Flexible agreement mechanism for dynamic meaning negotiation

(Extended Abstract)

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ABSTRACT

We introduce the *flexible approach for determining agents' orientation on ontology mappings* (FDO), which provides a flexible mechanism for agents to decide whether or not they support an argument about a mapping. Whilst this results in agents relaxing some preferences over suitable mappings, it produces a larger consensus of possible mappings due to the generation of a greater number of arguments in favour of the candidate mappings (compared to Laera *et al.*'s MbA approach), and better reflects the agents preferences than when only a single threshold and preference value are used.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent systems

General Terms

Algorithms, Theory

Keywords

Ontological reasoning, Argumentation

1. ONTOLOGICAL RECONCILIATION

As agents situated in open environments encounter other, unknown agents offering new services, they need to dynamically reconcile their *ontologies* (vocabularies) to support communication, due to the heterogeneity that permeates these environments which hinders seamless agent interaction. Reconciliation through the discovery of mappings between ontologies has been investigated at length by research efforts in *ontology alignment* [3]. However, few traditional alignment approaches are suitable for dynamic interaction scenarios, as they require human intervention or align the ontologies at design time. To address this limitation, Laera *et. al.* [4] proposed in their Meaning-based Argumentation (MbA) approach the use of argumentation to select a set of mappings (i.e. an *alignment*) that is mutually acceptable to the negotiating agents, from the union of disparate, precomputed alignments where different alignments may have previously been generated and then published or reused.

The reconciliation of ontologies can be viewed as a search for a mutually acceptable set of mappings between two ontologies (O_1 and O_2) given the agents' individual, private preferences over the mapping type (i.e. terminological, extensional, etc.). Approaches such as those proposed by Laera *et al.* [4] and dos Santos *et al.* [2] assume that mappings have an associated confidence value, and thus utilise both an acceptance threshold, ϵ, and their preferences to determine whether or not a candidate mapping is suitable for a task.

The search is conducted collaboratively, through the use of argumentation. By specifying arguments that *support* (or *refute*) different mappings, the negotiating agents identify a subset of mappings that are considered mutually acceptable. The arguments for each mapping are determined from the individual agent's preferences over the mapping types and its acceptance threshold. The argumentation then converges on a set of *agreed* mappings, i.e. mappings that are mutually acceptable to all negotiating agents. In the meaning based negotiation (MbA) approach by Laera *et al.*, an agent is only able to support those arguments whose grounds have the *highest* ranking in the ordering of agent preferences; all other mappings are rejected. Thus, agents effectively express a single preference towards one type of mapping, and would argue against any other type of mapping, thereby reducing the possibility of finding suitable agreements on a set of mappings; i.e. it fails to distinguish mappings that are *less preferred* from those mappings for which an agent is against. This results in smaller alignments, which may fail to sufficiently support the agent's subsequent communication. It may also fail to reflect the true preference of an agent, as different grounds supporting the choice or type of mapping may generate similar mappings in some cases.

2. THE FDO APPROACH

The FDO approach recognises how agents have different preferences over the types of mappings for use in interactions with other agents, which can influence the decision making process behind the negotiation. An agent would aim to maximise the use of those types of mappings with the highest preferences; however, since it needs to interact with other agents (with their own preferences) then it might decide to

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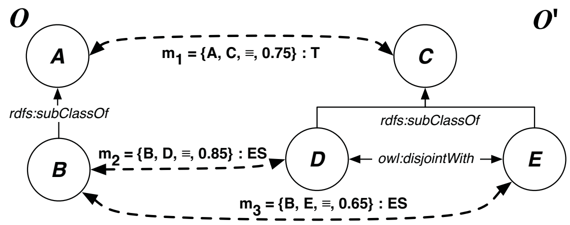

Figure 1: An alignment between O and O'

compromise, i.e. to agree to use a less preferred mapping type if this facilitates communication.

Given two agents ontologies O_1 and O_2, a mapping m between $e \in O_1$ and $e' \in O_2$ is a tuple $m = \langle e, e', n, r\rangle$, where e and e' are two entities (concepts, properties or individuals) between which a relationship r (such as equivalence or subsumption) is asserted, with a degree of confidence n. As with *MbA*, we define a Value-Based Argumentation Framework [1] for arguing over ontology alignments as a tuple $\langle AR, A, \mathcal{V}, \eta\rangle$ where the pair (AR, A) is a set of arguments together with the set of attacks defined over them. $\mathcal{V}$ represents the different types of ontological mismatches that can occur between ontologies; in our evaluation we consider terminological (T), internal structural (IS) and external structural (ES). The element η denotes a mapping, that associates the values $\mathcal{V}$ with the arguments AR, thereby specifying the type of mapping that is the object of an argument. An argument $x \in AR$ is defined as a triple $x = \langle G, m, \sigma\rangle$, where m is a mapping between entities of O_1 and O_2; G is the grounds justifying a prima facie belief in whether or not the mapping holds; and $\sigma \in \{+, -\}$ indicates whether or not the argument for m holds. An argument x is *attacked* by the assertion of its negation (*counter-argument*), thus an argument $y \in AF$ *rebuts* an argument $x \in AF$ if x and y are arguments for the same mapping but with different signs, e.g. if x and y are in the form $x = \langle G_1, m, +\rangle$ and $y = \langle G_2, m, -\rangle$. The VAF associates a value to each argument and has a preference ordering of these values.

The *FDO* approach defines an agent as a tuple $Ag_i = \langle O_i, VAF_i, Pref_i, \phi_i\rangle$, where O_i is an ontology, VAF_i is an instance of a VAF, $Pref_i$ is an ordering of the values in $\mathcal{V}$ and ϕ_i is a function mapping each v in $\mathcal{V}$ to a value $0 \leq z \leq 1$. $\phi_i(v)$ can be thought of as the minimum confidence threshold for Ag_i to argue in favour of a mapping of type v. The function $\tau : \mathcal{M} \rightarrow \mathcal{V}$ assigns a $v \in \mathcal{V}$ to every m mapping between O_1 and O_2. The function τ is used by an agent to determine its position wrt to a mapping m, *i.e.* whether to be in favour of or against m. The strategy used by the agent in deciding its position is the following: the agent is in favour of m if its minimum confidence threshold for the acceptability of this mapping n_m is greater or equal than $\phi_i(\tau(m))$, otherwise m is rejected. Therefore, the agents express how much they prefer each of the possible mapping types, and how willing they are to argue in their favour. The ordering of preferences is now only used by the VAF when dealing with arguments and their attacks.

The following example illustrates how the proposed *FDO* approach differs from the original *MbA* approach, assuming the two ontologies illustrated in Figure 1, with the mappings given with their relevant mapping types. Given two agents that wish to communicate: Ag_1 has the preference ordering ES$\succ$T; whereas Ag_2 has the preference ordering T$\succ$ES.

Approach	Mapping Type Preference	Acceptance Threshold	Arguments *in favor of +*	*against -*
MbA	ES $\succ$ T	0.5	$\{m_2, m_3\}$	$\{m_1\}$
	T $\succ$ ES	0.5	$\{m_1\}$	$\{m_2, m_3\}$
FDO	ES $\succ$ T	ES=0.5, T=0.7	$\{m_1, m_2, m_3\}$	$\{\}$
	T $\succ$ ES	T=0.5, ES=0.7	$\{m_1, m_2\}$	$\{m_3\}$

Table 1: Arguments supporting (+) or refuting (-) different mappings, given thresholds & preferences.

Table 1 shows the sets of mappings that will be argued in favour of (+) or against (-). Whilst *MbA* produces arguments against m_1 and m_2 the *FDO* approach does not.

3. EVALUATION AND CONCLUSION

The two approaches discussed above were evaluated using several ontologies taken from the OAEI 2007 and 2008 Conference Track repositories, representing different domain theories for the same, real-world domain, and thus reflecting *real-world heterogeneity*. The alignments between ontology pairs were generated using the *Alignment API* [3], producing mappings of type IS, ES and T. Different experiments were run over each of the pairwise ontologies using the VAF, but varying the approach for generating arguments.

When using *MbA*, the proportion of arguments against mappings averaged 78%, significantly greater than the 34% average of arguments generated against mappings with *FDO*. For example, when analysing external structural (ES) mappings vs internal structural (IS) ones, 1325 mappings on average were generated when using *FDO* compared to only 33 with *MbA*. The higher number of negative arguments generated by *MbA* suggests that it may result in a higher probability of generating empty alignments, thus resulting in unnecessary communication failure.

Thus, we have introduced a novel mechanism for determining whether agents are in favour or against ontology mappings during a process of dynamic selection of mutually acceptable alignements. The *flexible approach for determining agents' orientation on ontology mappings* (*FDO*) allows agents to express a minimum acceptability thresholds for each of the mapping types to include in the alignment used during communication. In this respect, *FDO* provides a more flexible framework than the Meaning-based Argumentation (*MbA*) approach when deciding whether agents support or refute a mapping. A systematic evaluation found that the *FDO* approach produces a considerably larger set of mutually acceptable mappings by reducing the number of mappings an agent refutes when compared with *MbA*.

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