# Automating Decision Making to Help Establish Norm-Based Regulations

## (Extended Abstract)

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## ABSTRACT

Norms have been extensively proposed as coordination mechanisms for both agent and human societies. Nevertheless, choosing the norms to regulate a society is by no means straightforward. The reasons are twofold. First, the norms to choose from may not be independent (i.e, they can be related to each other). Second, different preference criteria may be applied when choosing the norms to enact. On the one hand, this paper considers norm representation power and cost as alternative preference criteria. On the other hand, it identifies three different norm relationships –namely, generalisation, exclusivity, and substitutability. We show that the decision-making problem faced by policy makers can be encoded as a linear program, and hence solved with the aid of state-of-the-art solvers.

## Keywords

Normative systems; norm decision making; policy making; optimisation.

## 1. INTRODUCTION

In the literature, norms have been extensively studied as coordination mechanisms within both agent and human societies [8, 17]. Problems such as norm synthesis [18, 7], norm emergence [11, 20], or norm learning [16, 9, 15] have been widely studied in agent societies. As for human societies, e-participation and e-governance ICT systems are currently attracting a lot of attention [21, 10, 2]. Thus, for example, some regulatory authorities in European cities [6, 4, 5] are opening their policy making to citizens. This is also the case for some countries: New Zealand authorities are opening consultations about legislations related to different topics such as family violence[1] or pensions[3]. However, the number of regulations to discuss and enact could be large, so that managing them becomes a complex task.

Beyond the intrinsic complexity due to the number of norms to manage, choosing the norms to regulate a society is by no means straightforward. The reasons are twofold.

On the one hand, norms can be related. Norm relationships have been previously studied in the literature. Thus, for example, Grossi and Dignum [12] study the relation between abstract and concrete norms, whereas Kollingbaum, Vasconcelos et al. [13, 19] focus on norm conflicts —and solve them based on first-order unification and constraint solving techniques. We borrow some of the relationships identified in Morales et al.[14][1] and characterise three different binary norm relationships, namely, generalisation, exclusivity, and substitutability. Thus, we can consider a set of *individually desirable* norms and the fact that some norms in this set generalise some other specific norms in the set; and that some other norms are pair-wise incompatible (i.e., mutually exclusive); or interchangeable (i.e, substitutable). When this is the case, a regulatory authority should not select these norms to be simultaneously established in the society. This paper proposes to encode these relationships in terms of restrictions in linear programs that allows to find those norm subsets (subsets of the given set of norms) that are compliant with the constraints imposed by the associated norm relations.

On the other hand, this paper also characterises the problems that regulation authorities confront when considering different preference criteria over the norms to impose. In this manner, we specify the optimisation problem of finding the subset of norms that, in addition to comply with the relation constraints, maximizes represented norms. This problem can be specified as a single objective function in a binary linear program. Moreover, since norms have associated costs, it may also be of convenience to specify a multi-objective decision function that maximizes norm representation while minimizing associated norm costs.

Briefly, we assume that a regulatory authority has available a collection of *individually desirable* norms to impose together with an specification of the particular relationships that hold for these norms and that prevents all norms to be simultaneously deployed. Then, we model a problem that pursues to maximize the set of norms to establish under (a combination of) those previously mentioned criteria, namely, norm representation and associated costs. Subsequently, despite the computation complexity of these problems, state-of-the-art linear programming solvers can be used to automatically compute their solution.

### 1.1 Example

Figure 1 illustrates an example of a Norm Net that includes some norms (rules) of border control at an international airport. Norms are depicted as circles labeled as $n_1, \ldots, n_5$ respectively. In particular, they are defined as follows:

$$n_1 : Permission(\textit{all\_passengers, cross\_border})$$

[1]Morales et al. [14] identify substitutability, generalisation and complementarity relations.

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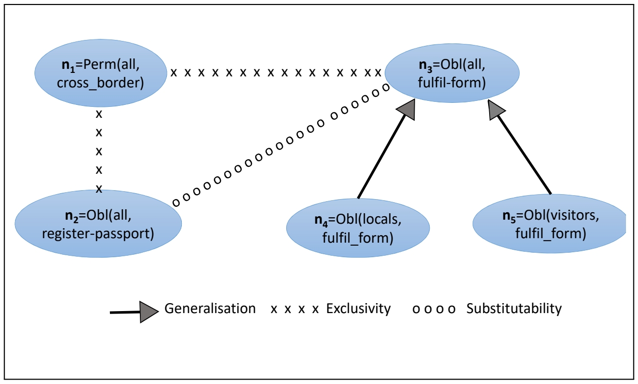


Figure 1: Norm Net example: rules of border control at an international airport.

$n_2$ : $Obligation(all\_passengers, register\_passport)$
$n_3$ : $Obligation(all\_passengers, fulfil\_form)$
$n_4$ : $Obligation(locals, fulfil\_form)$
$n_5$ : $Obligation(visitors, fulfil\_form)$

Norm $n_1$ rules free movement of passengers, allowing all passengers to cross the border without any additional action. On the other hand, norm $n_2$ requires all passengers to register their passport, and there is still a third rule $n_3$ that requires them to fulfil a form asking for passport information such as passport number, holder's name, or address.

We assume regulatory authorities are able to identify norm relationships. Regarding exclusivity relationships, first and second norms, as well as first and third norms, are exclusive. Figure 1 depicts such exclusivity relationships with an "x dotted" line. Additionally, there is a substitutability relationship between second and third norms (see "o dotted" line in Fig. 1). Finally, Figure 1 represents generalisation relationships between $n_3$ and $n_4$ and between $n_3$ and $n_5$ with an arrow line pointing to the general norm $n_3$.

## 2. NORM SYSTEM OPTIMISATION

As previously mentioned, the regulatory authority has available a collection $N$ of norms to impose together with a specification of their particular relationships. This collection of eligible norms and relationships constitute a Norm Net. We consider a Norm System $\Omega \subseteq N$ to be the set of norms chosen to be actually deployed in the society. Then we say that a Norm System $\Omega$ is *sound* iff it is both conflict-free and non-redundant. By conflict-free we mean that there are not exclusivity relationships, whereas it is non-redundant if there are not generalisation nor substitutability relationships.

Since a regulation authority pursues to incorporate as many norms as possible out of the individually-desirable ones in a Norm Net, we aim at the Norm System that *represents* the largest number of norms in the Norm Net. We can think of alternative norm representation power functions (e.g. a norm can represent itself, or all the norms it generalises), we just assume it to be a linear function: the so-called representation power function $r$.

Additionally, most often, regulation authorities cannot ignore the fact hat norm deployment has associated costs. Norm costs may represent monetary expenses derived from regulatory processes –such as norm establishment or norm enforcement– as well as non-monetary aspects –such as social implications or political correctness– that can be somehow quantified. We compute the cost of a given Norm System, by adding the cost of its norms, namely $cost(\Omega) = \sum_{n_i \in \Omega} c(n_i)$, where $c(n_i)$ stands for the cost of norm $n_i \in N$. Furthermore, we make the (reasonable) assumption that costs are bounded by a maximum budget $b$ (i.e., the price regulatory authorities are willing to pay) that is available to cover the expenses of imposing those norms in the resulting Norm System.

Then, we can cast the decision problem faced by the decision maker as the following multi-objective optimisation problem.

PROBLEM 1. *Given a Norm Net, a representation power function $r$, and a fixed budget $b$, the Maximum Norm System Problem with Limited Budget (MNSPLB) is the problem of finding a sound norm system $\Omega \subseteq N$ with maximum representation power and minimum cost limited by some non-negative budget $b$.*

Solving the MNSPLB amounts to solving a linear program that considers a set of binary decision variables $\{x_1, \ldots, x_{|N|}\}$, where each $x_i$ encodes the decision of whether norm $n_i$ is selected (taking value 1) for a Norm System or not (taking value 0). Additionally, $\mathcal{R}_{max}$ is defined to be the maximum representation power. From that, the combination of the maximisation of representation power and the minimisation of cost is encoded as follows:

$$max \left[ \frac{w_r}{\mathcal{R}_{max}} \cdot \sum_{i=1}^{|N|} x_i \cdot r(n_i) + w_c \cdot (y - \frac{1}{b} \sum_{i=1}^{|N|} x_i \cdot c(n_i) \right]$$

subject to (i) The binary constraints corresponding to the norm decision variables; (ii) The constraints that capture the generalisation, exclusivity, and substitutability relationships in the Norm Net; (iii) A constraint ensuring that the cost of the norm system does to go beyond the limited budget $b$; (iv) Linearised constraints on a binary indicator variable $y$ that allow us to turn the cost minimisation into a cost maximisation; and (v) A constraint considering the weights to measure the importance of maximising representation power ($w_r$) and minimising cost ($w_c$):

$$w_r + w_c = 1 \qquad w_r, w_c \in [0, 1]$$

Considering again the example from Section 1.1 (see also Figure 1) we consider the following costs: our regulatory authority has a limited budget $b$ of 5 monetary units; norm $n_1$ has no associated cost because it requires no additional actions; $n_2$ has an associated cost of 2, since it requires passengers to interact with passport registration machines and a few staff members; the cost of $n_3$ is 5 due to the fact that it requires form fulfilling, gathering, and post-processing; and $n_4$ and $n_5$, which are more specific than $n_3$, just cost 2. Hence: $b$=5, $c_1$=0, $c_2$=$c_4$=$c_5$=2, $c_3$=5. Moreover, we assume: (i) $r(n_1) = r(n_2) = r(n_3) = 1$, $r(n_4) = r(n_5) = 0.5$ be the representation power of our norms and $\mathcal{R}_{max} = 3$ be the maximum representation power; and (ii) The relative importance of norm representation and deployment cost to be $w_r = w_c = 0.5$. Then, if we encode the Maximum Norm System Problem with Limited Budget (VMNSPLB) problem, a linear program solver returns $\Omega = \{n_1\}$ as the optimally sound norm system. Nevertheless, if cost of norm $n_1$ is increased up to $c_1 = 6$, since not checking passports at the border may cause political problems with the neighbouring countries, the solver will then choose $\Omega = \{n_2\}$ to be the optimally sound norm system.

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