

# A Context-aware Normative Structure in MAS

## (Extended Abstract)

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## 1. INTRODUCTION

Many domains are characterized by agents that interact with each other in accordance with common rules or norms. In international trade, a trading network may include a variety of entities (e.g., software, organizations and people) that are largely autonomous, geographically distributed, and heterogeneous in terms of their operating environment, culture, social capital, and goals. In this context, agents represent real interests and real entities, i.e., different agents have different owners, goals, interests, and preconditions for collaboration. For example, importers are motivated by profit and quality of products, while customs authorities are motivated by safety and security concerns. At any given moment, most agents will be conditioned by different regulations and norms, originating from different institutional contexts.

In this paper, we propose an approach to represent and analyze sets of norms that takes into consideration both the interrelationships between different norms and the context of their application. This extends current approaches where dependence between norms is not explicitly considered. The representation of the influence of institutional contexts on norms facilitates a contextual refinement normative structure, which supports checking inconsistencies between norms. Our approach is different from those based on deontic reasoning, as we do not aim at identifying the deontic consequences of actions. In short, our framework will enable, given a set of norms represented as a graph or net, to check whether there is a possible way to comply with

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those norms, i.e., a path through the graph which indicates norm compliant at all steps.

## 2. NORMATIVE STRUCTURE

In the analysis of institutional statements, E. Ostrom [1] introduces the ADICO syntax which describes who (Attribute) is obliged/forbidden/permitted (Deontic) to do or achieve what (aIm), when and where (Condition), otherwise (Or else) leading to consequences of violation. In this paper, to model the possible relationships between norms in agent societies, we introduce three logical operators *AND*, *OR*, and *OE* (representing Or else) and define the norms as a composite entity which not only describes the components in ADICO syntax but also represents the relations among different dos and don'ts in a specific institutional context.

**DEFINITION 1 (NORM NET).** A Norm Net  $NN = (context, NS)$ , where *context* describes the institution within which a set of related norms *NS* exist.

Each norm net is associated with an institutional context which describes the environment of the institution where the norm net exists. Making the context explicit enables us to control the evolution of the norm net and to accommodate compliance and resolution of conflicts. A norm set *NS* is a nested structure composed of a set of hierarchically connected norms in a certain context. In a norm net, obligations and prohibitions may have corresponding sanctions while permissions usually do not. The norms and their sanctions are exclusive and conditional, i.e., either conform to the norms or accept the sanctions when violating the norms, which is in accordance with the semantic of *OE* operator.

For example, in the EU international trade regulations concerning the issue of *origin of goods*, a norm net can be constructed as  $NN_1 = (context_1, NS_1)$  where

- $context_1 =$  “non-preferential origin in the EU”,
- $NS_1 = OE( AND( AND( AND( n_{a1}, n_{a2} ), AND( n_{a3}, n_{a4} ) ), OR( n_{b11}, n_{b12} ) ), n_{b2} )$ , where
  - $n_{a1}$ : The certificate of origin shall measure  $210 \times 297$  mm.
  - $n_{a2}$ : A tolerance of up to minus 5 mm or plus 8 mm in the length shall be allowed.
  - $n_{a3}$ : The paper used shall be white, free of mechanical pulp, dressed for writing purposes and weigh at least  $64 \text{ g/m}^2$  or between 25 and  $30 \text{ g/m}^2$  where air-mail paper is used.

- $n_{a4}$ : The certificate of origin shall have a printed guilloche pattern background in sepia such as to reveal any falsification by mechanical or chemical means.
- $n_{b11}$ : The certificate of origin shall be printed in one or more of the official languages of the Community,
- $n_{b12}$ : depending on the practice and requirements of trade, in any other language.
- $n_{b2}$ : The certificate of origin shall not be approved when it is not in the prescribed format.

Figure 1 gives the graphical illustration of the norm net  $NN_1$  represented as an oval.  $NS_1$ , represented as a rectangle, is an *OE* connection of two norm sets  $NS_2$  and  $NS_3$ ,  $NS_3$  being the consequence of violating  $NS_2$ . Specifically, we use a dashed line to indicate the consequence  $NS_3$ .  $NS_2$  is composed of two sub norm sets  $NS_4$  and  $NS_5$  connected by *AND*. Following the same rules, we finally come to the rightmost norms that construct the norm net.

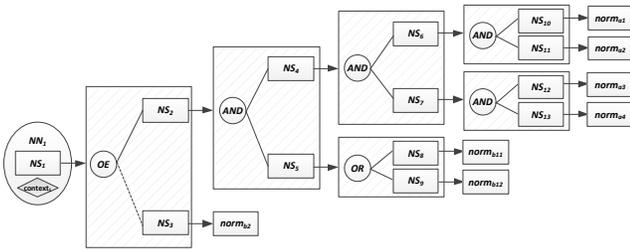


Figure 1: Graphical expression of  $NN_1$ .

### 3. CONTEXTUALIZATION

Laws and regulations are a system of textual rules and guidelines that are enforced through social institutions to govern behavior. They are specified as a normative structure, which describes the expectations and boundaries for agent behavior. We have already presented the representation of norms using *norm net* in Definition 1 to capture the declarative meaning of the law/regulation and also the relationships between them. However, in real world domains, norms are not specified at a single level of abstraction. An abstract norm net, resulting from the formalization of law/regulation, may have different extensions according to different contexts. Usually, laws are first issued at a higher abstraction level stating the dos, don'ts and sanctions to regulate actors' behavior. Based on this set of abstract norms, elaboration will be conducted according to the specific characteristics and requirements of different situations, which results into sets of contextual norms. This elaboration process facilitates detailed explanation of abstract norms in a concrete implementing environment.

Figure 2 depicts the process of modeling norms from abstract statements to concrete operation. It starts from an abstract norm net which describes the expectations and boundaries for agent behavior in general. At this level, specification of the norms of the system is abstract and assumed to be stable throughout the life cycle of systems. Meanwhile the actual implementation of the MAS should be flexible

and adapt to changing environments and contexts. Therefore, according to different contexts, the abstract norm net is transformed into sets of contextual norm nets which give more specific information on the roles, actions, conditions and the relations between the elaborated norms.

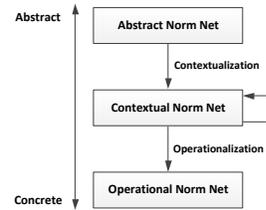


Figure 2: Contextualization and operationalization

Moreover, a contextual norm net can again be further contextualized in a recursive manner, which enables a flexible normative structure and makes it possible for designers at different levels to decide their norm elaborations. Finally, based on the contextual norm nets which contain enough information for the actors to reason about their dos and don'ts in a specific situation, the norms will be extended with operational aspects to capture the operational meaning of the norms.

### 4. CONCLUSIONS

In this paper, we proposed a normative structure that not only captures the characteristics of a single norm but also the relationships between norms. Given that agents in MAS interact with each other to achieve certain goals, the interrelated effects of norms on their behavior are very important for both individuals and the system. Therefore, the connections between norms should be explicitly indicated in a structural way. Moreover, contexts play an important role in the construction of norms, in the sense that the application of a norm heavily depends on its institutional context and a norm may have different interpretations in different situations. To this end, the concept of norm net in this paper expresses how a set of recursive norm sets organize in a hierarchy of contexts.

Most importantly, this paper presents a norm net contextualization process that describes norms from general to specific. This enables a modular approach for building normative structure and also distributes its complexity. Furthermore, following this contextualization process, actors can have a better understand of their dos and don'ts with the evolution of contextual norm nets. To verify the proposal, we map norm nets to Colored Petri Nets (CPNs) and incorporate agents/actors as colored tokens in the analysis, which presents the state transition process of norm nets and provides a potential approach for compliance checking on norms.

In future work, the normative structure will be extended to the operational level and a complete mapping for contextual norm nets will be built using advanced CPNs.

### 5. REFERENCES

- [1] E. Ostrom. *Understanding institutional diversity*. Princeton University Press, 2005.