# 5
# Applications of DynaCROM

## 5.1.
## Introduction

In this chapter, the applicability of DynaCROM is described via two usage scenarios from different domains. The first application is from the domain of multinational organizations and the second one is from the television domain. Both domains were chosen because they well illustrate important implicit contextual information that can be found in MAS.

Parts of the text describing the applicability of DynaCROM for the first application were recently published in [Felicíssimo *et al.*, 2007, 2008a, 2008b and 2008d], and the ones for the second application in [Felicíssimo, 2008e].

## 5.2.
## The CAT Tournament

In this section, the use of the DynaCROM approach for implementation, management and evolution of norms in NMAS is illustrated via a motivating scenario from the supply chain domain. In the scenario, a simplification of both the FIPA Contract-Net interaction protocol[11] (explained in the previous chapter) and the CAT competition are used in a realistic example.

### 5.2.1.
### DynaCROM at Work

In a DynaCROM NMAS, agents can request information about the contextual norms they are bound to, at a given moment, concretized in the application

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[11] Briefly, an American manufacturer wants to build 100 computers; he issues a CFP to suppliers; suppliers answer the CFP; the manufacturer chooses one proposal among the ones he received and informs his decision to the chosen supplier.

domain. This way, agents do not need to know in advance (*i.e.*, have hard coded inside them) all the (contextual) norms of each NMAS in which they will execute.

Norm-aware agents are more likely to make better choices, according to a specific criterion, because they are concerned with precise information. Knowing that, the system developer can continuously influence its NMAS by restricting or slackening some specific norms. So, buyers and sellers can be effectively matched in a good trade-off between making profit and attracting traders.

In the motivating example scenario, the following four component types are necessary to build a computer: CPU, motherboard, memory and hard disk. There are, at least, two suppliers for each component type with the base prices of their products predefined, as illustrated in Table 5.

Table 5. Computer components' information

| Description | Base price ( in USD) | Supplier |
|---|---|---|
| CPU | 750 | Pintel |
| CPU | 650 | IMD |
| Motherboard | 350 | Macrostar |
| Motherboard | 300 | Basus |
| Memory | 100 | Macrostar |
| Memory | 100 | Basus |
| Hard disk | 250 | Macrostar |
| Hard disk | 250 | Basus |

The four suppliers from the example (Pintel, IMD, Macrostar and Basus) were spread through different environments (*i.e.*, countries and states), as presented in Table 6. Basus and Macrostar are multinational organizations. A multinational organization is an enterprise that manages production branches located in at least two countries, which can also be across multiple continents. Corporate governance includes regulation of all possible relationships among the many players involved.

Table 6. Multinational supplier organizations

| Organization | Country | State |
|---|---|---|
| Pintel | USA | Missouri |
| IMD | USA | Virginia |
| Basus | Japan | Osaka |
| BasusUSA | USA | California |

| | | |
|---|---|---|
| Macrostar | China | Shanghai |
| MacrostarJapan | Japan | Hiroshima |

Norm-aware agents are influenced by the application of different contextual norms in a DynaCROM NMAS. Usually, organizations do not make their norms public. Thus, some norms for the multinational organizations' domain were created and organized into the contexts in which they apply in the example. For instance, the following environment norms hold for organizations presented in the *American* states:

*An Abstract Environment Norm for Calculating Prices:* In North America, a finished good from every organization is obliged to have its price increased by a fixed percentage (dependent of the seller location) as taxes, for immediate delivery or if the deliver address is in North America.

*Concrete Environment Norms for Calculating Prices:* a state corporate income tax rate of (a) *6.25* in *Missouri*; (b) *6.00* in *Virginia*; and, (c) *8.84* in *California* is obliged to be imposed on all sales.

Figure 20 illustrates the abstract environment norm for calculating prices concretized in the *Missouri* and *Virginia* environments. The norm is represented by the *OblToImposeAStateCorporateIncomeTax* norm instance that regulates the *ImposeAStateCorporateIncomeTax* action instance. The DynaCROM Environment concept was extended with the domain datatype property *hasAStateCorporateIncomeTaxOf* for concretizing the norm in each environment (*e.g.*, with the *6.00* value in *Virginia* and with the *6.25* value in *Missouri*).
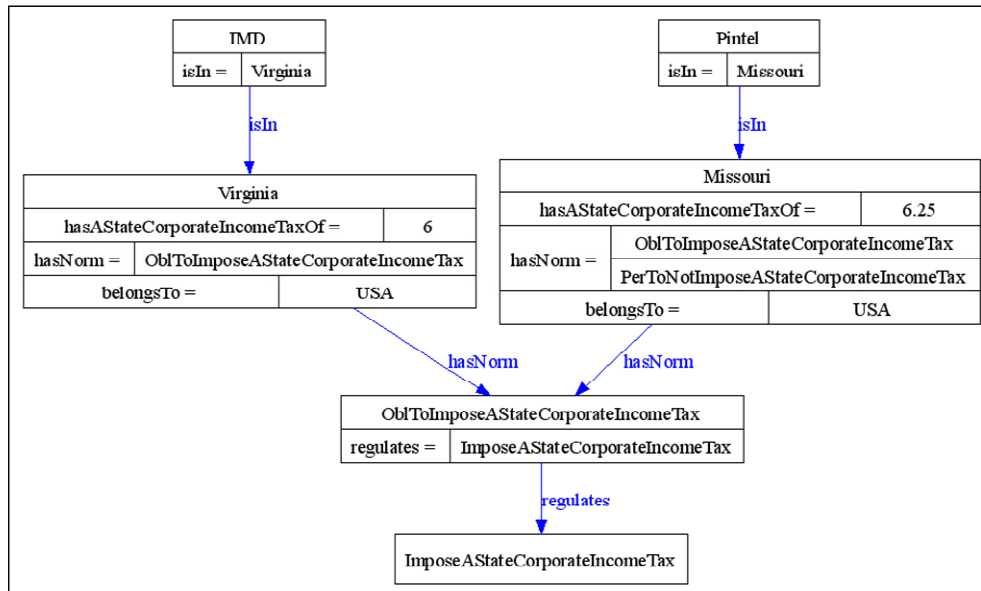
Figure 20 – Concrete environment norms for calculating prices

According to the present environment norms, if the manufacturer's purchase criterion is to minimize costs, then, he should choose to buy CPUs in IMD, instead of in Pintel, because the Virginia's state corporate income tax imposed of *6.00* is lower than the one of *6.25* from Missouri (both taxes informed by Dyna-CROM, in case of agents' requests). However, the following environment norm also holds in the example:

*A Concrete Environment Norm for Calculating Prices:* In *Missouri*, a *three day sales tax holiday* occurs every year from the first Friday in August until midnight on the Sunday following. Orders of computers and their components, with the maximum cost of $3,500, are eligible for tax free status during the holiday season.

Thus, during the three-day sales tax holiday occurring in Missouri, the manufacturer should choose to buy CPUs in Pintel because the Missouri's state corporate income tax is not imposed during the holiday season.

This is a trivial reason for choosing between two organizations, so, the following interaction and role norms were also created in the example:

*An Abstract Interaction Norm for Providing Discounts:* Suppliers are permitted to give up to a limited percentage of discounts if their products are bought in bundles.

*Concrete Interaction Norms for Providing Discounts:* (a) *Pintel* and *Macrostar* suppliers are permitted to offer *15%* discount if their products are

bought in bundles; and, (b) *IMD* and *Basus* suppliers are permitted to offer *10%* discount if their products are bought in bundles.

*An Abstract Role Norm for Accepting Placed Orders:* Suppliers are obliged to request a down payment for accepting placed orders*.*

*A Concrete Role Norm for Accepting Placed Orders:* (a) *IMD suppliers* are obliged to request a down payment of *10%* for accepting placed orders.

According to the present environment, role and interaction norms, the manufacturer should choose now to buy the bundle IMD/Basus in IMD. Based on the discount and tax information provided by DynaCROM, the manufacturer can reach the final price for a computer through the following calculation (all in USD): 650.00 (IMD CPU) + 300.00 (Basus Motherboard) + 100.00 (Memory) + 250.00 (Hard Disk) = 1,300.00 − 10% (IMD/Basus bundle discount) = 1,170.00 + 6.00% (Virginia's state corporate income tax) = 1,240.20.

However, if the manufacturer does not accept to make the down payment of 10% required by IMD suppliers for accepting placed orders, then, he should choose to buy the bundle Pintel/Macrostar in Pintel. There, the manufacturer can reach the final price for a computer through the following calculation (all in USD): 750.00 (Pintel CPU) + 350.00 (Macrostar Motherboard) + 100.00 (Memory) + 250.00 (Hard Disk) = 1,450.00 − 15% (Pintel/Macrostar bundle discount) = 1,232.50 + 6.25% (Missouri's state corporate income tax) = 1,312.61.

Figure 21 illustrates the concrete interaction norm for giving up to a limited percentage of discounts in *IMD* and *Basus* organizations. The norm is represented by the *PerToBasusAndIMDSellItemsInBundles* norm instance of *Basus* and by the *PerToIMDAndBasusSellItemsInBundles* norm instance of *IMD*. Both norm instances were created for regulating the *GiveUpToALimitedPercentageOfDiscount* action instance.

Basus suppliers perceiving that they are losing orders from the manufacturer, probably because of the IMD supplier norm for accepting placed orders, may complain with IMD suppliers. IMD suppliers can slacken this norm by simply removing the *OblToRequestADownPayment* norm instance from the *IMDSupplier* role instance (also illustrated in Figure 21).
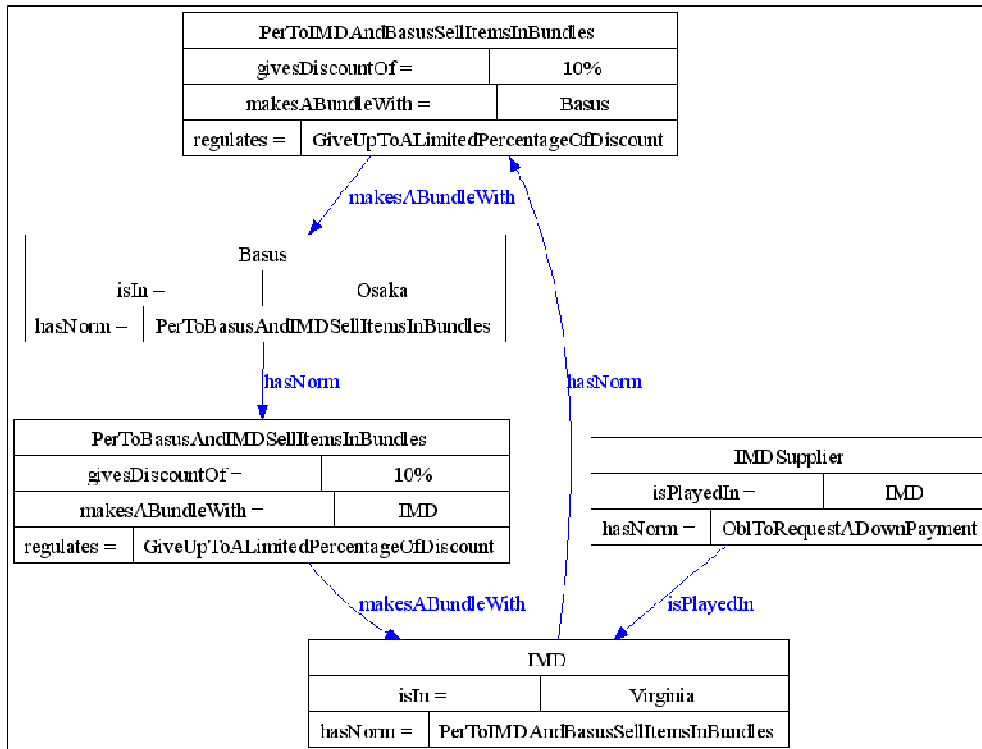
Figure 21 – Basus and IMD concrete norms

Another role norm that can be created in the example for influencing the manufacturer decision while his purchase criterion is still to minimize costs is as follows:

*An Abstract Role Norm for Providing Discounts:* Suppliers are permitted to give up to a limited percentage of discounts.

*Concrete Role Norms for Providing Discounts:* (a) *Macrostar suppliers* are permitted to give up to *5%* discount; and, (b) *Basus suppliers* are permitted to give up to *8%* discount on orders paid in cash.

The drawback of the norm for accepting placed orders presented in *IMD* and required for the *IMD/Basus* bundle can be relieved by applying the *Basus* norm that provides a better discount than the one provided by *Macrostar*. However, the discount is eligible in *Basus* organizations only for orders paid in cash, while in *Macrostar* organizations no condition is defined.

In order to decide where to buy memories and/or hard disks, the manufacturer can basically choose between *Japanese* or *Chinese* organizations. For motivating the agents' decision in this case, the following role norms were created in the example:

*An Abstract Organization Norm for Providing Warranty:* Organizations are obliged to give a limited lifetime warranty*.*

*Concrete Organization Norms for Providing Warranty:* a limited lifetime warranty of (a) *one year* in *Basus* organizations; and, (b) *six months* in *Macrostar* organizations is obliged to be given; (c) *MacrostarJapan* organizations are permitted to make an offer of *two years* limited lifetime warranty if a plus tax of *5%* is accepted to be paid*.*

Figure 22 illustrates the abstract organization norm for providing warranty concretized in the *Basus* and *Macrostar* organizations. The norm is represented by the *OblToGiveALimitedLifeTimeWarranty* norm instance that regulates the *GiveALimitedLifeTimeWarranty* action instance. The DynaCROM *Organization* concept was extended with the domain datatype property *hasLimitedLifeTimeWarranty* for concretizing the norm in each organization (*e.g.*, with the *SixMonths* value in *Macrostar* and with the *OneYear* value in *Basus*). The figure also illustrates the *PerToOfferALimitedLifeTimeWarrantyInMacrostarJapan* norm instance that regulates the *OfferALimitedLifeTimeWarranty* action instance in *MacrostarJapan* organizations.
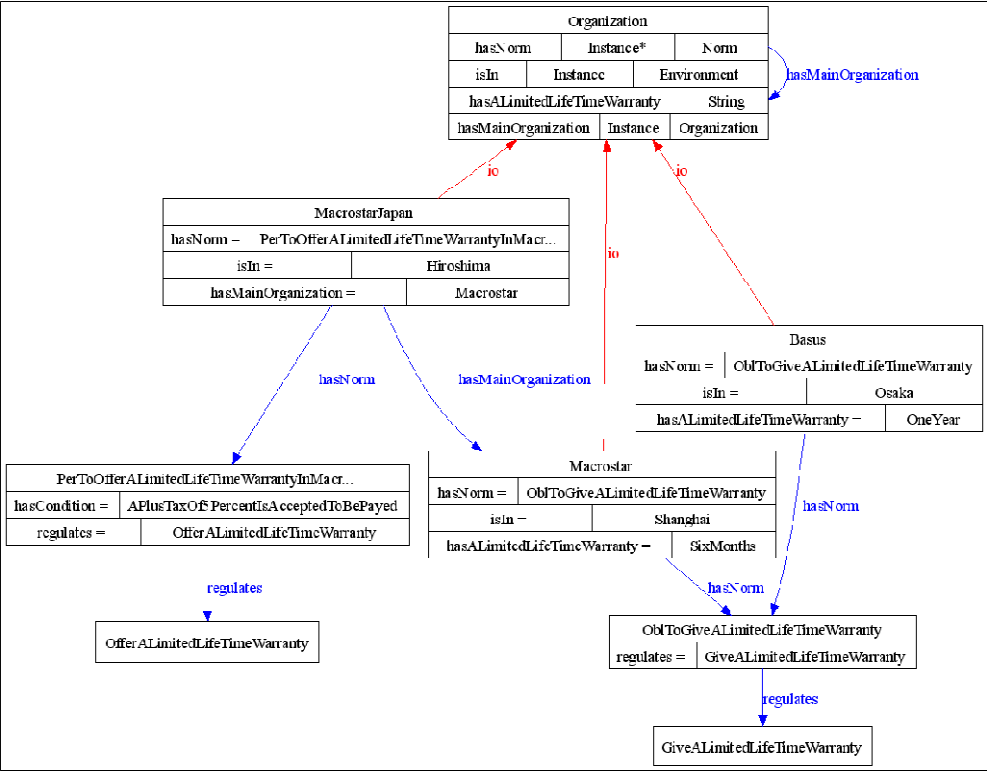


Figure 22 – Concrete organization norms for providing warranty

According to the present organization norms, if the manufacturer's purchase criterion now is to maximize the warranty period, then, he should choose to buy from a *MacrostarJapan* organization in order to obtain the *two-year* limited lifetime warranty. However, in *MacrostarJapan* orders must be paid in *JPY* and the manufacturer can only get a 5% discount from *Macrostar* suppliers. If the value is too high for him because of both the extra charge of *5%* for the warranty extension and the low discount, then, a lower price can be obtained withdrawing one year from the warranty when buying in *Basus*. There, he can get a *8%* discount from *Basus* suppliers if orders are paid in cash (with *JPY* in *Basus* or with *USD* in *BasusUSA*).

Nevertheless, when the *USA* and *Japan* are involved in a political crisis, *American* and *Japanese* organizations are forbidden to deal with each other according to the following political norm:

An Abstract Political Norm for Making Deals: organizations are forbidden to deal with each other when their countries are undergoing political crisis.

A Concrete Political Norm for Making Deals: American and Japanese organizations are forbidden to deal with each other when their countries are undergoing political crisis.

During the period of political crisis, the manufacturer cannot buy memories and/or hard disks from Basus and its sub-organizations or from *MacrostarJapan*. In order to prevent *Macrostar* from progressively raising its prices when *Basus* (its competitor) is not operating in the *American* market, the following economical norm is created in the example:

An Abstract Economical Norm for Operating in the Market: organizations are obliged to fix their prices for, at least, six months when their competing organizations are not operating in the market.

A Concrete Economical Norm for Operating in the Market: Chinese organizations are obliged to fix their prices for, at least, *six months* when their competing *Japanese organizations* are not operating in the market.

Figure 23 illustrates the *Chinese* economical norm for operating in the market when *Japanese* organizations are not operating there. The norm is represented by the *OblToMakePriceFixing* norm instance that regulates the *MakePriceFixing* action instance. The norm instance has the domain data type

properties *hasCondition* and *hasPeriod* for concretizing the norm in each organization (*e.g.*, when the *JapaneseOrgsNotOperatingInTheMarketing* condition is presented, prices from *Chinese* organizations are fixed in the market during *Six-Months*).
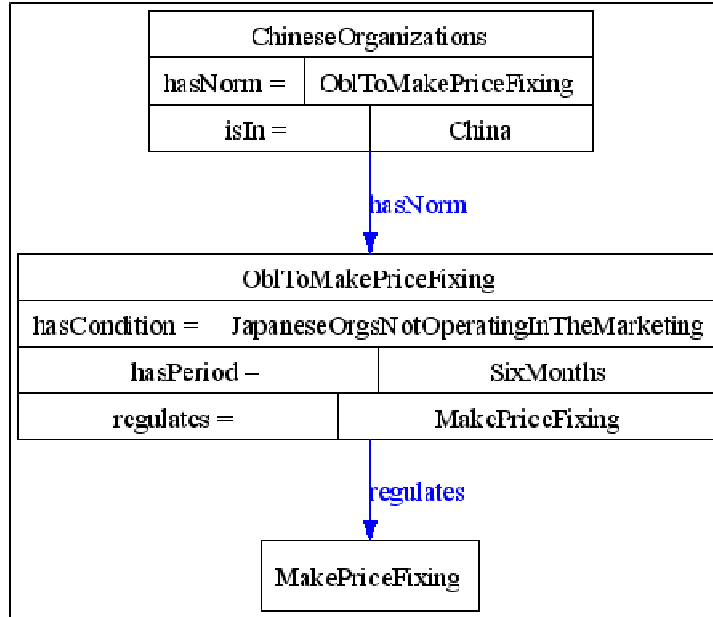


Figure 23 – A concrete economical norm for making price fixing

During the period of political crisis between *Japanese* and *American* organizations, the system developer should include the *Chinese* economical norm in the DynaCROM domain ontology instance of his NMAS and removed from there after this period.

Code 13 presents a domain rule that applies the *Chinese* economical norm in *Chinese* organizations. More precisely, the *Chinese* organizations from the domain (*e.g.*, the *Macrostar* one) are retrieved from the domain ontology instance due to the verification presented in (4); in (3), the *ObligationToMakePriceFixing* norm instance from *ChineseOrganizations* is inferred; and in (2), this norm is added to the analyzed *Chinese* organization retrieved in (4) (*e.g.*, the *Macrostar* one).

Code 13. A DynaCROM rule for applying an economical norm in Chinese organizations

```
(1)[DynaCROMRule_ChineseOrgsWithChineseNorms:
(2)  hasNorm(?Org,?ChineseOrgNorm)
(3)   <- hasNorm("ChineseOrganizations",?ChineseOrgNorm),
(4)      isIn(?Org, "China")]
```

A final example on how the system developer can influence the agents acting in a DynaCROM MAS is given when the purchase criterion of the manufacturer is to minimize the time for deliveries. For motivating the agents' decision in this case, the following organization norms were created in the example:
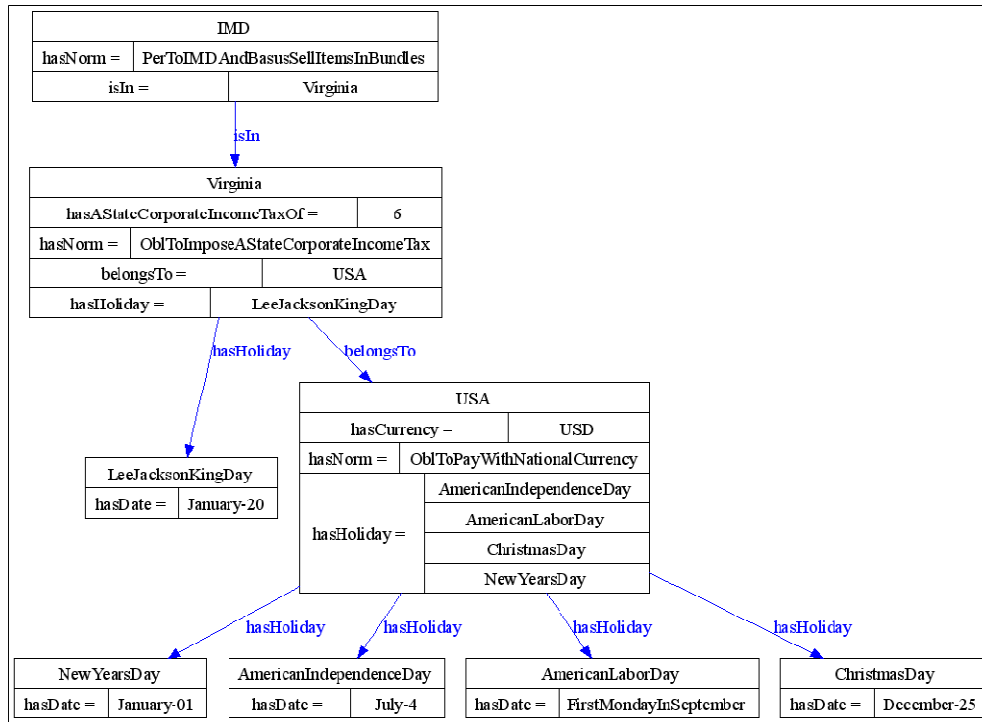
*An Abstract Organization Norm for Deliveries*: Organizations are prohibited from delivering orders during holidays to their final destinations.

*A Concrete Organization Norm for Deliveries*: (a) *BasusUSA* organizations are prohibited from delivering orders during holidays to their final destinations.

Precise information about holidays is an important data for organizations while they are planning deliveries. For instance, environments can have federal holidays, which are applied to all sub-environments of a country (*e.g.*, states, cities, etc.), and state holidays, which are applied to all sub-environments of a state (*e.g.*, cities, neighborhoods, etc.). Yet, holidays can be in the same dates, as Christmas Day (December, 25) and New Year's Day (January, 01), or in different dates, as Independence Day (*e.g.*, September, 07 in Brazil and July, 04 in USA) and Labor Day (*e.g.*, May, 01 in Brazil and in the first Monday of September in USA).

In order to represent the information about holidays, a *Holiday* concept and its *FederalHoliday* and *StateHoliday* sub-concepts were created in a DynaCROM domain ontology and, then, these concepts were concretized with domain values.

Figure 24 illustrates the holiday information that *BasusUSA* suppliers should consider while planning their deliveries in *IMD* for allowing their bundle offerings. In IMD, besides the Lee Jackson King's Day, a Virginia's holiday represented by the *LeeJacksonKingDay* holiday instance, other American holidays (as the ones illustrated in Figure 24) must also be considered.

Figure 24 – Holidays in *American* environments

Code 14 presents a DynaCROM domain rule that applies federal holidays in environments. More precisely, considering *Virginia* as an example of the given environment, the following composition process is executed, according to the domain ontology instance illustrated in Figure 24: in (4), the '*?OEnv*' variable is instantiated with the *USA* inferred value when the '*?Env*' variable is instantiated with the *Virginia* given value; in (3), the '*?FederalHolidays*' variable is instantiated with the inferred values about the *American* holidays (see those in Figure 24); and in (2), the inferred holidays are added as holidays of *Virginia*.

Code 14. A rule for applying federal holidays in environments

```
(1)[DynaCROMRule_EnvsWithFederalHolidays:
(2)  hasHoliday(?Env,?FederalHolidays)
(3)  <- hasHoliday(?OEnv,?FederalHolidays),
(4)     belongsTo(?Env,?OEnv)]
```

5.2.2.

**DynaCROM_SCAAR at Work**

In order to exemplify how DynaCROM and SCAAR work together for enforcing the norms of the example, the political norm: "*American* and *Japanese* organizations are prohibited from dealing with each other when their countries

are undergoing political crisis" is considered. The norm is enforced every time that the manufacturer agent accepts a proposal from a supplier agent by executing the '*buyAComputerComponent(...)*' method presented in Code 15.

Code 15. Part of a method to be implemented by manufacturer agents

```
(1)public abstract class APlanForManufacturerAgt{
(2) public void buyAComputerComponent(String
      computerComponent, int qtd, String chosenSupplier){

(4)… } }
```

The signature of the '*buyAComputerComponent(...)*' method is specified by the system developer of a DynaCROM NMAS and agent developers should implement their agents for executing according to this signature. For instance, Code 16 presents how the method must be called in the case that the manufacturer agent decides to buy from *MacrostarJapan*.

Code 16. A purchase's order to a supplier

```
buyAComputerComponent(memory, 100, MacrostarJapan)
```

In order to enforce the political norm according to the SCAAR solution, the control hook specific to the action to buy (represented by the execution of the '*buyAComputerComponent(...)*' method) triggers the agent's enforcement core for verifying if the execution of the action is compliant to its norms.

Code 17 presents an example of a SCAAR norm that a system developer wrote to regulate manufacturer agents of his NMAS (*e.g.*, the *American* ones) while they are dealing, during a political crisis, with *Japanese* organizations. The political norm is enforced due to the verification of lines 5 and 6 from Code 17.

The manufacturer agent informs its chosen supplier via the '*chosenSupplier*' parameter (line 2). Then, SCAAR verifies if the supplier is from a *Japanese* organization (lines 3 and 4). For the SCAAR verification, DynaCROM instantiates the '*agtEnv*' variable (line 3) according to the agent's current environment.

Code 17. Enforcing a political norm in the example

```
(1) SCAARNorm_PrhAmericanOrgsToDealWithJapaneseOrgs:
(2)  [FORBIDDEN(agt DO buyAComputerComponent(computerCom-
     -ponent, qtd, chosenSupplier) AND
(3)  (chosenSupplier.isIn(agtEnv)) AND
(4)  agtEnv.belongsTo("Japan")
(5)  IF(agt BE in Environment AND (agtEnv == domainEnv) AND
(6)   ("PrhToDealWithJapaneseOrganizations" isIn
      (domainEnv.hasNorm))]
```

5.2.3.

## DynaCROM_MOSES at Work

The enforcement of the political norm is also exemplified in MOSES. In this case, the enforcement is done when agents interact by exchanging messages. Code 18 illustrates an example when the manufacturer agent chooses a supplier agent by sending to him an ACCEPT_PROPOSAL message. This code is a continuation of Code 15.

Code 18. An ACCEPT_PROPOSAL message sent to a supplier agent

```
(3) … sendObjMsg(ACLMessage.ACCEPT_PROPOSAL, order,
                              myAgent, chosenSupplier); …
```

The political norm cannot be directly enforced by MOSES because the MOSES solution only supports the enforcement of obligation norms. Considering that: "if an act *is obligatory*, then, it *is permitted* and it *is not prohibited*", so, the enforcement of the political norm by MOSES will be explained via the obligation of the *American* manufacturer to deal only with *non-Japanese* organizations.

Figure 25 illustrates an example in which the political norm is enforced and Code 19 presents the example codified in MOSES. The *MissourianManufacturer* agent sends an ACCEPT_PROPOSAL message to the *JapaneseSupplier* agent. When the message arrives at the *ManufacturerPolice* agent, he requests DynaCROM the information about the nationality of the chosen supplier and adds the returned value in the 'supplierCountry' variable (see line 3 from Code 19). Then, the *ManufacturerPolice* checks the obligation to deal only with *non-Japanese* organizations (lines 4 and 5).
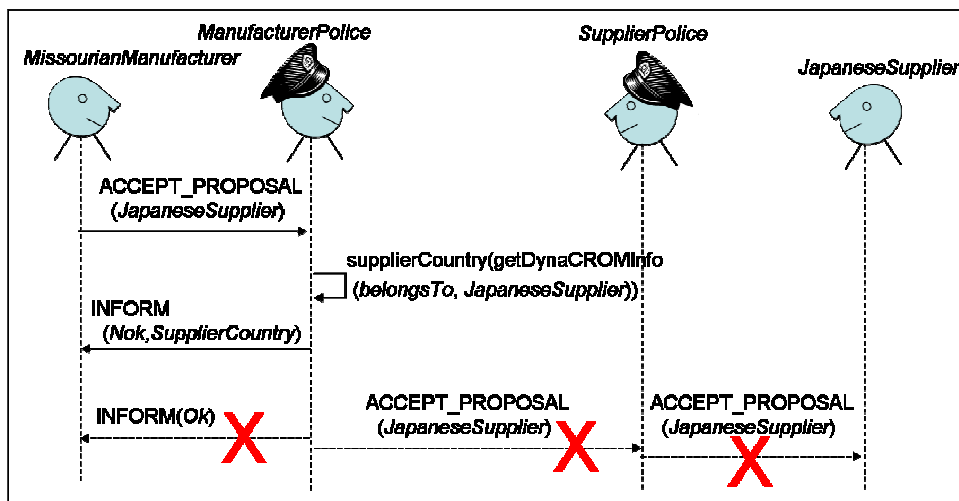


Figure 25 – Enforcement of a political norm by DynaCROM_MOSES

Code 19. Part of a MOSES law for enforcing the political norm

```
(1)   public void sent(…){
(2)    if (message.startsWith("ACCEPT_PROPOSAL")){
(3)     doAdd("supplierCountry(" + getDynaCROMInfo(belongsTo,
                            getMessageContent(message) + ")");
(4)    if "PrhToDealWithJapaneseOrganizations" isIn
       domainEnv.hasNorm{…
(5)     doImposeObligation("checkCountry", 1, "sec");}
(6)    return;
(7)   }}

(8)   public void obligationDue(Term obligationTerm){
(9)    if (obligationTerm.equals("checkCountry")){
(10)    if !(supplierCountry.equals("Japan")){
(11)     doForward();
(12)     doDeliver(CS.toString(),"INFORM(Ok)",sourceAddress); }
(13)    else{
(14)     doDeliver(CS.toString(),"INFORM(Nok,
                         SupplierCountry)",sourceAddress); …}
(15) }}

(16) public void arrived(…){
(17)  if (message.startsWith("ACCEPT_PROPOSAL")){
(18)   doDeliver();
(19)  return;
(20) }}
```

The political norm is enforced if the chosen supplier is *Japanese* (see lines 13 and 14). In this case, an INFORM(*Nok*,*SupplierCountry*) message is sent to the manufacturer agent in order to inform him that his message was not sent because an error had occurred with the value proposed for the '*SupplierCountry*' variable.

When the chosen supplier is a *non-Japanese* one, then, the *ACCEPT_PROPOSAL* message is forwarded to its recipient (the chosen supplier (lines 10 and 11)) and an INFORM(*Ok*) message is sent to the manufacturer agent (line 12) in order to inform him that his message was sent. When the message arrives at the *SupplierPolice* agent (line 17), he only delivers it to its final recipient (the *JapaneseSupplier* agent (line 18)).

## 5.3.
## TV Broadcasting

In this section, the use of the DynaCROM approach for implementation, management and evolution of norms in NMAS is illustrated via a motivating scenario from the television (TV) 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. This way, some solutions for norm enforcement (*e.g.*, MOSES, AMELI, etc.) do not work properly because their regulation is restricted to the interaction level. As consequence, agents are dependent on each other.

This limitation for regulation outlines the importance of a norm enforcement solution that enhances agents with a self-monitoring capability and, so, makes them independent on each other. With such capability, agents can (auto-)enforce norms from different levels of abstraction, besides doing it only for norms from the interaction level.

In next, DynaCROM is applyied in a motivating scenario from the television (TV) domain.

### 5.3.1.
### DynaCROM at Work

The applicability of DynaCROM, in the television domain, is exemplified via a motivating scenario in which data can be distributed among several countries by broadcaster agents from different TV Corporations. In the example, a (*direct* or *indirect*) hierarchy exists among their concepts, providing implicit contextual information for regulation in NMAS.

In order to represent the domain concepts of the example, the conceptual model illustrated in Figure 26 was conceived for the television domain, extending the DynaCROM ontology (originally presented in Figure 6). In the domain ontology, *TVBroadcaster* (a type of *Organization*) is subordinated to its respective *TVCorporation,* via the *isMemberOf* property, and each TV broadcaster has only one main organization (association via the *hasMainOrganization* inherited property). A *TVBroadcaster* is in an *Environment* (association via the *isIn* inherited property). An *Environment* is linked to its *Government* via the *hasGovernment* property. Each *Government* is linked to its *AudioAndMediaGovernmentAgency* via the *hasGovernmentAgency* property.

All concepts of the proposed conceptual model can also be linked to the DynaCROM *Norm* concept via the *hasNorm* property for holding the norms of the proposed NMAS. This way, norms are contextualized according to each concept of the domain.
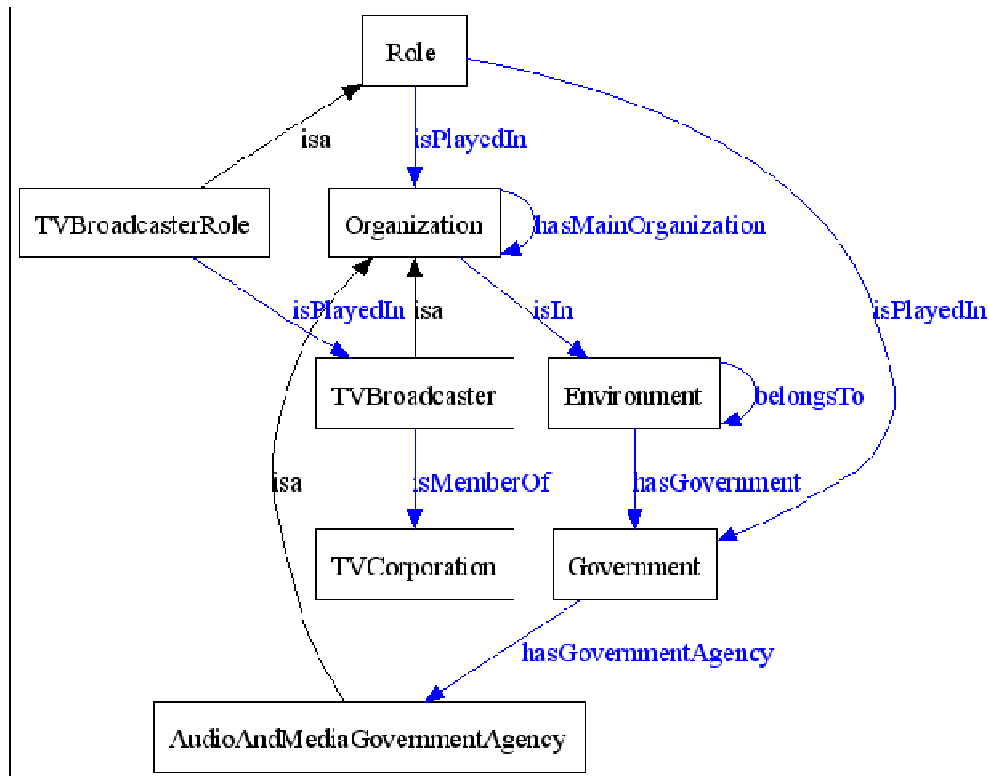
Figure 26 – A conceptual model for a NMAS from the television domain

A TV program is screened by a broadcaster agent playing the role in its broadcaster organization. A broadcaster agent 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 and country), government, government agency and TV Corporation.

For instance, besides others, the following norm of censorship to screen a TV program can be considered:

*A Television Norm for Censorship:* television programs are obliged to present their television content rating information to give audiences 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 domain. Considering the context of the Australian TV system, for instance, the norm is concretized 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 content ratings are obliged to be presented as follows: for ages of (i) *12* and up, (ii) *14* and up, and (iii) *18* and up; and, (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.

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. Excluding the Tasmania state, which does not have a broadcaster for the *Nine* TV Corporation, all other Australian states have broadcasters for the *ABC* and *Nine* TV Corporations, as presented in Table 7.

Table 7. TV broadcasters of the *ABC* and *Nine Australian* TV Corporations

| TV Broadcaster | TV Corporation | State | City |
|----------------|----------------|-------|------|
| ABN | ABC | New South Wales | Sydney |
| TCN | Nine | | Willoughby |
| ABV | ABC | Victoria | Melbourne |
| GTV | Nine | | |
| ABQ | ABC | Queensland | Brisbane |
| QTQ | Nine | | |
| ABS | ABC | South Australia | Adelaide |
| NWS | Nine | | |
| ABW | ABC | Western Australia | Perth |
| STW | Nine | | |
| ABT | ABC | Tasmania | Hobart |
| --- | Nine | | |
| ABN | ABC | Australian Capital | Canberra |
| TCN | Nine | Territory | |
| ABD | ABC | Northern Territory | Darwin |
| NTD | Nine | | |

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 in all of its broadcasters. So, the norm is represented by a government agency norm (illustrated in Figure 27 by the *OblToPresentTVRatingInfo* norm instance) that links the government agency and the *ScreenATVProg* action instances.
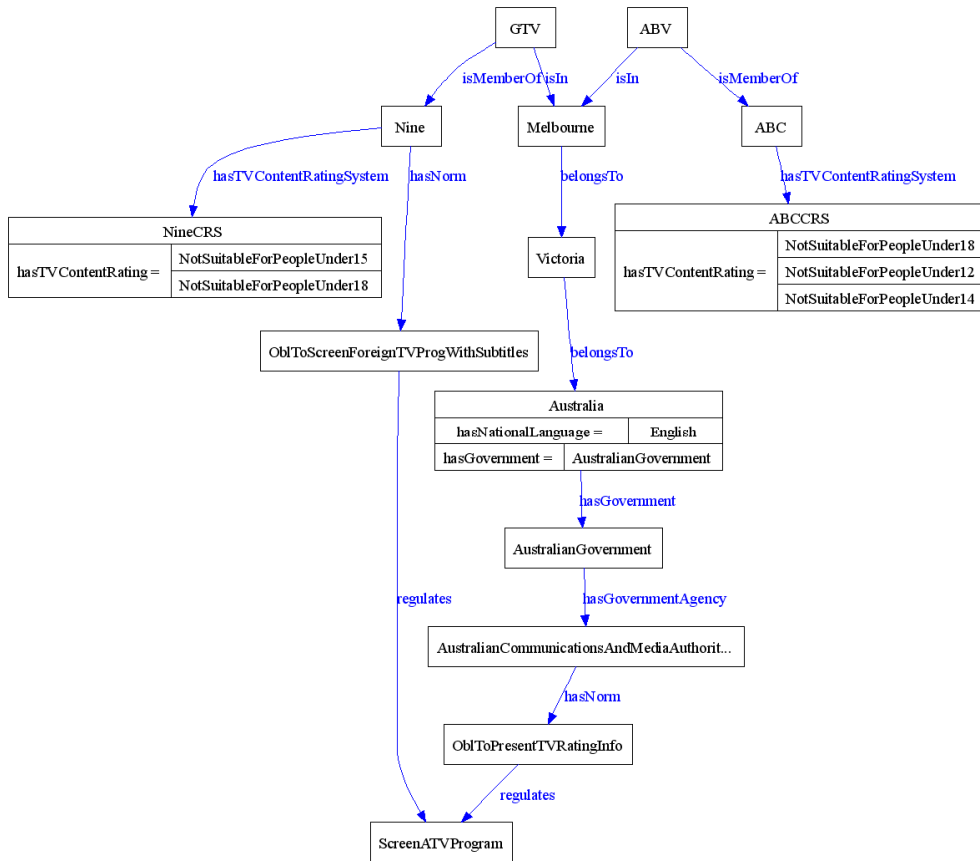
Figure 27 – An instance part of the conceptual model created for a Dyna-CROM NMAS from the television domain

Rules are used for applying the censorship norm in all TV broadcasters of the domain. Code 20 exemplifies a set of rules created for this purpose.

Code 20. Applying the censorship norm in broadcasters

```
(1)  [DynaCROMRule_GovWithGovAgencyNorms:
(2)    hasNorm(?Gov,?GovAgencyNorms)
(3)    <- hasNorm(?GovAgency,?GovAgencyNorms),
(4)        hasGovernmentAgency(?Gov,?GovAgency)]

(5)  [DynaCROMRule_EnvWithGovNorms:
(6)    hasNorm(?Env,?EnvGovNorms)
(7)    <- hasNorm(?EnvGov,?EnvGovNorms),
(8)        hasGovernment(?Env,?EnvGov)]

(9)  [DynaCROMRule_EnvWithOEnvNorms:
(10)   hasNorm(?Env,?OEnvNorms)
(11)   <- hasNorm(?OEnv,?OEnvNorms),
(12)       belongsTo(?Env,?OEnv)]

(13)[DynaCROMRule_OrgWithEnvNorms:
(14)   hasNorm(?Org,?OrgEnvNorms)
(15)    <- hasNorm(?OrgEnv,?OrgEnvNorms),
(16)        isIn(?Org,?OrgEnv)]
```

The '*DynaCROMRule_GovWithGovAgencyNorms*' (line 1 to 4 of Code 20) states that a given government will have its norms composed with the norms of its government agency. More precisely, considering *AustralianGovernment* as an example of the given government, the following composition process is executed, according to the domain ontology instance illustrated in Figure 27: in (4), the '*?GovAgency*' variable is instantiated with the *AustralianCommunicationAndMediaAuthority* inferred value  when the '*?Gov*' variable is instantiated with the *AustralianGovernment* given value; in (3), the '*?GovAgencyNorms*' variable is instantiated with the *OblToPresentTVRatingInfo* inferred value; and in (2), this norm is added to the *AustralianGovernment* instance.

Following a similar composition process, the '*DynaCROMRule_EnvWithGovNorms*' (line 5 to 8) states that a given environment will have its norms composed with the norms of its government; the '*DynaCROMRule_EnvWithOEnvNorms*' (line 9 to 12) states that hierarchical environments will have their norms composed; and the '*DynaCROMRule_OrgWithEnvNorms*' (line 13 to 16) states that a given organization will have its norms composed with the norms of its environment.

The final result of the inference process is that all TV broadcasters of the domain are obliged to present the television content ratings of their corporations to every broadcasted program. For instance, an agent playing the broadcaster role in a broadcaster organization member of *ABC* (*e.g.*, in *ABV*) is obliged to present a content rating for ages of *12*, *14* or *18*, and up to every broadcasted program.

In a DynaCROM NMAS, 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:

*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 broadcasted.

*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 the motivating scenario proposed, it was chosen that only the *Nine* TV Corporation holds the norm presented above. Thus, the norm is represented by the *OblToScreenForeignTVProgWithSubtitles* norm in-

stance that links the *Nine* TV Corporation and the *ScreenATVProg* action (all instances also illustrated in Figure 27).

Code 21 presents an example of a DynaCROM rule that applies the norm in TV broadcasters. Because the norm is only presented in the *Nine* TV Corporation, its broadcasters are the unique affected due to the verification of line 3. More precisely, considering *GTV* (a broadcaster of the *Nine* TV Corporation) as an example of the given broadcaster, the following composition process is executed, according to the domain ontology instance illustrated in Figure 27: 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.

A similar inference process (distinguished only by the input values for the '*?TVBroadcaster*' variable) results in the automatic implementation of the norm of the *Nine* TV Corporation in the other six TV broadcasters, all presented in Table 7.

Code 21. Applying corporation norms in their broadcasters

```
(1)[DynaCROMRule_TVBroadcasterWithTVCorpNorms:
(2) hasNorm(?TVBroadcaster,?TVCorpNorms)
(3)  <- hasNorm(?TVCorp,?TVCorpNorms),
(4)     isMemberOf(?TVBroadcaster,?TVCorp)]
```

## 5.3.2.
## DynaCROM_SCAAR at Work

In order to exemplify how DynaCROM and SCAAR work together for enforcing the norms of the example, the TV norm for censorship is considered. The norm is enforced every time that broadcaster agents screen a TV program by executing the '*screenATVProg()*' method presented in Code 22. The signature of the '*screenATVProg()*' method is specified by the system developer of a DynaCROM NMAS from the TV domain and agent developers should implement their agents for executing according to this signature.

Code 22. Part of a method to be implemented by broadcaster agents

```
(1)public abstract class APlanForBroadcasterAgt {
(2) public Object screenATVProg(){
(3)  Object agtTVProg[] = new Object[…];
(4)  agtTVProg = chooseATVProgram();
(5)  agtTVProg.TVRatingInfo = getTVRatingInfo(
```

```
                                        agtTVProg,TVContentRating);
(6)   agtTVProg.SubtileIn = getSubtitle(
                                        agtTVProg,NationalLanguage);

(8)… return agtTVProgram; } }
```

As previously presented, agents can request domain data to DynaCROM by calling the *getDynaCROMInfo(String infoRequested)* predefined method with the '*infoRequested*' parameter filled with the desired information.

In the case of the *screenATVProg()* method from Code 22, agents can request DynaCROM the information about the values of the *TVContentRating* (line 5) and *NationalLanguage* (line 6) parameters. For this, the *getDynaCROMInfo(TVContentRating)* and *getDynaCROMInfo(NationalLanguage)* respective method calls should be done.

Considering, as an example, an agent playing the broadcaster role in the *GTV* broadcaster organization, then, the agent is informed about both a list with the concrete elements (*NotSuitableForPeopleUnder15*, *NotSuitableForPeopleUnder18*), which is contextualized according to the *Nine* TV content rating system, and a string with the *English* concrete value, which is contextualized according to *Australia*.

Code 23 presents an example of a SCAAR norm that a system developer wrote to regulate the broadcaster agents of his NMAS while they screen a TV program (*i.e.*, to regulate the *ScreenATVProg* action instance from the Dyna-CROM domain ontology). A broadcaster agent informs its TV program via the '*agtTVProg*' parameter (line 2). Then, SCAAR verifies, in the parameter, if the value of its '*TVRatingInfo*' attribute is valid, *i.e.*, if the value proposed by the agent is one of the TV content rating of the TV broadcaster in which the agent is performing its role.

Code 23. Enforcing the obligation norm to present TV content rating information

```
(1)SCAARNorm_OblToPresentTVRatingInfo:
(2)[OBLIGED (agt DO screenATVProg(agtTVProg) AND
   ((agtTVProg.TVRatingInfo) isIn
   ((domainTVBT.hasTVContentRatingSystem).hasTVContentRating)))
(3) IF (agt BE in TVBroadcaster AND (agtTVBT == domainTVBT)
(4) AND ("OblToPresentTVRatingInfo" isIn (domainTVBT.hasNorm)))]
```

The list with all TV content ratings of a specific broadcaster is informed by DynaCROM via automatic execution of progressive inferences. Code 24 exemplifies the case in which DynaCROM infers the TV content ratings of the *Nine* TV Corporation for an agent playing the broadcaster role in the *GTV* organization.

Code 24. Part of a SCAAR norm concretized by DynaCROM

```
(2)…((agtTVProg.TVRatingInfo) isIn
    ((GTV).hasTVContentRatingSystem).hasTVContentRating)))
  …
    ((NineCRS).hasTVContentRating)
  …
    (NotSuitableForPeopleUnder15,NotSuitableForPeopleUnder18)
  …]
```

DynaCROM instantiates the '*(domainTVBT.hasTVContentRatingSystem).hasTVContentRating*' variable, which is presented in line 2 of Code 23, by applying the rule of Code 25 to all broadcasters from the domain ontology that fulfill the norm condition inherited from their related instances (following the rules of Code 20). The norm is enforced each time that it is presented in the analyzed TV broadcaster ontology instance due to the verification occurred in lines 3 and 4 of Code 23 (answered by DynaCROM).

Code 25. Applying TV content rating systems in TV broadcasters

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

It is important to remark here that the result of the execution of the rule presented in Code 25 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 insertion, in the domain ontology, of the value *NotSuitableForPeopleUnder13* as a new TV content rating of the *Nine* TV content rating system), it is automatically forwarded to its broadcasters (*e.g.*, *TCN* and the other broadcasters from the *Nine* TV Corporation presented in Table 7) in the next execution of DynaCROM, without the need to restart the system.

Code 26 presents another example of a SCAAR norm. The norm was written by a system developer in order to regulate the broadcaster agents of his NMAS while they screen a foreign TV program. A broadcaster agent informs its TV program via the '*agtTVProg*' parameter (line 2). Then, SCAAR verifies, in the

parameter, if the value of its '*SubtitleIn*' attribute is equal to the expected value of the '*dTVBT.hasNationalLanguage*' variable (line 2).

Code 26. Enforcing the obligation norm to present subtitles

```
(1)SCAARNorm_OblToScreenFTVProgWithSubtitles:
(2)[OBLIGED(agt DO screenATVProg(agtTVProg) AND
    (agtTVProg.SubtitleIn == dTVBT.hasNationalLanguage))
(3) IF(agt BE in TVBroadcaster AND (agtTVBT == dTVBT) AND
(4)    (agtTVProg.isForeign) AND
(5)    ("OblToScreenForeignTVProgWithSubtitles" isIn
        (dTVBT.hasNorm)))]
```

DynaCROM instantiates the '*dTVBT*' and '*dTVBT.hasNationalLanguage*' variables applying the rules of Code 27 to all broadcasters from the domain ontology that fulfill the norm condition inherited from their related corporations (following the rule from Code 21). For instance, DynaCROM instantiates the '*dTVBT.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 27. Adding the information about the national language expected by broadcasters

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

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

5.3.3.

## DynaCROM_MOSES at Work

As stated in [Serban *et al.*, 2001], "*it should be pointed out that the concept of law under LGI has a fundamental limitation: it can regulate only interaction between agents, having no sway over the structure and internal behavior of individual agents.*"

Thus, because the norm enforcement of MOSES is limited to the interaction level, then, it was necessary, for the example, to create an agent for representing the TV device and its respective police agent. Both agents are illustrated in the right side of Figure 28. There, the norm to screen a foreign TV program is enforced every time that the agent sends an INFORM message with the TV pro-

gram to be broadcasted, as illustrated in Figure 28 and codified in Code 28. This code is a continuation of Code 22.
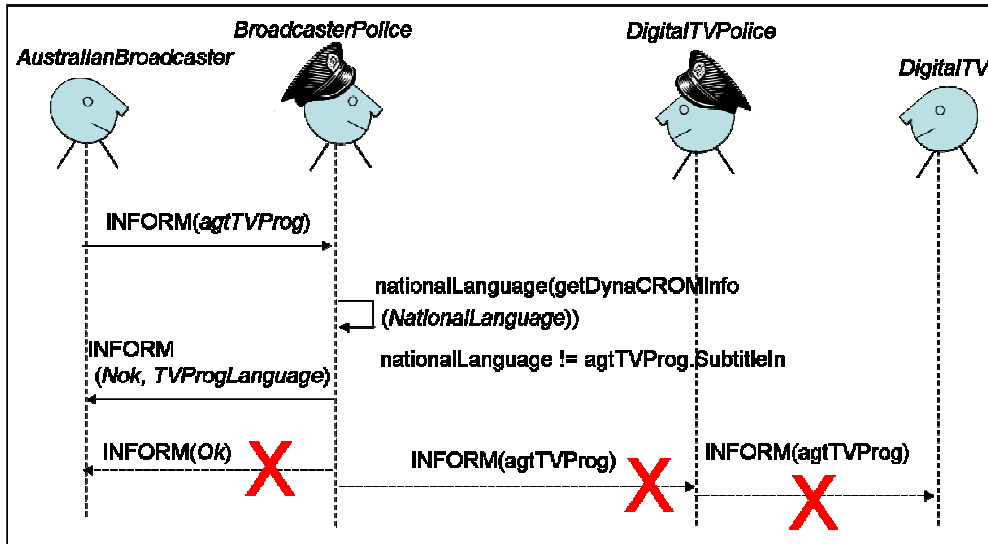


Figure 28 – Enforcement of the norm to screen a foreign TV program

Code 28. An INFORM message sent by a broadcaster agent

```
(7)    sendObjMsg(ACLMessage.INFORM,agtTVProg,myAgent,digitalTV);
```

Code 29 presents the example codified in MOSES. When the message arrives at the *BroadcasterPolice* agent, he requests DynaCROM about the value of the expected national country (line 3) of the Australian broadcaster agent and, then, checks the obligation to screen a foreign TV program with subtitles in the national language of the country in which the TV program is broadcasted (lines 4 and 5).

If the national language and the subtitle of the TV program sent by the broadcaster agent are the same (lines 9 and 10), then, the message is forwarded to its recipient (line 11) and an INFORM(*Ok*) message is sent to the supplier agent (line 12) in order to report him that his message was sent. When the message arrives at the *DigitalTVPolice* agent (line 17), then, he only delivers it to its final recipient (the *DigitalTV* agent (line 18)).

However, if the languages are different, as is the case illustrated in Figure 28, then, an INFORM(*Nok,TVProgLanguage*) message is sent to the Australian broadcaster agent (line 14) in order to inform him that his message was not sent because an error occurs with its proposed value for the '*TVProgLanguage*' variable.

Code 29. Part of a MOSES law for enforcing the norm to screen a foreign TV program

```
(1)   public void sent(…){
(2)    if (message.startsWith("INFORM")){
(3)     doAdd("nationalLanguage(" + getDynaCROMInfo(National-
                             Language) + ")");
(4)     if "OblToScreenForeignTVProgWithSubtitles" isIn
                                        domainEnv.hasNorm{…
(5)      doImposeObligation("checkLanguage", 1, "sec");}
(6)     return;
(7)   }}

(8)   public void obligationDue(Term obligationTerm){
(9)    if (obligationTerm.equals("checkLanguage")){
(10)   if (nationalLanguage.equals
          (" + getMessageContent(message) + ").SubtitleIn)){
(11)     doForward();
(12)     doDeliver(CS.toString(),"INFORM(Ok)",sourceAddress); …}
(13)    else{
(14)     doDeliver(CS.toString(),"INFORM(Nok,
                 TVProgLanguage)",sourceAddress); …}
(15)  }}

(16) public void arrived(…){
(17)  if (message.startsWith("INFORM")){
(18)   doDeliver();
(19)   return;
(20)  }}
```

## 5.4.
## Discussion

In this chapter, the applicability of DynaCROM is demonstrated through two usage scenarios from different domains. In the scenario of a market based control, the aspect of interoperability in multinational organizations is investigated; and in the scenario of TV broadcasting, the aspect of self-regulated agents is investigated. For both scenarios, it was explained how DynaCROM works, including its solution for contextualization, concretization, representation and composition of norms, and also how DynaCROM works integrated with MOSES and SCAAR for the (contextual) norm enforcement in a DynaCROM NMAS.

DynaCROM may also use an external thesaurus, as the WordNet one [WordNet, URL], for giving other possibilities as input to enforcers [Breitman *et al.*, 2005; Felicissimo, 2004]. This way, when the "*English language*" value is given by a broadcaster agent instead of simply the "*English*" value, for instance, then, the used enforcer correctly infers that the regulated agent is compliant to the norm.

In summary, the applicability of the DynaCROM methodology and its contextualized answers, in different domains, indicates that DynaCROM is a flexible, modular, well suitable solution to operationalize regulative norms in MAS.