Flexible Deadlines for Directed Obligations in Agent-based Business Contracts

(Extended Abstract)

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ABSTRACT

In B2B contract enactment, cooperation should be taken into account when modeling contractual commitments through obligations. We advocate a directed deadline obligation approach, taking inspiration on international legislation over trade procedures. Our proposal is based on authorizations granted in specific states of an obligation lifecycle model. Flexible deadlines provide an additional level of cooperation between contractual agents. Moreover, agents increase their decision-making options concerning obligations.

Categories and Subject Descriptors

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

Keywords

Norms, Normative Behavior, Contract, Deadline

1. INTRODUCTION

In cooperative Virtual Organizations, agents (enterprise delegates) share their competences in a regulated way, through commitments expressed as norms in contracts. The importance of pursuing a common goal demands for flexibility of operations: agents should facilitate compliance of their partners, because group success also benefits each agent's private goals, which are not limited to the business in progress, but also concern future opportunities that may arise.

Many approaches to normative multi-agent systems are abstracted away from their potential application domain, and give deontic operators an universal semantics (e.g. deadline obligations are violated if the obliged fact does not happen before the deadline). We argue that in some domains – such as business contracts – this approach is not desirable. For instance, the UN Convention on Contracts for the International Sale of Goods (CISG) [4] establishes what parties may do in case of deadline violations. In some cases, obligations may be fulfilled after the deadline (Article 48), which may themselves be extended (Articles 47 and 63), denoting a flexible and even cooperative facet of trade contracts.

We propose a different approach to model obligations in MAS for the business contracts domain. Following a cooperative business performance posture, we argue that obligations should be directed, and that deadlines should be flexible. In our model, authorizations are granted on specific states of a lifecycle for time-framed directed obligations.

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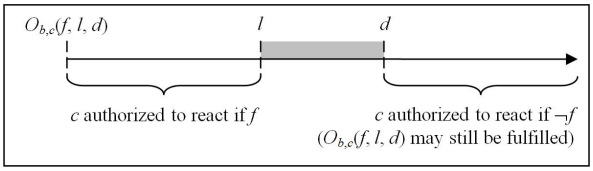

Figure 1: Directed oblig. with liveline and deadline.

2. DIRECTED DEADLINE OBLIGATIONS

Deontic operators (such as obligations) can be modeled with different features. Our proposal for handling contractual obligations combines deadline [1] and directed [3] obligations. We also cope with the fact that anticipated fulfillments are not always welcome (in CISG's Article 52, this is the case when storage costs are relevant). An obliged fact should therefore be obtained within a time window, delimited by a *liveline* and a *deadline*. A norm $s \rightarrow O_{b,c}(f, l, d)$ indicates that if s then b (*bearer*) is obliged towards c (*counterparty*) to bring about f (*fact*) between l (*liveline*) and d (*deadline*). If b does not bring about f between l and d, then c is *authorized* to react against b (see figure 1, where the shaded area indicates the period of time within which the achievement of f will certainly fulfill the obligation).

2.1 Temporal Violations

Figure 2 contains the state transition diagram for directed obligations with livelines and deadlines. The obligation is active ($O_{b,c}(f, l, d)$) when prescribed by a norm (whose situation *sit* became true). When l arises, it becomes pending, unless an anticipated achievement of f occurs; in this case there is a liveline violation ($LViol_{b,c}$). If the deadline occurs before f, there is a deadline violation ($DViol_{b,c}$). If f occurs while the obligation itself is not yet in a viola-

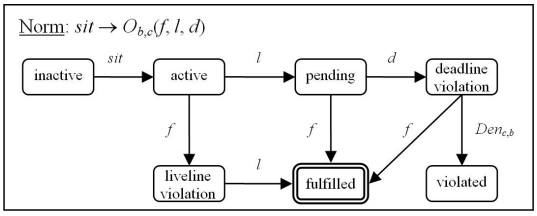

Figure 2: Lifecycle of a directed obligation with liveline and deadline.

tion state ($Viol_{b,c}$), the obligation is fulfilled ($Fulf_{b,c}$). The counterparty's reaction to a deadline violation will change the obligation's state if the agent chooses to deem the obligation as violated, by *denouncing* this situation: $Den_{c,b}$ is a denounce from c regarding the failure of b to comply with his obligation. Once the fact being obliged is brought about, the obligation cannot be violated. In case of an anticipated achievement of f, we only need l to consider the obligation as fulfilled. This does not, however, prevent the counterparty from reacting to this early fulfillment in other less strict ways (which can be captured by appropriate norms whose situation is based on $LViol_{b,c}$ and other facts).

Using temporal logic (namely its *before* operator B), the following relations express the semantics of our obligations:

- $O_{b,c}(f, l, d) \wedge (f\ B\ l) \models LViol_{b,c}(f, l, d)$
- $O_{b,c}(f, l, d) \wedge l \wedge (f\ B\ d) \models Fulf_{b,c}(f, l, d)$
- $O_{b,c}(f, l, d) \wedge (d\ B\ f) \models DViol_{b,c}(f, l, d)$
- $DViol_{b,c}(f, l, d) \wedge (f\ B\ Den_{c,b}(f, l, d)) \models Fulf_{b,c}(f, l, d)$
- $DViol_{b,c}(f, l, d) \wedge (Den_{c,b}(f, l, d)\ B\ f) \models Viol_{b,c}(f, l, d)$

Belated fulfillments are allowed before denounces, according to the fourth relation above.

2.2 Implementation with Rules

If we want to develop appropriate tools to monitor contracts at run-time, we need to ground this semantics into a reasoning engine capable of responding to events in a timely fashion. Using a rule-based inference engine, we define the following (forward-chaining) rules:

- $O_{b,c}(f, l, d) \wedge f \wedge \neg l \rightarrow LViol_{b,c}(f, l, d)$
- $O_{b,c}(f, l, d) \wedge l \wedge f \wedge \neg d \rightarrow Fulf_{b,c}(f, l, d)$
- $O_{b,c}(f, l, d) \wedge d \wedge \neg f \rightarrow DViol_{b,c}(f, l, d)$
- $DViol_{b,c}(f, l, d) \wedge f \wedge \neg Den_{c,b}(f, l, d) \rightarrow Fulf_{b,c}(f, l, d)$
- $DViol_{b,c}(f, l, d) \wedge Den_{c,b}(f, l, d) \wedge \neg f \rightarrow Viol_{b,c}(f, l, d)$

Each relation of the form $(e_1\ B\ e_2)$ is translated into a conjunction $e_1 \wedge \neg e_2$. This allows us to detect the moment at which the *before* relation holds, and consequently to reason about its consequences. Relative deadlines (common in business contracts) require timestamping events, which allows for a refinement on the implementation of these rules (not shown for space restrictions).

3. DECISION-MAKING

The authorization approach described above enriches the decision-making space. Besides their own commitments, counterparties may decide over directed obligations after deadlines (a violation state is determined by his choice to denounce). In a contract, both parties bear obligations to obtain certain facts, which benefit counterparties. A contract contains further norms dependent on the fulfillment or violation of previous obligations. In order to model the decision making process, we need to assess an agent's valuations on the obligation states and facts he is able to bring about. Let $v_a(f)$ and $v_a(S)$ denote the valuation agent a makes of fact f or state S, respectively (as in [2], where these are used to check correctness of contracts, while we focus on the course of contract execution). When valuating fulfillment or violation states, agents should take into account what further commitments those states trigger. Focusing on the counterparty, for an obligation $O_{b,c}(f, d)$ we have:

$v_c(O_{b,c}(f, d)) > 0$	obl. is asset for counterparty
$v_c(f) > v_c(O_{b,c}(f, d))$	c benefits from f
$v_c(Fulf_{b,c}(f, d)) \leq 0$	c may acquire obligs. after
$v_c(Viol_{b,c}(f, d)) \geq 0$	c may be compensated after

We may now say that c should denounce (and thus obtain the violation) if $v_c(f) + v_c(Fulf_{b,c}(f, d)) < v_c(Viol_{b,c}(f, d))$. We consider that valuations may vary with time (it makes sense to think of $v_c(f)$ as possibly decreasing with time).

Even when the above condition does not hold, c may still opt for tolerating the less preferred situation of failure for matters of conflicting goals. On the other hand, in environments enriched with social features agents can exploit, they can decide to behave cooperatively even when they have to bear a contained disadvantage – more than being altruistic, agents may try to enhance their trust awareness in the community, from which they will benefit in future interactions.

4. SUMMARY

Most implementations of norms in MAS ignore the need for having directed obligations from bearers to counterparties. This is because in those approaches obligations are seen as (implicitly) directed from an agent to the normative system itself. It is up to the system to detect violations and to enforce the norms which are embedded in the environment. On the contrary, contractual obligations are negotiated into contracts and directed to specific contractual partners.

We started from previous theoretical approaches to model authorizations, and developed a more concrete formalization by linking authorizations with a flexible model of deadlines. Obligation violations are now dependent on the counterparty will to claim them. Agent decision-making is enriched in our model, because both parties involved in directed obligations may have a say regarding their violation. When considering such obligations as interlinked through norms in a contract, agents should evaluate the consequences of fulfillment and violation states as stated in the contract. Furthermore, in "socially rich" environments, agents should explore the value of future relationships by enhancing their perceived trustworthiness and predisposition to facilitate compliance.

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