How to Concretize Norms in NMAS? An Operational Normative Approach Presented with a Case Study from the Television Domain

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Abstract

A major challenge in the research of multiagent systems (MAS) is the design and implementation of open MAS in which norms can be effectively applied to their entities and easily managed. Open MAS can be extremely dynamic due to heterogeneous agents that migrate among them in order to obtain resources or services not found locally. In this scenario, it is not reasonable to expect that foreign agents will know in advance all the norms of the MAS in which they will execute. In this paper, we present a case study from the television domain in which our DynaCROM approach is used. From the individual agents' perspective, DynaCROM is an information mechanism that makes application agents aware of the norms they are bound to in a given moment. From the system developers' perspective, DynaCROM is a methodology for norm management in MAS. Notwithstanding that a regulated MAS should have its norms enforced, we also present the integration of DynaCROM and SCAA in the paper. SCAA is the current solution of DynaCROM for enforcing its contextual norms.

1 Introduction

Openness has led to software systems that have no centralized control and that are formed of autonomous entities [19]. Key characteristics of such systems are heterogeneity, conflicting individual goals and limited trust [1]. We assume that multiagent systems (MAS) are an example of open systems in which the action of heterogeneous, self-interested agents may deviate from the expected behavior in a context.

MAS can be extremely dynamic due to heterogeneous agents that migrate among them for obtaining resources or services not found locally. In order to prevent malicious actions and to build agent trust in a MAS, norms can be used for defining which actions are permitted, obliged and prohibited to be performed by agents so that the system does not reach an undesirable state. Agents should be able to take into account the existence of social norms in their decisions (either to follow or violate a norm) and to react to violations of the norms by other agents [4]. Norms can also be viewed as event-driven rules that trigger under appropriate conditions of events happening and, by doing so, create, update or cancel commitments affecting a predefined set of agents [14].

Normative MAS (NMAS) as an area of research has become a major issue in the field of MAS and it can be situated at the intersection of normative systems and MAS. A NMAS is a system that conforms to or is based on norms [2]. Important works concerning NMAS (e.g., [8], [10], [23]) have been proposed recently. However, these solutions usually consider norms with a valid universal meaning in an application domain; do not support the direct design and implementation of norms specific to the application domain (e.g., political, economical, religious norms); do not support the management of norms during system execution (i.e., norm description off-line and norm enforcement on-line); and, expect that agents already must be aware of the (predefined) system norms.

In order to remedy the drawbacks listed above, we propose to extend the notion of NMAS with an extra layer – called a contextual normative level – in which norms are embodied with domain values according to agents’ current contexts. Our proposition follows the ideas first proposed by Dignum in [7] and then refined in [17], however, these works mainly address formal issues while our work the practical ones by providing an implemented solution as a proof-of-concept for our ideas.

Our DynaCROM approach (meaning dynamic contextual regulation information provision in open MAS) [13] is, from the individual agents’ perspective, an information mechanism that makes application agents aware of the norms they are bound to in a given moment. In this way, agents can simply be concerned with the applicable regulation information and, so, released from knowing in advance all the norms of the MAS in which they will execute. From the system developers’ perspective, DynaCROM is a methodology for norm management in MAS that
facilitates the tasks of norm design, implementation and integration with regulated agents.

In short, DynaCROM supports the implementation of concrete norms contextualized in NMAS. Contextual norms are norms described with more precise details because they are bound to the context that prescribe an application domain. We consider context as any implicit information that can be used to characterize the situation of agents and to provide relevant information and/or services to them, where relevancy depends on agent tasks [6].

In this paper, we illustrate the use of our DynaCROM approach for norm appliance in MAS via a motivating scenario from the television domain. In the scenario, agents are self-efficient in terms that they perform their tasks without the necessity to interact with other agents from the domain. In this way, some solutions for norm enforcement (e.g., [23], [10]) do not properly work because their regulation is restricted to the interaction level. Thus, we chose the SCAAR solution (meaning Self-Controlled Autonomous Agents geneRator) [5] for enforcing DynaCROM norms. SCAAR enhances agents with a self-monitoring capability that avoids norm violation in different levels of regulation.

The remainder of this paper is organized as follows. Section 2 briefly describes the main assets of DynaCROM necessary for the understanding of the paper and, in section 3, the use of these assets are exemplified via a motivating scenario from the television domain. For the domain, a DynaCROM NMAS is proposed. Section 4 explains how openness is guaranteed in our DynaCROM NMAS and section 5 shows how its norms can be enforced. Before concluding and presenting future work, Section 6 positions our work with respect to two other approaches.

2 Norm Information Provision in MAS

A major challenge in NMAS is how norms can be effectively applied to their agents and easily managed. These tasks are arduous because norms are usually written for general purposes, hindering a more precise regulation.

DynaCROM proposes to system developers a methodology for norm appliance and management in MAS. This methodology guides them to embody abstract norms with contextualized domain values in order to refine regulation information. Following this methodology, the system developer should define and classify his norms in the context in which they apply in the application domain. For instance, the norm “marriage is only valid between Jewish people” should be classified as a Judaism norm that is contextualized in the religious domain.

For representing norms contextualized in application domains, DynaCROM proposes a contextual normative ontology in which information is provided to heterogeneous agents with a common understanding about well-defined system regulation. An ontology is a conceptual model that embodies shared conceptualizations of a given domain [18]; a contextual ontology is an ontology that represents localized domain information [3] (e.g., USD is the national currency of USA); and, a contextual normative ontology is a contextual ontology that has a Norm concept as a central asset. This concept should be instantiated with norms contextualized differently according to basic MAS entities (i.e., environments, organizations, roles and agent interactions [22]) or specific domain entities. The DynaCROM ontology can have its concepts composed in somehow that result in sets of independent norms in which the semantic of one norm can influence the semantics of the others. For the composition process, a system developer has to write ontology-driven rules (i.e., rules written according to the ontology structure) and, then, DynaCROM automatically infer composed contextual information. For the inference process, DynaCROM has an inference rule engine that executes the following tasks: (i) read an ontology instance to get data (i.e., concept instances and relationships), (ii) read a rule file to get how concepts must be composed, and (iii) infer an ontology instance based on the previous readings. An overview of this process is illustrated in Fig. 1.

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1 See in [12] another case study with a motivating scenario from the domain of multinational corporations and focusing on agents’ decisions based on contextual norms.

2 DynaCROM is implemented in JADE [20], but it can also be applied in other platforms by implementing their facade design pattern provided for the agent unit.
norms are automatically forwarded to agents in the next DynaCROM execution. Thus, the dynamics of the process is an important asset of DynaCROM compared with other normative solutions (e.g., [5], [10], [23]) because it permits the management of norms at the system runtime, providing the flexibility necessary for regulation regarding social changes characteristic of MAS.

3 A Television Normative MAS

In order to illustrate our DynaCROM approach, we propose a scenario from the television (TV) domain in which data can be distributed among several countries by broadcaster agents from different TV corporations. In the scenario, a (direct or indirect) hierarchy exists among their concepts, providing implicit contextual information for regulation in MAS.

The conceptual model illustrated in Fig. 2 was conceived to represent our motivating scenario. There, a TVBroadcaster (a type of Organization) is subordinated to its respective TVCorporation by the isMemberOf property, and each TV broadcaster has only one headquarters (hasHeadquarters inherited property). A TVBroadcaster is in an Environment (isIn inherited property). An Environment is linked to its Government by the hasGovernment property. Each Government is linked to its AudioAndMediaGovernmentAgency by the hasGovernmentAgency property.

Fig. 2. A conceptual model for norm appliance in TV MAS

All concepts of the proposed conceptual model can be linked to a Norm concept by a hasNorm property for holding the norms of our proposed NMAS. In this way, norms are contextualized in each concept of the domain. For instance, we can consider, besides others, the following norm of censorship to screen a TV program:

A Television Norm for Censorship: television programs are obliged to present their television rating information for giving spectators an idea of the suitability of the program for children and/or adults.

This norm is an abstract one and, thus, must be translated to a concrete norm according to the context in which it applies in the TV domain. Considering the Australian TV system, for instance, the norm can be contextualized differently in the Australian Broadcasting TV corporation (ABC) and in the Special Broadcasting Service TV corporation (SBS) – two governmental TV corporations – and also in the Nine TV corporation (Nine) – a commercial one – as follows:

(Concrete) Television Norms for Censorship:
(a) In the ABC and SBS TV corporations, TV ratings are obliged to be presented as follows: for ages of (i) 12 and up, (ii) 14 and up, and (iii) 18 and up; (b) in the Nine TV corporation, TV ratings are obliged to be presented as follows: for ages of (i) 15 and up, and (ii) 18 and up.

TV programs are screened by broadcaster agents playing the role in broadcaster organizations, meaning that the norm for censorship must be applied to all of them. The SBS TV corporation has only one broadcaster, the SBS TV broadcaster, which is situated in the city of Sydney, in the state of New South Wales. The ABC and Nine TV corporations have broadcasters distributed in the Australian territory, as presented in Table 1. Excluding the Tasmania state, which does not have a broadcaster for the Nine TV corporation, all others states have broadcasters for the two TV corporations.

Broadcaster agents can be directly influenced by the norms of its organization (via the isPlayedIn property) and/or indirectly influenced by the norms of its environments (e.g. city, state, country), government, government agency and TV corporation.

Table 1. TV broadcasters of Australian TV corporations

<table>
<thead>
<tr>
<th>TV Broadcaster</th>
<th>TV Corp.</th>
<th>State</th>
<th>City</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABN TCN</td>
<td>ABC</td>
<td>New South Wales</td>
<td>Sydney</td>
</tr>
<tr>
<td>ABV GTV</td>
<td>ABC</td>
<td>Victoria</td>
<td>Melbourne</td>
</tr>
<tr>
<td>ABQ QTO</td>
<td>ABC</td>
<td>Queensland</td>
<td>Brisbane</td>
</tr>
<tr>
<td>ABS NWS</td>
<td>ABC</td>
<td>South Australia</td>
<td>Adelaide</td>
</tr>
<tr>
<td>ABW STW</td>
<td>ABC</td>
<td>Western Australia</td>
<td>Perth</td>
</tr>
<tr>
<td>AFT</td>
<td>ABC</td>
<td>Tasmania</td>
<td>Hobart</td>
</tr>
<tr>
<td>ABN TCN</td>
<td>ABC</td>
<td>Australian Capital Territory</td>
<td>Canberra</td>
</tr>
<tr>
<td>ABD NTD</td>
<td>ABC</td>
<td>Northern Territory</td>
<td>Darwin</td>
</tr>
</tbody>
</table>
Considering basic criteria for the development of software, it is not reasonable to expect that the censorship norm of each TV corporation will be implemented inside all of its broadcasters. So, the norm is represented by a government agency norm (illustrated in Fig. 3 by the *OblToPresentTVRatingInfo* norm instance) that links the government agency and the *ScreenATVProg* action instances.

Rules are used for applying the censorship norm in all TV broadcasters from the domain. For readability purposes, Code 1 presents those rules written following a simplified syntax for rule inference engines, as for the Jena [21] used one. The ‘*DynaCROMRule_GovWithGovAgencyNorms*’ (line 1 to 4) states that a given government will have its norms composed with the norms of its government agency. For instance, the following process is executed for the *AustralianGovernment* given value: in (4), the ‘*GovAgency*’ variable is instantiated with the *AustralianGovernment* value; in (3), the ‘*GovAgencyNorms*’ variable is instantiated with the *OblToPresentTVRatingInfo* inferred value; and in (2), this norm is added to the *AustralianGovernment* instance.

Fig. 3. An instance part of the conceptual model for norm appliance and management in our television NMAS.
An (Abstract) TV Corporation Norm to Screen a Foreign Television Program: foreign television programs are obliged to be screened with subtitles in the national language of the country in which they are broadcast. A (Concrete) TV Corporation Norm to Screen a Foreign Television Program: (a) broadcasters of the *Nine* TV corporation are obliged to screen foreign programs with subtitles in English.

In the application domain of our motivating scenario, it was chosen that only the *Nine* TV corporation holds the norm presented above. Thus, the norm is represented by the *OblToScreenForeignTVProgWithSubtitles* norm instance that links the *Nine* TV corporation and the *ScreenATVPprog* action, all instances also illustrated in Fig. 3. Code 2 presents a DynaCROM rule that apply the norm in TV broadcasters. Because the norm is only presented in the *Nine* TV corporation, thus, its broadcasters are the unique affected by the verification of line 3. For instance, considering *GTV* (a *Nine* TV broadcaster), the following process is executed: in (4), the ‘'?TVCorp’ variable is instantiated with the *Nine* inferred value when the ‘'?TVBroadcaster’ variable is instantiated with the *GTV* given value; in (3), the ‘'?TVCorpNorms’ variable is instantiated with the *OblToScreenForeignTVProgWithSubtitles* inferred value; and in (2), this norm is added to the *GTV* instance.

For instance, when an agent is playing the broadcaster role in a broadcaster organization member of ABC (e.g., in ABV), the agent is automatically informed by DynaCROM about the TV content ratings inherited from ABC (i.e., for ages of 12, 14 or 18, and up). An action can be regulated by one or more contextual norms. Another norm that can be considered in the TV domain, while screening a TV program, is as follows:

**Code 2. Applying corporation norms in their broadcasters**

(1) [DynaCROMRule_TVBroadcasterWithTVCorpNorms:
(2) hasNorm(?TVB, ?TVCorpNorms)
(3) <- hasNorm(?TVCorp, ?TVCorpNorms),
(4) isMemberOf(?TVB, ?TVCorp)]
DynaCROM infers domain data and apply it in its concepts following the composition process illustrated in Fig. 1. For permitting this, the system developer should write the rules for data composition and, then, according to these rules and a domain ontology instance, DynaCROM automatically infers data. For instance, Code 4 presents a rule for adding the information about the TV content rating system of each TV corporation from the domain ontology in their broadcasters.

The result of the inference process is that all the eight TV broadcasters of the ABC TV corporation are informed about the ABC TV content rating system (according to the values of the ABCCRS instance from the domain ontology), the seven TV broadcasters of the Nine TV corporation are informed about the Nine TV content rating system (according to the values of the NineCRS instance from the domain ontology), and the SBS TV broadcaster is informed about the SBS TV content rating system. Once any information is updated in the TV content rating system of a TV corporation (e.g., the NotSuitableForPeopleUnder13 new TV content rating information value is inserted in the Nine TV content rating system), it is automatically forwarded to its broadcasters (e.g., TCN and the others from Table 1) in the next execution of DynaCROM, without the need to restart the system.

**Code 4. Applying content rating systems in broadcasters**

```plaintext
(1) [DynaCROMRule_TVBroadWithContentRatSystem:
    2) hasTVContentRatingSystem(?TVBroadcaster, ?TVCorpCRS)
(3) <- hasTVContentRatingSystem(?TVCorp, ?TVCorpCRS),
(4) isMemberOf(?TVBroadcaster, ?TVCorp)]
```

Code 5 presents another example of rules for composing domain data. The ‘DynaCROMRule_EnvWithOEnvNationalLangInfo’ (line 1 to 4) states that hierarchical environments will be added with the information about the national language of their countries; and, the ‘DynaCROMRule_TVBroadcasterWithNationalLang’ (line 5 to 8) states that a given TV broadcaster will also be added with the information about the national language of its country. The same rules could be exactly used (without any change) in the case that in the domain, besides Australian corporations, exist corporations from other countries, for instance, a Brazilian corporation. The result would be that TV broadcasters are obliged to screen foreign programs with subtitles in Portuguese (the national language of Brazil).

**Code 5. Applying national languages in broadcasters**

```plaintext
(1) [DynaCROMRule_EnvWithOEnvNationalLangInfo:
    2) hasNationalLanguage(?Env, ?OEnvNatLang)
(3) <- hasNationalLanguage(?OEnv, ?OEnvNatLang),
(4) belongsTo(?Env, ?OEnv)]

(5) [DynaCROMRule_TVBroadcasterWithNationalLang:
    6) hasNationalLanguage(?TVBroadcaster, ?EnvNatLang)
(7) <- hasNationalLanguage(?TVBroadcaster, ?EnvNatLang),
(8) isIn(?TVBroadcaster, ?Env)]
```

## 5 Contextual Norm Enforcement

DynaCROM is an approach for implementing dynamic NMAS in which norms can be updated at system runtime, and also for continuously supporting agents with precise information about their current norms. Nevertheless, a regulated NMAS should verify if a performed action is legal or illegal based on its defined norms, which should also be enforced. Therefore, experiments were done integrating DynaCROM with SCAAR and MOSES, two solutions for norm enforcement. In SCAAR [5] the norm enforcement is based on agents’ internal behaviors; in MOSES [23] it is based on agents’ external behaviors. For both solutions, DynaCROM works providing precise norm information as their input. As the enforcement solution is not the focus of DynaCROM, so, we do not deal with problems related to this part (e.g., malfunction of the enforcer).

In the following sub-section we will describe the integration of DynaCROM and SCAAR, leaving the one with MOSES to be detailed in a future publication. SCAAR was chosen for working with DynaCROM because its mechanism is not restricted to the interaction level, permitting the enforcement of norms from other levels of abstractions (e.g., from domain levels like the TV broadcaster one).

**DynaCROM and SCAAR Working Together**

SCAAR is a norm enforcement mechanism that enhances agents with a self-monitoring capability for avoiding norm violation. SCAAR utilizes control hooks to trigger an enforcement core each time a regulated action occurs. When agents spontaneously incorporate the DynaCROM behavior, aiming to receive updated system norms, they also incorporate SCAAR. In the incorporation process, DynaCROM automatically replaces the headers of the regulated methods implemented inside agents, which have their signature predefined by DynaCROM, to the methods enhanced with the SCAAR control hooks. Control hooks can be inserted inside agents’ code before a regulated action, for preventing norm violation, or after, for detecting norm violation. This is a decision of the system developer when implementing the DynaCROM headers to be replaced in agents’ codes. Once a regulated action starts running, its control hook triggers the agent enforcement core for the verification and/or enforcement of norm compliance. Norms are represented by Petri nets [24] for verification of compliance, and inhibitor arcs are used to permit the norm enforcement.

If the system developer decides to use the SCAAR norm prevention mechanism in his regulated MAS, then, when a tentative of violation occurs with an obligation or prohibition norm, the enforcement core blocks the execution of the infringing action and informs it to DynaCROM; if the system developer decides to only use the SCAAR norm detection mechanism, then, when a norm violation occurs with an obligation or prohibition norm, the enforcement core informs it to DynaCROM. For a permitted norm, no specific action is taken by SCAAR.
For DynaCROM and SCAAR work together properly, the system developer should write the abstract norms of his system according to both the SCAAR syntax and the DynaCROM domain ontology’s structure and, then, concretize these norms with instance values in the domain ontology. Concrete actions and norms must be written in the same way in both SCAAR norms and DynaCROM domain ontology. For the enforcement process, DynaCROM reads the ontology and rule files to automatically instantiate the abstract norms with domain values (see Fig. 1), providing concrete norms as input to SCAAR. SCAAR considers norms written according to the following definition, in which each term represents a set of clauses.

Norm Definition.
N ((a DO A [AND P]) [IF (a BE in S [AND P])])
N := OBLIGED | FORBIDDEN
a := an agent playing a system role
A := an action expression
P := a proposition concerning A or S
S := a state

The exact identification of parameters and their attributes are predefined in the specification of the abstract classes of a DynaCROM NMAS and, so, must be respected by the system developer while writing SCAAR norms. For instance, Code 6 presents an example of a SCAAR norm that the system developer should write to regulate the broadcaster agents from his system while they screen a TV program (i.e., to regulate the ScreenATVProg action instance from the DynaCROM domain ontology). A broadcaster agent informs its TV program via the ‘agtTVProgram’ parameter (line 2). Then, SCAAR verifies in the parameter, if the value of its ‘SubtitleIn’ attribute is equal to the expected value of the ‘domainTVBT.hasNationalLanguage’ variable. DynaCROM instantiates the ‘domainTVBT’ and ‘domainTVBT.hasNationalLanguage’ variables applying the rules from Code 5 to all broadcasters from the domain ontology that fulfill the norm condition inherited from their related corporations (following the rule from Code 2). For instance, DynaCROM instantiates the ‘domainTVBT.hasNationalLanguage’ variable with the English value when the agent is in the GTV broadcaster. The norm is inherited from Nine, the hierarchical TV corporation of GTV.

Code 6. Enforcing the obligation to present tv rating information
(1)SCAARNorm_OblToPresentTVRatingInfo: (agtTVProg.TVRatingInfo) isIn ((GTV).hasTVContentRatingSystem).hasTVContentRating)
   -- (NineCRS).hasTVContentRating
   -- (NotSuitableForPeopleUnder15, NotSuitableForPeopleUnder18)_.

Code 7. Part of a SCAAR norm concretized by DynaCROM
(2)_{(agtTVProg.TVRatingInfo)isIn ((GTV).hasTVContentRatingSystem).hasTVContentRating) }
   -- (NineCRS).hasTVContentRating
   -- (NotSuitableForPeopleUnder15, NotSuitableForPeopleUnder18)_.

Code 8. Enforcing the obligation to present subtitles
(1)SCAARNorm_OblToScreenFTVProgWithSubtitles: (agtTVProg.SubtitleIn == dTVBT. hasNationalLanguage)
(2)OBLIGED (agt DO ScreenATVProg(agtTVProg) AND (agtTVProg.SubtitleIn == dTVBT. hasNationalLanguage)
(3) IF (agt BE in TVBroadcaster AND (agtTVBT == dTVBT AND (agtTVProg.isForeign) AND (agtTVProg.TVRatingInfo) isIn (dTVBT.hasNorm))]

DynaCROM may use an external thesaurus, as the WordNet one [27], for giving other possibilities as input to the SCAAR enforcement [11]. In this way, when the “English language” value is given by a regulated agent instead of simply the “English” value, for instance, then, SCAAR correctly infers that the agent is compliant to the norm.

6 Related Work

Electronic Agent-Based Organizations. The OMNI framework (meaning Organizational Model for Normative Institutions) is proposed in [26] for modeling agent organizations. Currently, OMNI does not provide a solution for the implementation and integration of its specifications in a given NMAS. Thus, DynaCROM can provide a flexible solution for implementing agent organizations by representing the OMNI scenes, roles and group of roles in its ontology. Furthermore, this ontology also can be freely enriched with domain concepts and other particular fields for any concept. The integration of organizational data in the NMAS transparently occurs when agents incorporate DynaCROM and, then, start receiving domain information.
Electronic Agent-Based Institutions. Electronic institutions [9], or simply EI, are agent-based institutions with their focus on the institutional aspect of organizations. An EI can be specified and verified by using the ISLANDER [8] graphical tool and it uses the AMELI [10] agent-based middleware as an infrastructure that mediates agents’ interactions while enforcing institutional norms. DynaCROM can be used in AMELI by feeding governor agents with precise norm information according to agents’ current contexts, or it can be used in EI in the place of AMELI for enforcing institutional norms. The main advantage in using DynaCROM as the EI enforcement mechanism is that the great number of messages exchanged between agents and their respective governors, and between governor agents and scene manager agents is minimized. This is because, with DynaCROM, each regulated agent is enhanced with an enforcement core responsible for enforcing the system norms. Yet, agents are relieved to know in advance all the norms of the EI in which they will play.

7 Conclusion

The motivating question of our research is how norms can be effectively applied to the entities of NMAS and how they can be easily managed. Our ongoing work, named DynaCROM, intends to be a straightforward method for smoothly applying and managing regulations in NMAS as well as for enforcing precise contextual norms. DynaCROM is still a work in progress, but we agree that it already has contributions for the domain of NMAS. DynaCROM’s main contributions are: (i) a contextual normative ontology to explicitly represent the semantics of classified norms; (ii) a definition of a norm composition process that makes it easy to update regulation at system runtime; and (iii) a solution for enforcing contextual norms. DynaCROM is not tightly coupled with a particular enforcement mechanism. In this paper, we present the first results of the integration of DynaCROM and SCAA for enforcing the contextual norms of a NMAS from a television domain. We also started an experiment using the MOSES norm enforcement mechanism. For future work, we will continue the experiments with SCAA and MOSES in order to compare their results. Moreover, we intend to analyze how well-founded inputs from DynaCROM can minimize conflicting norms in NMAS.

References