x from an element of S. S set-supports x iif there exist a sequence* $a_1R_1a_2 \ldots a_{n-1}R_{n-1}a_n$ with $n \geq 2$ such that $\forall i = 1 \ldots n-1, R_i = support$ with $a_n = x$ and $a_1 \in S$.

The notation "set-defeat" and "set-support" means that the defeat and the support relations apply to sets of arguments.

Definition 10. Let $S \subseteq A$, let $x \in A$. S *defends* collectively x *iff* $\forall y \in A$, if $\{y\}$ set-defeats x then $\exists z \in S$ such that $\{z\}$ set-defeats y.

Internal coherence is taken into account by following definition.

Definition 11. Let $S \subseteq A$. S is *conflict-free iif* $\nexists x, y \in S$ such that $\{x\}$ set-defeats y.

External coherence is taken in account by following definition.

Definition 12. Let $S \subseteq A$. S is a *safe-set iif* $\nexists x \in A$ such that S set-defeats x and either S set-supports x or $x \in S$.

Thus, the notion of acceptability is defined as:

Definition 13. Let $S \subseteq A$. S is a *stable-extension* of a *BAF iif* S is *conflict-free* and $\forall x \notin S$, *S set-defeats x.*

If S is a *stable-extension* and S is also *safe* then S is closed for R_{sup}.

Accordingly, three different definitions for *admissibility* are presented, from the most general one to the most specific one.

Definition 14. A set S of arguments is a *d-admissible* set if $S \subseteq A$ and S is conflict-free and defends all its elements (“*d*” means “in the sense of Dung”).

Definition 15. A set S of arguments is a *s-admissible* set if $S \subseteq A$ and S is a *safe-set* and defends all its elements (“*s*” means “safe”).

Definition 16. A set S of arguments is a *c-admissible* set if $S \subseteq A$ and S is *conflict-free*, closed for R_{sup} and defends all its elements (“*c*” means “close for R_{sup}”).

Definition 17. A set of arguments S *d-preferred (or s-preferred or c-preferred) extension* if $S \subseteq A$ and it is maximal (with respect to set inclusion) *d-admissible (or s-admissible or c-admissible)* set of A respectively.

III. PROPOSAL

The proposed approach exploits the explicitly defined relations of arguments in the Bipolar Argumentation Framework in order to persuade the other agent to change its position about a mapping.

A. Assumptions

This work assumes a multi-agent system running in an open environment, where each agent is uniquely identified by its name. Each agent has a knowledge base expressed by an ontology. For the purpose of communication, agents need to establish a consensual alignment between their ontologies. The process of achieving a consensual alignment must be completely automatic and not require any human user involvement.

Furthermore, we assume that each agent is able to generate an alignment (M) (i) by itself using an internal ontology matching system (OAS) or (ii) by cooperation with other specialised agent(s). In both cases, the alignment is a set of correspondences represented in a 4-tuple as described in section I. For each correspondence $m_i \in M$, a set of justifications is provided, explaining why the correspondence has been generated or why a given correspondence is not included in M. Agents will use such justifications to exchange arguments in order to support its proposed correspondences and to attack other agent proposals in case of divergence.

B. Exploiting BAF

Since we are concerned with ontology mappings, we can define an argument as follows. An argument $x \in A$ is a 4-tuple such that $x = \langle id, m, G, p \rangle$, where id is a unique identifier, m is a correspondence such that $m = \langle e, e', R, n \rangle$, G is the set of justifications attacking and supporting m and p is one of $\{+, -\}$ depending on whether the argument is supporting or attacking m, respectively. Therefore, based on BAF definitions, p is concluded based on G.

In order to achieve a consensual agreement about mappings, agents (i.e. agent A and agent B) follow a sequence of steps expressed in the script of Fig. 3.

As a first step, each agent obtains its set of mappings M^{Ag} (M^A and M^B respectively).

In the second step, each agent exchanges all $m_i \in M^{Ag}$ with the other agent, so they are acquainted with the other’s mappings (M'). With the aim of protecting private information, the confidence of each mapping might be omitted.

```
1.  $M^A = OAS^A(O_1, O_2)$
    $M^B = OAS^B(O_1, O_2)$
2.  $M' = M^A \cup M^B$
3.  $BAF^A = BuildBAF(M^A, M')$
    $BAF^B = BuildBAF(M^B, M')$
4.  $Do$
5.  {  $pref^A = PrefExtension(BAF^A)$
       $pref^B = PrefExtension(BAF^B)$
6.     $MP^A = ExtractMappings(pref^A)$
       $MP^B = ExtractMappings(pref^B)$
7.     $\langle Agree, Disagree, s \rangle = Evaluate(MP^A, MP^B)$
8.     $if\ (s \neq true)$
9.     {  $X^A = ArgsToPersuade(Disagree)$
          $X^B = ArgsToPersuade(Disagree)$
10.       $BAF^A = UpdateBAF(BAF^A, X^A, X^B)$
          $BAF^B = UpdateBAF(BAF^B, X^B, X^A)$
11.    }
12. } $While(s \neq true)$
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Fig. 3 Script describing the argumentation process

In the third step, each agent builds its own BAF model taking in account all known mappings (M'). This includes two processes. First, for each known mapping one *position argument* is created (p_i), such that $\forall m_i \in M' \longrightarrow \exists p_i \in A$. At this point, p_i is in favour of m_i if that mapping belongs to the agents’ previously generated set of mappings (i.e. $m_i \in M^{Ag}$) and against m_i otherwise (i.e. $m_i \notin M^{Ag}$). Second, each agent enriches the existing set of arguments with other arguments supporting and attacking the position arguments. These arguments are normally provided by the matching algorithms that generated M^{Ag}. For each matching algorithm or external entity, the agent needs to normalize the argument both (i) in terms of value (e.g. given a threshold value t_r decide if that algorithm argues in favour (i.e. $n \geq t_r$) or against (i.e. $n < t_r$) a given correspondence) and (ii) in terms of form (e.g. how to transform the result of the matching algorithm into a semantic argument in the form of $value1\ operator\ value2$). In the end, interpreting the semantic of each argument, supporting and attacking relations between arguments are explicitly defined in R_{att} and R_{sup}respectively.

In the fifth step, each agent evaluates its preferred extensions. If multiple preferred extensions exist, the agent chooses the one that better fits the agent’s interests. For this purpose we are using a fixed point algorithm adapted from [13] which is responsible for a gradual valuation of arguments following the principles stated in [11]. Those principles are (i) argument valuation depends on the values of its direct attacks and of its direct supporters, (ii) when the quality of the support increases then the value of the argument increases and when the quality of attacks increases then the value of the argument decreases, and (iii) when the quantity of the supports/attacks increases then the quality of supports /attacks increases.

In the sixth step, each agent extracts the proposing alignment considering its preferred extension. The result is a set of the mappings corresponding to the position arguments present in the preferred extension. This is denoted by MP^{Ag}.

In the seventh step, both agents evaluate the common agreement and the common disagreement. Therefore, the agreement (MA) and the disagreement (MD) correspond to:

$$MA = MP^A \cap MP^B$$
$$MD = (MP^A \cup MP^B) - MA$$

According to the resulting (dis)agreement, agents need to decide together if it is worth continuing arguing with each other. If it is not worth continuing arguing, it means that (i) both agents are satisfied with the current agreement (e.g. MD is empty or is not relevant), and (ii) agent's relative position did not change for the last i iterations. Thus, the argumentation process ends with the current agreement as output. If both agents agree carrying on the argumentation, agents follow to the ninth step.

In the ninth step, each agent selects, generates or retrieves arguments with the aim of persuading the other to change its current position (current preferred extension). To succeed, agents must employ arguments that are unknown to the other agent. Note that a preferred extension is a consistent position inside BAF which is defensible against all known arguments.

Finally in the tenth step, each agent updates its BAF model with the arguments from the previous step. These arguments are also exchanged with the other agent. For each received argument, the agent needs to check and interpret it in order to decide if that argument should be considered or not. When considering it, the agent's BAF model is updated according to the argument's semantics (i.e. attacking or supporting which arguments), hopefully driving the agents to an incrementally growing consensus. The agents resume execution at step five.

IV. WORKED EXAMPLE

In order to better explain our approach we present a worked example. Imagine that agents Ag_A and Ag_B need to interact with each other. The knowledge base of Ag_A is expressed according to the ontology O_1 while Ag_B's knowledge base is expressed according to the ontology O_2. For space reasons and for the sake of brevity, both ontologies are partially shown in TABLE I.

TABLE I

EXCERPTS OF ONTOLOGIES O_1 AND O_2

O_1 Ontology	**O_2 Ontology**
$Vehicle \sqsubseteq \top$	$Vehicle \sqsubseteq \top$
$Automobile \sqsubseteq Vehicle$	$Car \sqsubseteq Vehicle$
$Van \sqsubseteq Automobile$	$CableCar \sqsubseteq Car$
$Utility \sqsubseteq Automobile$	$UtilityCar \sqsubseteq Car$
$Sport \sqsubseteq Automobile$	$SportCar \sqsubseteq Car$
$Jeep \sqsubseteq Automobile$	$Limousine \sqsubseteq Car$

Based on both agent's ontologies, each agent generates an alignment between O_1 and O_2. Thus, let us assume that Ag_A's initial alignment is $M^A = \{m_1, m_2, m_3, m_4\}$ and Ag_B's initial alignment is $M^B = \{m_1\}$. For the sake of clarity, the description considers that two mappings from two agents are the same if the mappings have the same *id*. In practice though, a reconciliation process of mappings would be required. These mappings are described in TABLE II.

TABLE II

MAPPINGS UNDER DISCUSSION

id	e	e'	R	n
m_1	$O_1{:}Vehicle$	$O_2{:}Vehicle$	$=$	n_1
m_2	$O_1{:}Automobile$	$O_2{:}Car$	$=$	n_2
m_3	$O_1{:}Utility$	$O_2{:}UtilityCar$	$=$	n_3
m_4	$O_1{:}Sport$	$O_2{:}SportCar$	$=$	n_4

Next, agents share their initial mappings, generating $M' = (M^A \cup M^B) = \{m_1, m_2, m_3, m_4\}$.

Next, each agent builds its own BAF model. First, for each known mapping, one position argument is created. Since, M' has four mappings there will also exist four position arguments. Yet, while Ag_A is in favour of all mappings, Ag_B is just in favour of m_1 and against all the others (TABLE III).

TABLE III

SET OF POSITION ARGUMENTS OF Ag_A AND Ag_B RESPECTIVELY

id	m	G	p
p_1	m_1		$+$
p_2	m_2		$+$
p_3	m_3		$+$
p_4	m_4		$+$

id	m	G	p
p_1	m_1		$+$
p_2	m_2		$-$
p_3	m_3		$-$
p_4	m_4		$-$

In that sense, agents' position arguments p_2, p_3 and p_4 are contradictory while there is a consensus about p_1. Next, with the help of OAS, each agent enriches its own set of arguments (A) in order to support and attack the position arguments. The set of arguments used by Ag_A and Ag_B are presented in TABLE IV and TABLE V respectively. Because agent's OAS are different, arguments might be contradictory, even if using similar matching algorithms. This situation occurs between arguments a_6 and b_6, and between a_8 and b_9.

TABLE IV

SET OF ARGUMENTS OF Ag_A

id	m	G	p
p_1	m_1		$+$
a_1	m_1	$Label(Vehicle) = Label(Vehicle)$	$+$
p_2	m_2		$+$
a_2	m_2	$Label(Automobile) = Label(Car)$	$-$
a_3	m_2	$Synonyms(Label(Automobile), Label(Car))$	$+$
a_4	m_2	$SuperClass(Automobile) = SuperClass(Car)$	$+$
p_3	m_3		$+$
a_5	m_3	$Label(Utility) = Label(UtilityCar)$	$+$
a_6	m_3	$SuperClass(Utility) = SuperClass(UtilityCar)$	$+$
p_4	m_4		$+$
a_7	m_4	$Label(Sport) = Label(SportCar)$	$+$
a_8	m_4	$SuperClass(Sport) = SuperClass(SportCar)$	$+$

TABLE V
SET OF ARGUMENTS OF Ag_B

id	m	G	p
p_1	m_1		$+$
b_1	m_1	$Label(Vehicle) = Label(Vehicle)$	$+$
p_2	m_2		$-$
b_2	m_2	$Label(Automobile) = Label(Car)$	$-$
b_3	m_2	$SubClass(Automobile) = SubClass(Car)$	$-$
p_3	m_3		$-$
b_4	m_3	$Label(Utility) = Label(UtilityCar)$	$+$
b_5	m_3	$Siblings(Utility) = Siblings(UtilityCar)$	$-$
b_6	m_3	$SuperClass(Utility) = SuperClass(UtilityCar)$	$-$
p_4	m_4		$-$
b_7	m_4	$Label(Sport) = Label(SportCar)$	$+$
b_8	m_4	$Siblings(Sport) = Siblings(SportCar)$	$-$
b_9	m_4	$SuperClass(Sport) = SuperClass(SportCar)$	$-$

To complete the BAF model, each agent interprets each argument in its BAF model to define the existing binary relations (i.e. R_{att} and R_{sup}) between arguments. For instance, in Ag_A the argument A_2 is against the acceptance of m_2, while argument A_3 and A_4 suggest its acceptance. Fig. 4 depicts the graph representation of Ag_A 's BAF model and Fig. 5 depicts the graph representation of Ag_B's BAF model, based on the semantic interpretation of arguments.

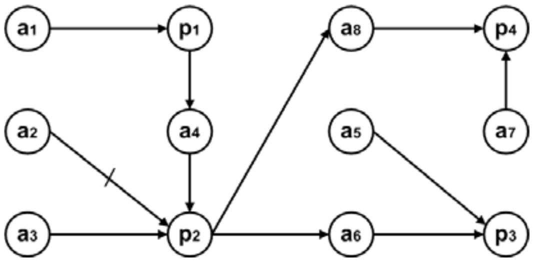

Fig. 4 Graph representation of Ag_A initial BAF model

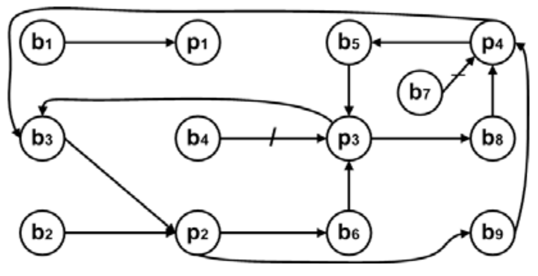

Fig. 5 Graph representation of Ag_B initial BAF model

Next, each agent computes its current preferred extension:

$$pref^A = \{p_1, a_1, p_2, a_3, a_4, p_3, a_5, a_6, p_4, a_7, a_8\}$$

$$pref^B = \{p_1, b_1, p_2, b_2, b_3, p_3, b_5, b_6, p_4, b_8, b_9\}$$

Based on these, agents exchange the preferred mappings, which are those corresponding to the position arguments:

$$MP^A = \{m_1, m_2, m_3, m_4\}$$

$$MP^B = \{m_1\}$$

As a result, a consensus is achieved about m_1, such that the consensus alignment is defined as $MA = \{m_1\}$. On the other hand, $MD = \{m_2, m_3, m_4\}$. Then, Ag_A will try to persuade Ag_B to accept m_2, m_3 and m_4 while Ag_B intends to do the opposite, i.e. to persuade Ag_A to give up from m_2, m_3 and m_4. For that, agents exchange arguments in order to support their positions and at the same time to persuade the other to change its position. For instance, Ag_A might use arguments a_3 and a_4 to persuade Ag_B to accept m_2 while Ag_B might use arguments b_2 and b_3 to persuade Ag_A to give up on m_2. Analysing exchanged and accepted arguments, Ag_A might update its BAF model with b_3 and the respective relations with p_2, p_3 and p_4 and discard argument b_2 due its equivalence (grounds and position) with a_2. On the other hand, Ag_B might update its BAF model with arguments a_3 and a_4. A similar process runs for m_3 and m_4.

As a result, suppose that Ag_Aupdates its BAF model with arguments b_3, b_5, b_6, b_8 and b_9, and that Ag_B updates its BAF model with arguments a_3, a_4, a_6 and a_8. Moreover, both agents have considered a_1, a_2, a_5 and a_7 equivalent to b_1, b_2, b_4 and b_7 respectively. Though, after computing the preferred extension, Ag_A maintains the same preferred extension while Ag_B 's preferred extension has evolved to $\{p_1, b_1, \neg p_2, a_3, a_4, \neg p_3, b_4, a_6, \neg p_4, b_7, a_8\}$. Consequently, agents reach a consensus about all mappings under discussion, and therefore no further iterations are required.

Notice that nothing prevents that (i) no consensus about all mappings is achieved, (ii) more iterations are needed to achieve an extended agreement, (iii) neither of the agents change the preferred extension and (iv) both agents change the preferred extension.

V. RELATED WORK

Despite a significant amount of research existing in the area of argumentation-based negotiation [14] in multi-agent systems, just a little have been applied to ontology alignment. In [5] the authors present an ontology negotiation protocol that enables agents to exchange parts of their ontology in order to converge on a single, shared ontology, consisting of the union of all the terms and their relations. Yet, no negotiation of divergent parts of the ontologies is addressed by this work. In [6] the authors introduce an ontology of the negotiation domain, in which several dimensions of the negotiation process are described. While this ontology can help characterising the negotiation scenario, it does not address the process itself.

An approach for ontology alignment negotiation is described in [15], where the alignment is composed of a set of semantic bridges (SBs) and their inter-relations. By the means of utility functions, each agent evaluates a confidence value and according to that value SBs are classified as mandatory, proposed, negotiable or rejected. Agents' pursue consensus by relaxation (concession) mechanisms upon the utility functions, reclassifying the semantic bridges to other sets.

The work presented in [16], [17] and [18] is based on the Value Argumentation Framework (VAF) [19]. The VAF [19] extends the AF in order to accommodate different interests and preferences over arguments through the notion of audience. An audience is one ordered set of discrete values defined *a priory*. Thus, each argument is related or promotes one of those values. An audience states if an attack fails or succeeds according to the values that are promoted by the arguments involved. However, and contrary to BAF the support relation is represented implicitly. In [16] the VAF is instantiated to address the same problem addressed in this work. However, candidate mappings are provided by a single OAS. In [17] the notion of audience was extended to include the concepts of certainty and uncertainty, but is applied to the ontology alignment composition problem [7]. Similar to [17], the work presented in [18] extends the notion of audience to include the concept of strength to arguments. However, this strength is directly given by matching algorithms which are themselves the audience values.

VI. CONCLUSIONS

This paper proposed an argumentation-based negotiation approach for ontology mappings. For each divergent position, i.e. in favour or against a given mapping, parties must exchange arguments to support each one's position. Received arguments are further interpreted in order to update the party argumentation model, maintaining or changing position. Hence, an iterative and incremental process of reaching consensus is followed.

The proposal grounds on the Bipolar Argumentation Framework in which supporting and attacking arguments relationships are explicitly stated. The adopted model explicitly states the relationships between the so called position arguments and common arguments. This modelling approach exposes the importance of the mappings themselves in the argumentation process, promoting their influence (either positive or negative) on the other arguments and mappings. The result is a close and intricate relationship graph, yet manageable by multi-objective decision approaches such as fixed-point computation, Analytical Network Process or Belief Propagation.

The arguments relationships are extracted by semantic interpretations of the mappings provided by generic OAS and in scope of other arguments and mappings. This process has not yet been systematized into a general interpretation framework, as it is very dependent on the semantics employed by the OAS.

Because the developed experiences are not conclusive with respect to the (dis)advantages of this approach compared with concession-based approaches, the team will develop more experiences and will investigate the combination of both approaches, i.e. argument-based and concession mechanisms.

Another interesting research direction is related to the fact that, for the moment, each party shares a common argument rationale, i.e. they know the semantics of all possible kinds of argument that can be used even when they are not using it. Future work will investigate ways to allow parties to employ unknown arguments instead of rejecting them. For that, learning mechanisms and the contribution of influencing third parties is envisaged.

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