DynaCROM
An approach to implement regulative norms in normative multiagent systems


Carolina Felicissimo, PUC - RIO RJ, Brazil
Jean-Pierre Briot, LIP6 – UPMC Paris, France
Caroline Chopinaud, LIP6 – UPMC Paris, France
Carlos Lucena, PUC – RIO RJ, Brazil
Multiagent systems
- Heterogeneous agents
- Autonomous agents

Use of norms
- Prevention of malicious actions
- Maintain trust between the agents
- Define desired or dreaded behaviors
  - Permission – Obligation – Prohibition

Normative multiagent systems
- Submitted to norms during the execution
- Decision by considering the norms
- Acceptation of the norms
- Violation of the norms and sanctions
Goal

Implementation guidelines to operationalize regulative norms in a normative multiagent system.
OutLine

• The DynaCROM methodology
  ◦ Contextual Norm Classification
  ◦ Contextual Norm Representation
  ◦ Contextual Norm Composition

• The SCAAR framework
  ◦ Self-controlled agents
  ◦ Automatic generation process

• The DynaCROM – SCAAR combination

• Conclusion
THE DYNACROM METHODOLOGY
Specificites of DynaCROM

- An information mechanism
  - Provides the agents with *contextual norms*

- A methodology for norm management
  - Design – Implementation - Integration

- Related work
  - OMNI (Organization Model For Normative Institutions) [Vasquez-Salceda et al., MST’04]
  - Electronic Agent-Based Institutions [Esteva, AAMAS’02]
Contextual norm classification

- **Multiagent System composition**
  - Environments
  - Organizations
  - Agents playing Roles
  - Agents Interacting

- **Norm informations contexts in DynaCROM**
  - Set of basic concepts with top-down architecture
    - Environment
    - Organization
    - Role
    - Action
  - Addition of domain-dependent contexts
    - To represent application specific norms
Contextual norm representation

Contextual Normative Ontology
Contextual norm composition

- Dynamic composition during the execution
  - Ontology-driven rule written by the system developers
  - Instanciation of the ontology
  - Information of the agents about contextual norms
THE SCAAR FRAMEWORK
Prevention of undesirable behaviors

Control Mechanism
Monitoring / Detection / Regulation

MONITORING
Error
Interaction
REGULATION
Autonomy

Il is prohibited
Il is obliged...
It is prohibited...

...
The generation of self-controlled agents

Control description
- It is prohibited
- It is obliged
- ...

Language for norms

Automatic Generation

Petri nets

Application description

Set of Concepts

Dynamic norms verification

CONTROL PART
- Monitoring
- Violation Detection

Self-Controlled agent

BEHAVIOR PART
- Strategies of regulation

Introspective architecture

Weaving
Petri net generation

Norm

Correspondence between
The language and the
Dynamic Deontic Logic [Meyer89]

Logic expression

Translation DDL in Petri net

{Petri nets}

Merging rules

PETRI NET
# The language for norms

<table>
<thead>
<tr>
<th>The language for norms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Law</strong> ::= {<strong>Agents</strong>} <strong>Deon</strong></td>
</tr>
<tr>
<td><strong>Agents</strong> ::= agt_id: <strong>Agent</strong> [suchThat <strong>Prop</strong>]</td>
</tr>
<tr>
<td><strong>Deon</strong> ::= <strong>FORBIDDEN Exp</strong> [<strong>BEFORE Deadline</strong>]</td>
</tr>
<tr>
<td><strong>Deadline</strong> ::= <strong>Exp</strong></td>
</tr>
<tr>
<td><strong>Context</strong> ::= <strong>Deon</strong> <strong>AFTER COMPACT</strong> [+sec]</td>
</tr>
<tr>
<td><strong>Exp</strong> ::= <strong>State</strong></td>
</tr>
<tr>
<td><strong>COMPACT</strong> ::= <strong>Action</strong></td>
</tr>
<tr>
<td><strong>State</strong> ::= agt_id be <strong>SMST</strong> [suchThat <strong>Prop</strong>]</td>
</tr>
<tr>
<td><strong>Action</strong> ::= agt_id do <strong>SMTH</strong> [suchThat <strong>Prop</strong>]</td>
</tr>
<tr>
<td><strong>Agent</strong> ::= an <strong>AGENT</strong> sub-concept</td>
</tr>
<tr>
<td><strong>SMTH</strong> ::= an <strong>ACTION</strong> sub-concept</td>
</tr>
<tr>
<td><strong>SMST</strong> ::= a <strong>FEATURE</strong> sub-concept</td>
</tr>
<tr>
<td><strong>PROP</strong> ::= properties on the concept attributes</td>
</tr>
</tbody>
</table>
**The language to Dynamic Deontic Logic**

<table>
<thead>
<tr>
<th>Correspondence between the language and the DDL Dynamic Deontic Logic [Meyer88]</th>
</tr>
</thead>
<tbody>
<tr>
<td>FORBIDDEN $\alpha$</td>
</tr>
<tr>
<td>FORBIDDEN $\alpha_1$ BEFORE $\alpha_2$</td>
</tr>
<tr>
<td>OBLIGED $\alpha_1$ BEFORE $\alpha_2$</td>
</tr>
<tr>
<td>$\phi$ AFTER $\gamma$</td>
</tr>
<tr>
<td>$\phi$ IF $\beta$</td>
</tr>
<tr>
<td>$\gamma$ THEN $\alpha$</td>
</tr>
<tr>
<td>$\gamma$ AND $\alpha$</td>
</tr>
<tr>
<td>$\phi + \text{sec}$</td>
</tr>
</tbody>
</table>
The basic Petri nets
The rules of merging

\[ [\alpha] \phi \]

\[ \phi_1 \lor \phi_2 \]

\[ \beta \lor \phi \]
An example of generation

- FORBIDDEN (ACT2) AFTER (ACT1) BEFORE (ACT3)
  - [ACT1](done(ACT3) ∨ F(ACT2))

```
ACT1
<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

ACT1
<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

ACT3
<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

done(ACT3)
<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

F(ACT2)
<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>

ACT2
<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
</table>
```
An example of generation

- FORBIDDEN (ACT2) AFTER (ACT1) BEFORE (ACT3)
  - \([\text{ACT1}](\text{done(ACT3)} \lor F(\text{ACT2}))\)
An example of generation

- FORBIDDEN (ACT2) AFTER (ACT1) BEFORE (ACT3)
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An example of generation

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  - \([\text{ACT1}] (\text{done}(\text{ACT3}) \lor F(\text{ACT2}))\)
An example of generation

- FORBIDDEN (ACT2) AFTER (ACT1) BEFORE (ACT3)
  - [ACT1](done(ACT3) \lor F(ACT2))
An example of violation detection

FORBIDDEN (ACT2) after (ACT3) before (ACT3).

Control part

AGENT

Behavior part

ClauseAction1(...) PC1(ACT1)
... ...
... PC2(ACT2) ClauseAction2(...)
ClauseAction3(...) PC3(ACT3)
FORBIDDEN (ACT2) after (ACT3) before (ACT3).
An example of violation detection

FORBIDDEN (ACT2) after (ACT3) before (ACT3).

Control part

Behavior part

ClauseAction1(…)
PC1(ACT1)

... ...

PC2(ACT2)
ClauseAction2(…)

ClauseAction3(…)
PC3(ACT3)
An example of violation detection

FORBIDDEN (ACT2) after (ACT3) before (ACT3).

Behavior part

ClauseAction1(…)
PC1(ACT1)
...
...
PC2(ACT2)
ClauseAction2(…)

ClauseAction3(…)
PC3(ACT3)

Control part

AGENT
An example of violation detection

FORBIDDEN (ACT2) after (ACT3) before (ACT3).

Behavior part

ClauseAction1(…)
PC1(ACT1)
...
...
...
PC2(ACT2)
ClauseAction2(…)

Control part

AGENT

ClauseAction3(…)
PC3(ACT3)
An example of violation detection

FORBIDDEN (ACT2) after (ACT3) before (ACT3).

Behavior part

- ClauseAction1(…)
- PC1(ACT1)
- ...
- ...
- PC2(ACT2)
- ClauseAction2(…)
- ClauseAction3(…)
- PC3(ACT3)

Control part
An example of violation detection

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...
...
PC2(ACT2)
ClauseAction2(…)

ClauseAction3(…)
PC3(ACT3)

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ACT2

ACT3

AGENT
An example of violation detection

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Behavior part

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PC1(ACT1)
...
...
...
PC2(ACT2)
ClauseAction2(…)

ClauseAction3(…)
PC3(ACT3)
An example of violation detection

FORBIDDEN (ACT2) after (ACT3) before (ACT3).

Control part

ACT1

ACT2

ACT3

Behavior part

ClauseAction1(…)
PC1(ACT1)

…

…

PC2(ACT2)
ClauseAction2(…)

ClauseAction3(…)
PC3(ACT3)

Information of violation

AGENT
DYNACROM AND SCAAR COMBINATION
Working together
An example (1) - Context

An American manufacturer wants to build a computer

<table>
<thead>
<tr>
<th>Description</th>
<th>Base price (USD)</th>
<th>Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pintel CPU</td>
<td>750</td>
<td>Pintel</td>
</tr>
<tr>
<td>IMD CPU</td>
<td>650</td>
<td>IMD</td>
</tr>
<tr>
<td>Pintel Motherboard</td>
<td>350</td>
<td>Macrostar</td>
</tr>
<tr>
<td>IMD Motherboard</td>
<td>300</td>
<td>Basus</td>
</tr>
<tr>
<td>Memory 2 GB</td>
<td>150</td>
<td>Macrostar</td>
</tr>
<tr>
<td>Memory 2 GB</td>
<td>100</td>
<td>Basus</td>
</tr>
<tr>
<td>Hard disk 500 GB</td>
<td>200</td>
<td>Macrostar</td>
</tr>
<tr>
<td>Hard disk 500 GB</td>
<td>150</td>
<td>Basus</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organization</th>
<th>Country</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pintel</td>
<td>USA</td>
<td>Missouri</td>
</tr>
<tr>
<td>IMD</td>
<td>USA</td>
<td>Virginia</td>
</tr>
<tr>
<td>Basus</td>
<td>Japan</td>
<td>Osaka</td>
</tr>
<tr>
<td>BasusUSA</td>
<td>USA</td>
<td>California</td>
</tr>
<tr>
<td>Macrostar</td>
<td>China</td>
<td>Shanghai</td>
</tr>
<tr>
<td>MacrostarJapan</td>
<td>Japan</td>
<td>Hiroshima</td>
</tr>
</tbody>
</table>
An example (2) – DynaCROM norms

AIDDSupplier

\[ \text{isPlayedIn} = \text{IMD} \]
\[ \text{hasNorm} = \text{ObligationToRequestADownPayment} \]

IMD

\[ \text{isIn} = \text{Virginia} \]

ObligationToRequestADownPayment

\[ \text{hasPercentageOfDownPayment} = 10 \]
\[ \text{regulate} = \text{AcceptAPlacedOrder} \]

Virginia

\[ \text{hasAStateCorporateIncomeTaxOf} = \delta \]
\[ \text{hasNorm} = \text{ObligationToImposeAStateCorporateIncomeTax} \]
\[ \text{belongsTo} = \text{USA} \]
\[ \text{hasHoliday} = \text{LeeJacksonKingDay} \]

AcceptAPlacedOrder

USA

\[ \text{hasCurrency} = \text{USD} \]
\[ \text{hasNorm} = \text{ObligationToPayWithNationalCurrency} \]
\[ \text{hasHoliday} = \text{AmericanIndependenceDay} \]
\[ \text{AmericanLaborDay} \]
An example (3) – SCAAR norms

1. SCAARNorm1 - [(agt: aGenericAgent)
2. OBLIGED(agt DO PayWithNationalCurrency)
3. WITH environment.hasCurrency = agtInformedCurrency)
   (USA).hasCurrency = USD
   USD = USD
4. IF (agt BE in Environment WITH
5. ((environment = agtInformedEnvironment) OR
6. (environment.belongsTo = agtInformedEnvironment))]
   USA = USA

1. Rule1 - [ruleForEnvWithOEnvNorms:
2. hasNorm(?Env,?OEnvNorms)
   hasNorm(Virginia, ObligationToPayWithNationalCurrency)
3. <- hasNorm(?OEnv,?OEnvNorms),
   hasNorm(USA,ObligationToPayWithNationalCurrency)
4. belongsTo(?Env,?OEnv)]
   belongsTo(Virginia,USA)
Conclusion

- Decrease the complexity of norms management in MAS
  - Decoupling information in Contexts

- The DynaCROM solution
  - Application of contextual norms
  - Management regulation in MAS

- Main Contributions
  - Top-down classification for contextual norms
  - Contextual normative ontology
  - Norm composition process

- Enforcement mechanism
  - Currently, the SCAAR framework
  - DynaCROM is not tightly coupled with a particular enforcement mechanism
Questions?

THANKS FOR YOUR ATTENTION