ECAI 2012
Luc De Raedt et al. (Eds.)

doi:10.3233/978-1-61499-098-7-895

Reasoning for Agreement Technologies

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Abstract. We present a logical viewpoint on agreement technologies by combining reasoning methods for aggregation, norms, dependence, argumentation, and trust. Starting from the agreement technologies tower, we introduce an architecture for the agreement process with interacting reasoning processes. We discuss the input/output perspective on reasoning for agreement technologies, the combination of reasoning methods, the role of abstraction, and game theoretic foundations.

1 Agreement Technologies

Billhardt *et al.* [2] envision that methods and mechanisms from the fields of semantic alignment, norms, organization, argumentation and negotiation, as well as trust and reputation are part of a "sandbox" to build software systems based on a technology of agreement. Based on a well known definition of coordination as management of dependencies between organisational activities [11], they distinguish the detection of dependencies from taking a decision on which coordination action to apply. Their call-by-agreement interaction method first establishes an agreement for action, and the actual enactment of the action is requested thereafter. The normative context determines rules of the game, i.e. interaction patterns and additional restrictions. The so-called agreement technologies tower of semantic alignment, norms, organization, argumentation, negotiation, trust and reputation is visualized in Figure 1.

Figure 1. Agreement Technologies Tower [2]

Semantic technologies form the basis to deal with semantic mismatches and alignment of ontologies to give a common understanding of norms or agreements, defining the set of possible agreements. Norms and organizations determine constraints that the agreements, and the processes to reach them, have to satisfy. Organisational structures define the capabilities of the roles and the power and authority relationships among them. Argumentation and negotiation methods are used to make agents reach agreements. The agents use trust mechanisms that summarise the history of agreements and subsequent agreement executions in order to build long-term relationships between the agents. Billhardt *et al.* emphasize that these methods may well benefit from each other.

The challenge we raise here is: how to combine existing reasoning methods for semantic alignment, norms, organizations, argumentation, and trust?

2 Agreement Process

Instead of combining the technologies in a sandbox, we introduce a combined agreement process, whose architecture is visualized in Figure 2.

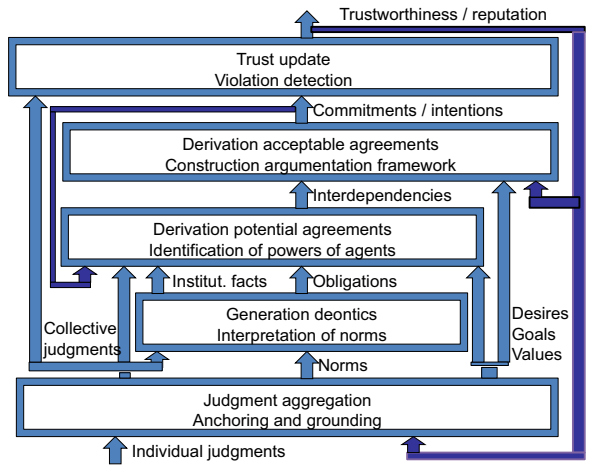

Figure 2. Architecture of Agreement Process

The individual judgments and preferences are grounded in observations and opinions, and aggregated into collective judgments, norms, desires, values and goals. The collective judgments and the norms in force are interpreted [4], and used to generate institutional facts, obligations and permissions. The collective judgments, institutional facts and obligations are used to identify the actions the agents can perform, and their power to satisfy the desires and goals of themselves as well as of other agents. This creates a network of dependencies among the agents. The dependencies among the agents can be used to construct an argumentation framework. Based on the desires and goals of the agents, they negotiate and commit to acceptable agreements. The resulting intentions are fed back into the argumentation and negotiation component, when new agreements are negotiated. The behavior of agents and their commitments is monitored, and in case of detection of violations of agreements the trustworthiness and reputation of the involved agents is updated. The trustworthiness of agents is fed back into the judgment aggregation operator, as well as in the argumentation and negotiation component.

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3 Reasoning

The agreement technologies sandbox suggests a bottom up approach, in the sense that each reasoning technique is studied in its own community, with its own conferences and its own journals. There is a semantic web conference and journal, a deontic logic in computer science and normative multiagent systems conference, an argumentation conference and journal, and so on. The challenge of reasoning for agreement technologies is to define the relations among them, such that a coherent framework arises. In that sense, the architecture of the agreement process introduced in this paper is more top down. We now discuss how these reasoning techniques can be combined.

3.1 Input/output perspective

The input/output perspective on the architecture of the agreement process considers each individual reasoning method as a black box, defined by its input/output behavior, and studies their interaction. Makinson and van der Torre [10] introduce input/output logic for norms to generate institutional facts, obligations and permissions. Bochman [3] uses it to define argumentation in a causal framework. The normative theory can be used to formalize Castelfranchi's theory of dependence networks and social commitments, which has to be extended with a theory or roles. Singh [12] specializes the general way to treat conditionalization in input/output logic for the setting of trust with inferences for completion, commitments, and teamwork that do not arise with conditionals in general, but are important for an understanding of trust.

Missing is an input/output perspective on semantic alignment. Fragments of classical logic such as description logics are used to reason about ontologies, but have less to say about aggregation and alignment. We propose to adopt a judgment aggregation perspective for this step [9].

3.2 Combining reasoning

We adopt Gabbay's combining or fibring logic methodology [8]. The reasoning methods can be applied to each other in many ways. For example, judgment aggregation can be applied to judgment aggregation itself to set the agenda and the voters, in the original doctrinal paradox [9] it applies to (constitutive) norms, and it can be applied to argumentation to merge argumentation frameworks. Norms defining aggregation principles are applied to judgment aggregation, meta-norms apply to norms themselves, constitutive norms apply to organizational structures such as roles, epistemic norms apply to argumentation. The formal analysis of many of these interactions has only begun recently.

3.3 The role of abstraction

Dung [7] introduces abstraction in argumentation, which is a very useful concept to combine reasoning using instantiation. For example, abstract arguments are typically instantiated by rules, which can be interpreted as norms. In this way, instantiated argumentation can be seen as arguing about norms. This idea can be further generalized. For example, abstract normative systems can be used to instantiate norms with arguments. This can also be combined, such that an abstract argument is instantiated with an abstract norm, which itself is instantiated again with arguments. In this way, we can argue about the norms which govern our argumentation. Moreover, dependence networks can be seen as abstractions from BDI models [6, 5]. We foresee that the logical framework for agreement technologies will lead to a general framework of abstraction, refinement and instantiation of reasoning methods.

3.4 Game theoretic foundations

Though we emphasized the logical reasoning methods in our architecture, we can as well give game theoretic foundations for each black box. Judgment aggregation may be seen as belief and goal merging, as studied in knowledge representation, but it may also be seen as a branch of social choice. Tennenholtz game theoretic artificial social systems represent norms as social laws. The theory of power in organizations is derived from coalitional or cooperative game theory. The generalization of Dung's abstract theory of argumentation is dominance theory used in economics. Finally, trust and reputation mechanisms can be studied as social choice methods too [1].

4 Summary

We have introduced an initial input/output architecture for agreement technologies. We use logic as the unifying technology with game theoretic foundations, but we do not aim for a unified semantics, for example by representing each reasoning form within modal logic, classical logic, or argumentation theory. The architecture keeps the representations and methods used in each domain, and combines their reasoning tasks. We are now developing a case study, analyzing both economic and legal aspects of the model.

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