Multiagent Systems (SMA-UPC)

4. Multiagent Systems Design
Part 5:
Coordination models:
Social Models

Electronic Institutions

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Multiagent Systems (SMA-UPC)

Introduction to Electronic Institutions

- **Institutions as Social Structures**
- **e-Institutions**
- **Approaches in Literature**

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Introduction

- Open multi-agent systems (MAS) have to cope with several issues
  - Heterogeneity among members
  - Comunication
  - Participants' trust

  }
  - *Coordination*
  - *Cooperation*

  - Agent **Autonomy** VS **Control**

- Idea: multi-agent design can benefit from social abstractions
  - Study the problem from the societal and the individual points of view.

Introduction
Institutions as Social Structures

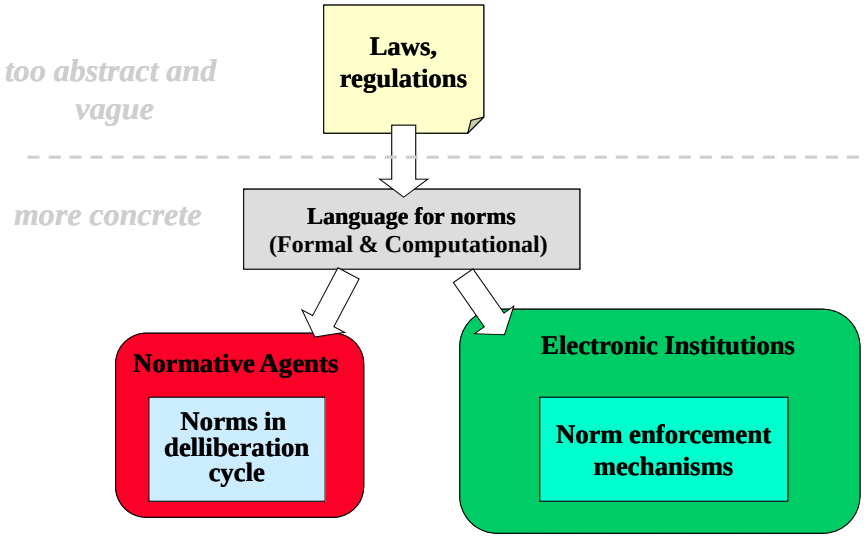
- Social Structures define a social level to enhance coordination by means of *interaction patterns*
- Institutions are a kind of social structure where a corpora of constraints shape the behaviour of the members of a group
- The definition of a (human) Institution uses to include
  - Regulations about the interactions
  - Conventions: 'institutional facts' vs 'brute facts'
    - e.g. 1 : *'murder'* (vs killing)
    - e.g. 2 : *'incest'* (vs sexual act)
    - e.g. 3 : *'ownership'* (vs physical possession)
    - e.g. 4 : *'marriage'* (vs living together)
  - Procedures and protocols for creating and determining institutional facts

Introduction
e-Institutions

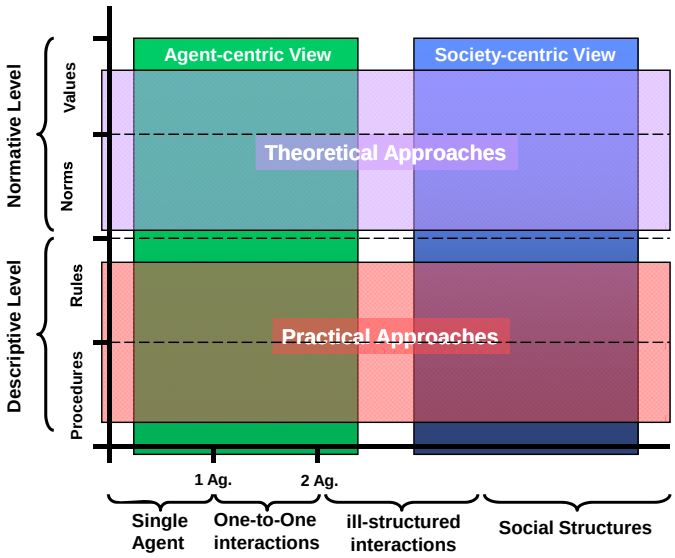
- An e-Institution is the computational model of an institution through
  - The specification of the institution's *norms* in (some) suitable formalism(s).
  - The specification of the institution's procedures and protocols
- In the context of MAS they:
  - reduce uncertainty of other agents' behaviour
  - reduce misunderstanding in interaction
  - allows agents to foresee the outcome of an interaction
  - simplify the decision-making (reduce the possible actions)

- Agent **behaviour guided by Norms**

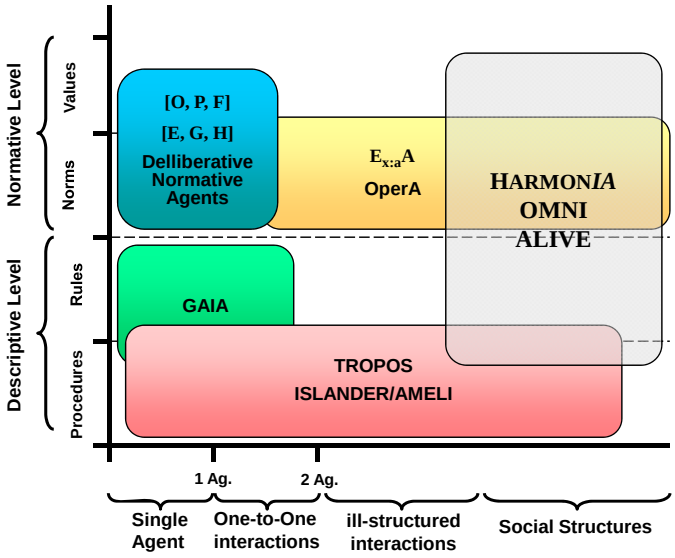
Introduction
Why a Language for Norms?



State of the Art (I)



State of the Art (II)



Norms from the Agent perspective

- **Influence of norms in Agent behaviour**
- **Possible World semantics**
- **Norms in the agent interpreter**

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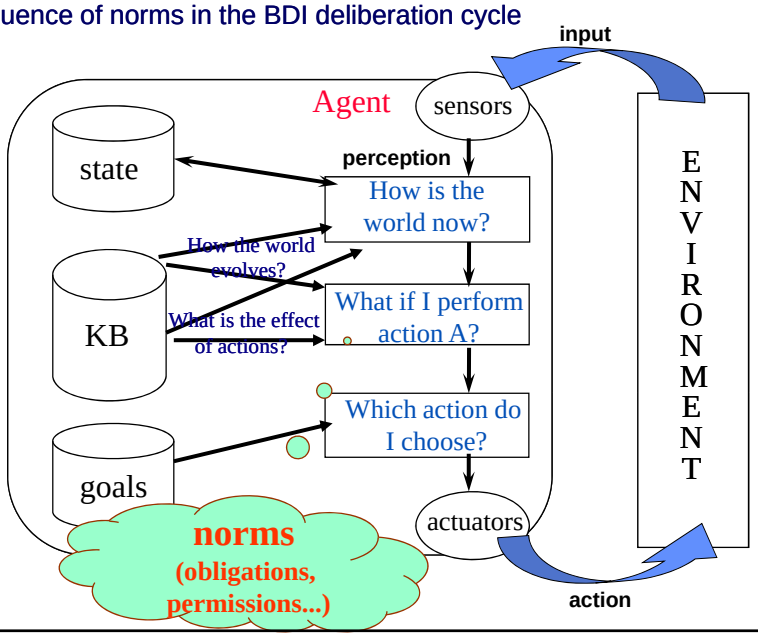
Norms and Agents (I)

Influence of norms in the BDI deliberation cycle



Norms and Agents (II)

- How do norms influence the behaviour of the agent?
  - Agent has no knowledge about norms
  - Norms are built-into the agent's code
  - Norms are built-into the plans and protocols the agent uses
  - Norms are explicit elements in the agent's reasoning
    - Agent may or may not adopt the norms
    - Agent may or may not follow the norms
      - agent follows the norm whenever possible
      - agent violates the norm sometimes
      - agent violates the norm always if possible

Norms and Agents (III)

- Problems:
  - Norms are more abstract than the procedures
  - Norms do not have operational semantics

Example:

Regulation: "It is forbidden to discriminate potential recipients of an organ based on their age (race, religion,...)"

Formal norm: F(discriminate(x,y,age))

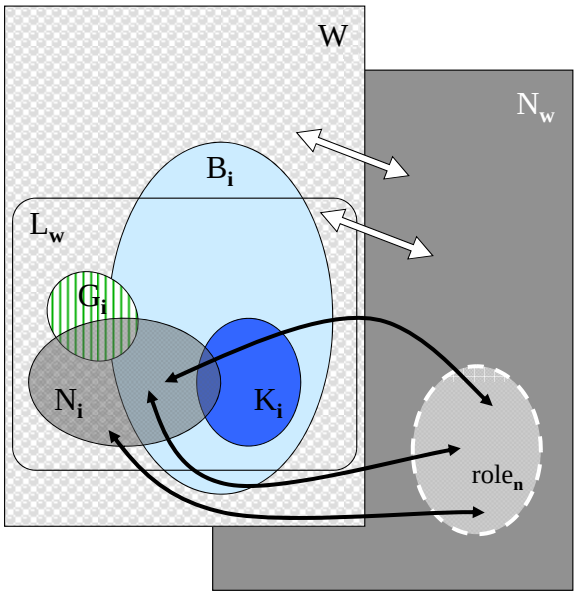
Procedure: does not contain action "discriminate"

Norms and Agents (IV)

- Most of the approaches talk about norms, but a close-up look shows that they are working at completely different levels of abstraction
- Idea: there are several levels of abstraction involved in a normative system

Norms and Agents (V)

Possible Worlds Semantics



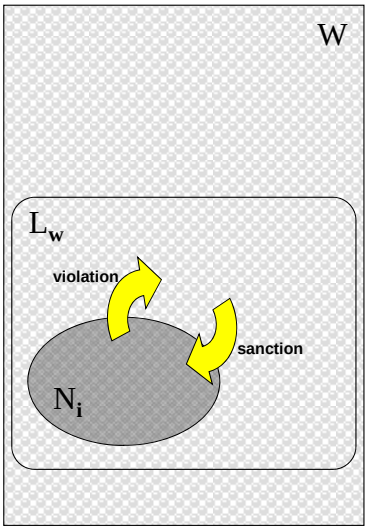
Norms and Agents (V)

Legally accesible worlds

- The concept of legally accessible worlds allows to describe
  - wanted (legal) and unwanted (illegal) behaviour
  - acceptable (safe) and unacceptable (unsafe) states
- *Violations* when agents breaks one or more norms, entering in an illegal (unsafe) state.
- *Sanctions* are actions to make agents become legal (safe) again.
- Sanctions may include the actions to recover the system from a violation

Safety

Soundness



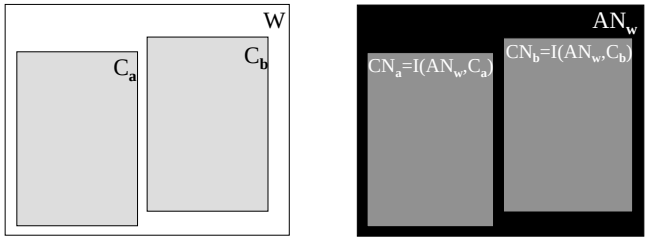
Norms and Agents (VI)

- Problem: in this model interpretation of norms is completely done by the agents.
  - How to ensure that two agents that play the same role have similar sound interpretations of the norms that apply to them?
- Solution: to fix part of the interpretation in a given context.

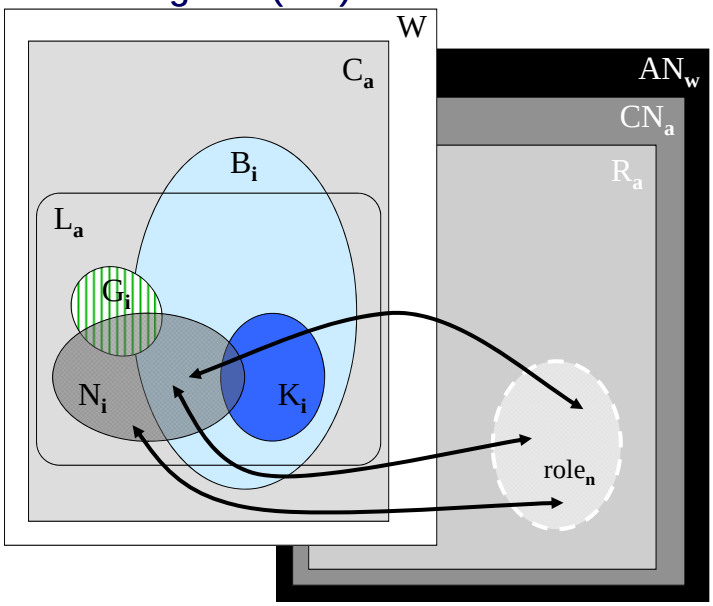
- Idea: Agents do not have a relation with the WHOLE world but a part → context of an agent.

Norms and Agents (VII)

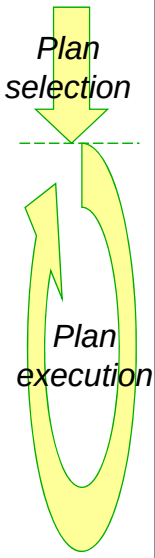
- A Context is a set of worlds with a shared vocabulary and a normative framework
- Effects on the Normative Dimension
  - The generic norms applied to the world as a whole are called Abstract Norms.
  - Concrete Norms are interpretations of the abstract norms in a given context



Norms and Agents (VIII)



Norms and Agents (IX)




```
Agent Control Loop Version 7
1.
2.   B := B0;
3.   I := I0;
4.   while true do
5.        get next percept ρ;
6.        B := brf(B, ρ);
7.        D := options(B, I);
8.        I := filter(B, D, I);
9.        π := plan(B, I);
10.       while not (empty(π)
                  or succeeded(I, B)
                  or impossible(I, B)) do
11.            α := hd(π);
12.            execute(α);
13.            π := tail(π);
14.            get next percept ρ;
15.            B := brf(B, ρ);
16.            if reconsider(I, B) then
17.                 D := options(B, I);
18.                 I := filter(B, D, I);
19.            end-if
20.            if not sound(π, I, B) then
21.                 π := plan(B, I)
22.            end-if
23.       end-while
24.  end-while
```

Norm obligations add actions to the set of options and may define some priorities or precedence

Norm prohibitions delete actions from the set of options

Norms from the Institutional perspective

- **SMART normative model**
- **AMELI/ISLANDER**
- **HARMON*IA***
- **OMNI**

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SMART Normative Systems model

Fabiola Lopez y Lopez, Mike Luck and M. d'Inverno.

- It is based in the SMART agent specification framework presented by d'Inverno and Luck [8].
  - The framework defines concepts such as
    - *objects*,
    - *agents* (which are objects with goals)
    - *autonomous agents* (which are agents with motivations).
  - This framework is developed in the Z specification language [9].
- The SMART framework has been extended [2][7] to introduce, as part of the framework, representations of
  - *norms*
  - *normative agent*
  - *Normative MAS*
- The authors have also presented an architecture for autonomous social and normative agents in order to reason about norms.

SMART Normative Systems model

Normative MAS

NormativeMAS

$$
\begin{array}{l}
AgentWorld \\
nmasname : NMASName \\
members : \mathbb{P}\, AgentName \\
generalnorms : \mathbb{P}\, Norm \\
enforcenorms : \mathbb{P}\, Norm \\
rewardnorms : \mathbb{P}\, Norm \\
legislationnorms : \mathbb{P}\, Norm \\
environment : EnvState \\
\hline
members \subset idagents \\
\forall\, ag : members \bullet (normativeAg\ ag).norms \cap generalnorms \neq \varnothing \\
\forall\, sn : generalnorms \bullet sn.addressees \subseteq members \\
\forall\, en : enforcenorms \bullet (\exists\, n : generalnorms \bullet enforces\ (en, n)) \\
\forall\, rn : rewardnorms \bullet (\exists\, n : generalnorms \bullet rewardnorm\ (rn, n)) \\
\forall\, ln : legislationnorms \bullet legislate\ (ln, environment)
\end{array}
$$

SMART Normative Systems model

Norm definition

Norm

$normativegoals : \mathbb{P}\, Goal$
$addressees : \mathbb{P}\, AgentName$
$beneficiaries : \mathbb{P}\, AgentName$
$context : EnvState$
$exceptions : EnvState$
$rewards : \mathbb{P}\, Goal$
$punishments : \mathbb{P}\, Goal$

$normativegoals \neq \emptyset$
$addressees \neq \emptyset$
$context \neq \emptyset$
$context \cap exceptions = \emptyset$
$rewards \cap punishments = \emptyset$

SMART Normative Systems model

Norm adressees, legislators, defenders and promoters

- Norms are related not only with the agents that should fulfil it or enforce it, but also with agents such as the one that issued the norm, the one(s) responsible of its enforcement (the *defenders*, the one that modified it or the one(s) that may be affected by a non-compliance of the norm.

AuthoritiesNMAS

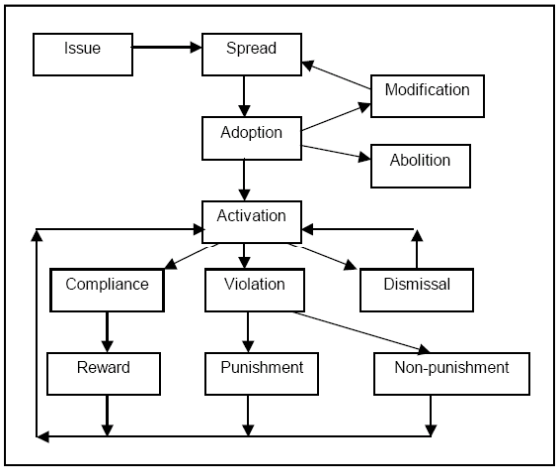
$NormativeMAS$
$legislators : \mathbb{P}\, AgentName$
$defenders : \mathbb{P}\, AgentName$
$promoters : \mathbb{P}\, AgentName$

$\forall lg : legislators \bullet (\exists lnorm : legislationnorms \bullet lg \in lnorm.addressees)$
$\forall df : defenders \bullet (\exists enorm : enforcenorms \bullet df \in enorm.addressees)$
$\forall pm : promoters \bullet (\exists rnorm : rewardnorms \bullet pm \in rnorm.addressees)$

SMART Normative Systems model

Norm Lifecycle

- Norms are not modelled as static constraints but as objects that can have several states (such as *issued*, *active*, *modified*, *fulfilled* or *violated*),



SMART Normative Systems model

Norm Lifecycle

NMASState

$NormativeMAS$

$allinstances : \mathbb{P}\, NormInstance$

$activenorms : \mathbb{P}\, NormInstance$

$fulfillednorms : \mathbb{P}\, NormInstance$

$unfulfillednorms : \mathbb{P}\, NormInstance$

$rewardednorms : \mathbb{P}\, NormInstance$

$punishednorms : \mathbb{P}\, NormInstance$

$\forall in : allinstances \bullet (\exists n : generalnorms \bullet isnorminstance\ (in, n))$

$\forall na : activenorms \bullet activenorm\ (na, environment)$

$\forall fn : fulfillednorms \bullet fulfilled\ (fn, environment)$

$\forall ufn : unfulfillednorms \bullet (\neg\, fulfilled\ (ufn, environment))$

$\forall rn : rewardednorms \bullet (\exists rgn : rewardnorms \bullet$
$(rewardnorm\ (rgn, rn) \wedge fulfilled\ (rgn, environment)))$

$\forall pn : punishednorms \bullet (\exists egn : enforcenorms \bullet$
$(enforces\ (egn, pn) \wedge fulfilled\ (egn, environment)))$

SMART Normative Systems model

Norms and the concept of Power

- They also have analysed in [7] the different power relations that may arise in an agent society,
  - *institutional power*: social structures define norms that entitle agents to direct the behaviour of others (*institutional power*)
  - *personal power*: the power of an agent given by its capabilities to satisfy goals and the power of other agents to benefit or to hinder those goals.
- However,
  - no implementation of the architecture applying it to a real problem has been reported in literature,
  - there are no tools to support the development of a normative multi-agent system following their framework.

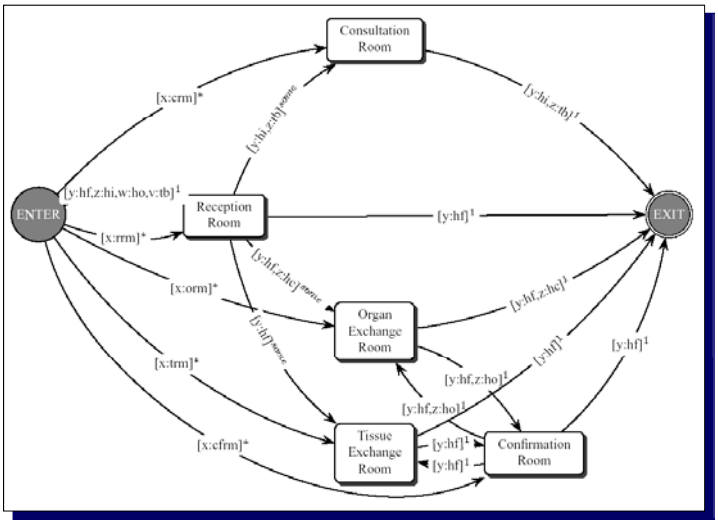
AMELI

M. Esteve, J.A. Rodriguez-Aguilar and P. Noriega

- AMELI [3] is an institution middleware that is based in an electronic institution specification (ISLANDER).
- The ISLANDER framework [4] [3] is composed of:
  - A Dialogical Framework
    - Linguistic and social structure (roles) to give meaning to agent interactions,
  - A Performative Structure
    - scenes and relationships between scenes (navigation, precedence, causality)
  - Rules
    - Role-dependent conventions to establish social commitments
- Two hypotheses:
  - All agent actions are messages, observable by the e-institution
  - An Agent should never break the norms.

AMELI

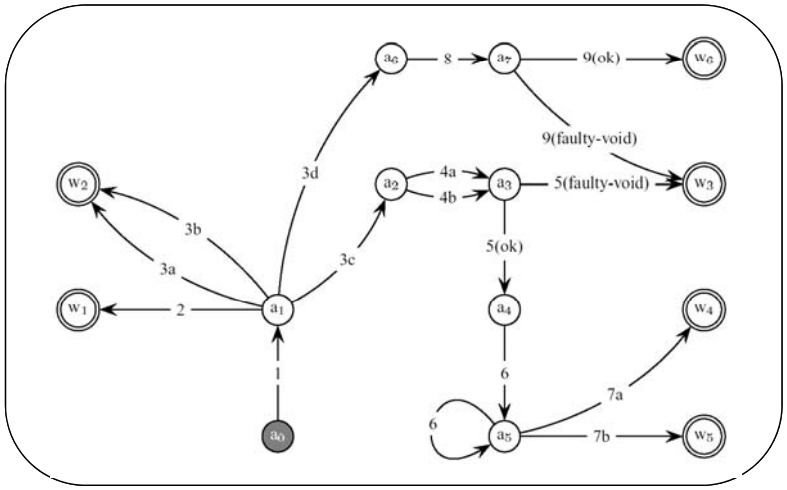
ISLANDER: Performative Structure (I)



AMELI

ISLANDER: Performative structure (II)

- Scene conversational graphs: *Reception Room*



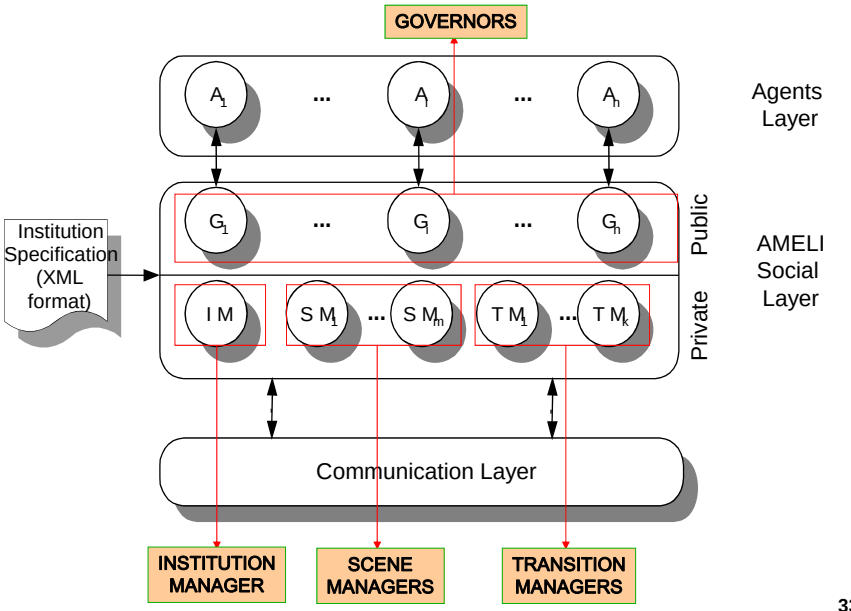
AMELI
Role of the AMELI middleware

- The AMELI middleware aims to:
  - Mediate and facilitate agent communication within conversations (scenes).
  - Coordinate and enforce:
    - to guarantee the correct evolution of each conversation (preventing errors made by the participating agents by filtering erroneous illocutions, thus protecting the institution).
    - To guarantee that agents' movements between scenes comply with the specification.
    - To control which obligations participating agents acquire and fulfil.
  - Manage information to facilitate participating agents the information they need to participate in the institution.

AMELI
Social Layer

- The current implementation of the social layer is composed of four types of agents:
  - An *institution manager* that starts the institution, authorises agents to enter, and controls the creation of scenes.
  - *Scene managers* responsible for governing scenes.
  - *Transition managers* control agents' movements between scenes.
  - *Governors* devoted to mediate the interaction of an agent with the rest of agents within the institution and to control agents' obligations.
    - Facilitates to the agent some information about the state of the institution.
    - Coordinates with other agents of the social layer for the correct execution of the institution.
    - Keeps track whether the agent pending acquires new obligations and fulfils some of its pending obligations.

AMELI



AMELI

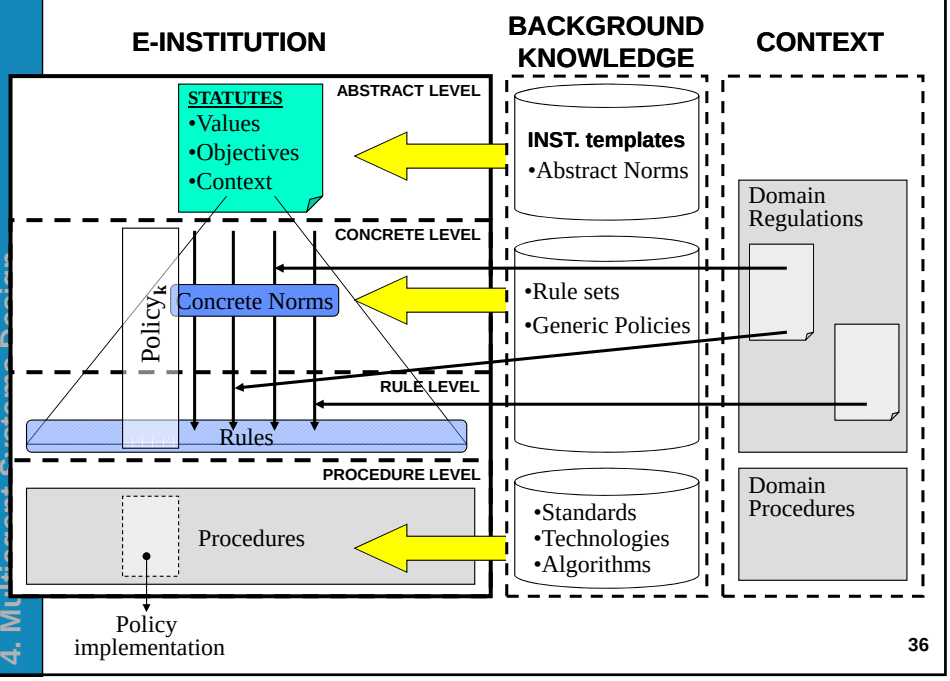
Limitations

- AMELI comes with a toolkit to help create institutional specifications, create the associated governors and create an e-Institution instance from an ISLANDER specification.
- But:
  - Weak notion of norms (norms only as restrictions, not as preference shapers).
  - Norms are never to be broken → no autonomy
  - Norms are only defined at the action-interaction level → too low-level
  - The only actions that can be controlled are messages
  - Message interactions are defined step by step → no flexibility.
  - Norm handling is done by the Governors, not the agents → agents cannot reason about the norms
  - No mechanism designed for the agents to introduce the norms in their reasoning → designer tends to hard-code them.

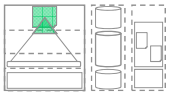
HARMONIA

J. Vázquez-Salceda

- Approaches in literature were too theoretical (e.g. SMART) or too practical (e.g. AMELI)
  - There was a gap between the specification of abstract norms and the concrete implementation inside e-Organizations
- **HARMONIA** [1] is a multi-level framework that proposes a formal connection between the different abstraction levels of a Normative System
  - It distinguishes between normative and practical levels
  - Analysis of Context in Normative Systems
    - *context and norms, nested contexts, super-contexts' influence*
  - Establishes connection between formal specification and agent implementation
    - top-down: design guidance
    - bottom-up: track the origins of a protocol/plan
  - Norm enforcement as detecting illegal worlds



HARMONIA
Abstract Level



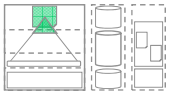
- The statutes define the
  - Values
  - Objectives
  - Context

  of the organization.

E.g.: Organización Nacional de Trasplantes:

> The main objective of ONT is to increase the number of organ donations and the subsequent increase in available organs for transplants.
> The ONT operates according to the regulation of the national health system and it strives to distribute the donated organs in the most a appropriate and correct way according to the current technical knowledge and according to the ethical principles of equality.

HARMONIA
Abstract Level: Abstract Norms (I)



- Values are beliefs that we have about what is important and thus about how things should be.
  - *"Appropriate distribution"*
  - *"Distribution according to ethical principles of equality"*
  - *"Fairness of transaction"*
  - *"Respect privacy of persons"*
- Values can be considered as the most abstract level on which norms are expressed.
- The values of an organization can be defined by the set of Abstract Norms specified within the org. that contributes to that value

$$D(\text{equity}) =:= \{F_{ONT}(\text{discriminate}(x,y,age)),\ O_{ONT}(\text{find\_best\_recipient}(organ)),\ \ldots\}$$
$$D(\text{appropriate}(\text{distribution}) =:= O_{ONT}(\text{appropriate}(\text{distribution}))$$

HARMONIA
Abstract Level: Abstract Norms (II)

- Problem: These norms are too abstract, as they use concepts that are not fully described in the organization's ontology.
  - *"It is forbidden to **discriminate** based on age"*

$$F_{ONT}\,(\text{discriminate}(x,y,age)),$$

- Norms can be abstract in the following ways:
  - They refer to an abstract action
  - They use terms that are vague
  - They abstract from temporal aspects
  - They abstract from agents and or roles
  - They refer to actions or situations that are not (directly) controllable and/or verifiable by the organization

HARMONIA
Abstract Level: Abstract Norms (III)

- example 1: Abstract actions

*"a living donor should **consent** to the donation of an organ"*

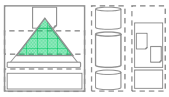
$$\left.\begin{array}{l}\text{sign(donor,contract)} \cup \text{carry(donor,will)} \cup \\ \text{tell(donor,family)}\end{array}\right\} \Rightarrow_{ONT} \text{Consent(donor)}$$

- example 2: Vague terms

*"the ONT is obliged to ensure that the distribution of organs and tissues is **appropriate**"*

$$\left.\begin{array}{l}O_{ONT}(\text{ensure\_quality(organ)}) \wedge \\ O_{ONT}(\text{ensure\_compatibility(organ, recipient)})\end{array}\right\} \Rightarrow_{ONT} O_{ONT}(\text{appropriate(distribution)})$$

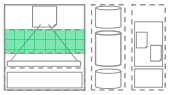
HARMONIA
Abstract/Concrete Level:Representing Norms



- Formal representation of norms needed
- Which logic?
  - Abstract and Concrete Norms permit, oblige or prohibit
  - Concrete Norms may be conditional
  - Concrete Norms may have temporal aspects
  - Concrete Norms are relativized to roles

⇨ variant of Deontic Logic

HARMONIA
Concrete Level: Concrete Norms

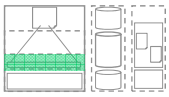


- Concrete norms are the result of translating the abstract norms in the context of the organization into norms that make use of terms and actions that are defined in the organization's ontology.

$$O_{hosp}(consent(donor(p,x)) < done(transplant(hosp,x,p,q)))$$

- Problem: HOW is a concrete norm like this implemented in an e-Organization?

HARMONIA
Rule Level (I)

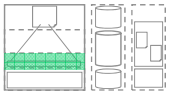


- Translation from Normative dimension to a Descriptive one
  - Idea: reduction from Deontic Logic to Dynamic Logic [J.-J. Meyer]

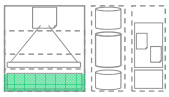
$$O_{hosp}(consent(donor(p,x)) < do(transplant(hosp,x,p,q)))$$
$$\downarrow$$
$$[transplant(hosp,x,p,q))]done(consent(donor))$$

$$O_{buyer}(pay(goods,seller,price) < do(exit(buyer)))$$
$$\downarrow$$
$$not(done(pay(goods,seller,price))) \rightarrow [exit(buyer)]V(fine(buyer))$$

HARMONIA
Rule Level (II)



- Rules, Violations and Sanctions
  - Violation rules define violations
  - A violation is composed by
    - pre-conditions
    - sanction
    - side effects
  - Pre-conditions are used by Police Agents to detect violations.
  - Sanctions are used by Flexible Normative Agents to reason about the utility of breaking the related rule.
  - Side effects are used by internal agents to recover the system from the violation.



HARMONIA
Procedure Level

- Idea: the final implementation of the system
- Formally, translation from Dynamic Logic to a Procedural Language:

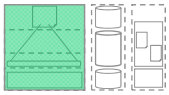
$$\{P\}\ a\ \{Q\} \equiv P \rightarrow [a]Q$$

- Example:

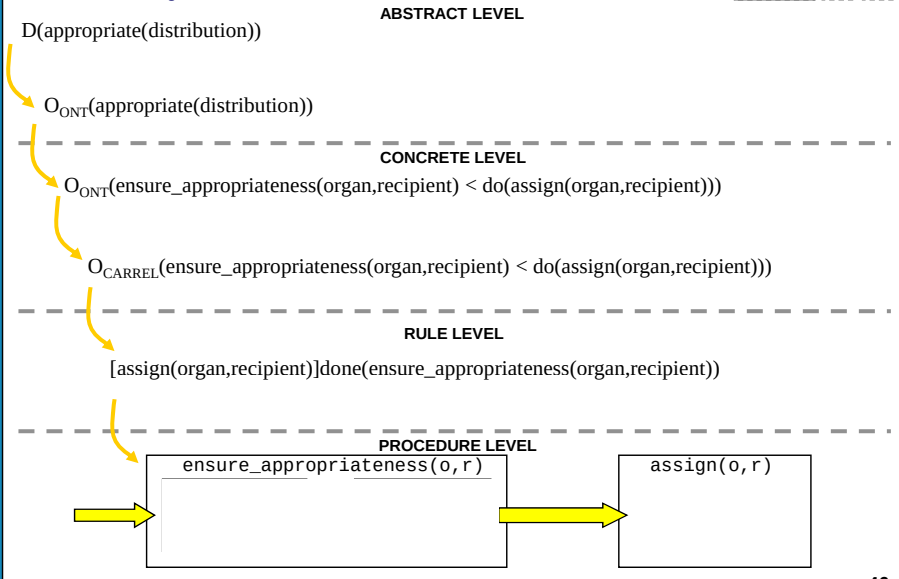
(not(done(assign(o, r))) ∧ done(ensure_appropriateness(o,r)))
→ [assign(o,r)] done(assign(o, r)

↓

{*not(done(assign(o, r))) & done(ensure_appropriateness(o,r))*}
`assign(o,r)`
{*done(assign(o, r))*}

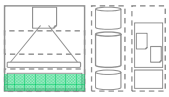


HARMONIA
Connecting with the Procedure Level



HARMONIA

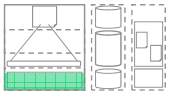
Procedure Level: Implementing Norms in eInstitutions (I)



- Implementation of norms from institutional perspective ≠ Implementing a theorem prover to check protocol compliance
- Implementation of a safe environment (***norm enforcement***)
- 2 options depending on control over agents
  - Defining constraints on unwanted behaviour
  - Defining violations and reacting to these violations
- our assumptions:
  - Norms can be sometimes violated by agents
  - The internal state of agents is neither observable nor controllable
    - actions cannot be imposed on an agent's intentions
    - agents as black boxes
    - only their observable behaviour and actions

HARMONIA

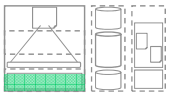
Procedure Level: Implementing Norms in eInstitutions (II)



- Norm enforcement is not centralized but distributed in a set of agents, the Police Agents
  - They check if a given (observable) action was legal or illegal given the violation conditions defined for that context.
- The Agent Platform should assist the Police Agents, providing fast, very efficient aids for norm enforcement as additional platform services and mechanisms.
- *A) Detection of the occurrence of an action*
  - Police Agents may become overloaded checking ALL actions
  - **black list mechanism** (of actions to monitor) *e.g., assign*
  - **action alarm mechanism** (alarm to the Police Agent)
  - The Police Agent checks if conditions for a violation apply.

HARMONIA

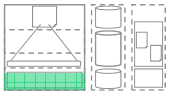
Procedure Level: Implementing Norms in eInstitutions (III)



- *B) Detection of activation/deactivation of norms*
  - activation = when condition C is true
  - deactivation = when P holds, A is done or C is false
  - reaction time: time allowed between norm activation and reaction
  - Depending on the complexity to check C, the platform should implement the appropriate **fast-access data structures** and/or **processing mechanisms** to reduce Police Agents´computation burden
- *C) Deadline control*
  - a **clock trigger mechanism** to detect that a deadline has passed

HARMONIA

Procedure Level: Example of Norm violation definition

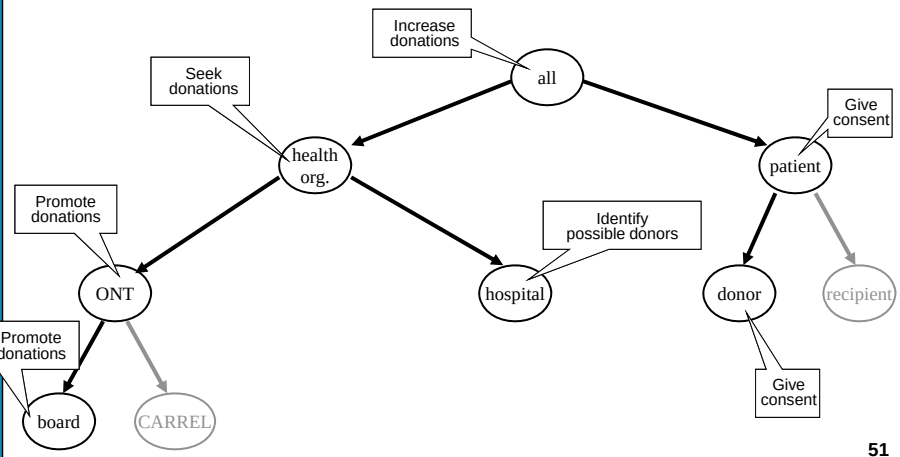


Norm condition	FORBIDDEN($allocator$ DO $assign(organ, recipient)$) IF NOT($hospital$ DONE $ensure\_quality(organ)$))
Violation condition	NOT($done(ensure\_quality(organ))$ AND $done(assign(organ, recipient))$
Detection mechanism	$\{detect\_alarm(assign,'starting');$ $check(done(ensure\_quality(organ)));\}$
Sanction	$inform(board,$"NOT($done(ensure\_quality(organ))$ AND $done(assign(organ, recipient))$")
Repairs	$\{stop\_assignation(organ);$ $record($"NOT($done(ensure\_quality(organ))$ AND $done(assign(organ, recipient))$", $incident\_log);$ $detect\_alarm(ensure\_quality,'done');$ $check(done(ensure\_quality(organ)));$ $resume\_assignation(organ);\}$

HARMONIA

All levels: Roles (I)

- Role definition guided by goal distribution
  - Origin: Objectives in Statutes
- Distribution of responsibilities



HARMONIA

All levels: Roles (I)

- Role definition guided by goal distribution
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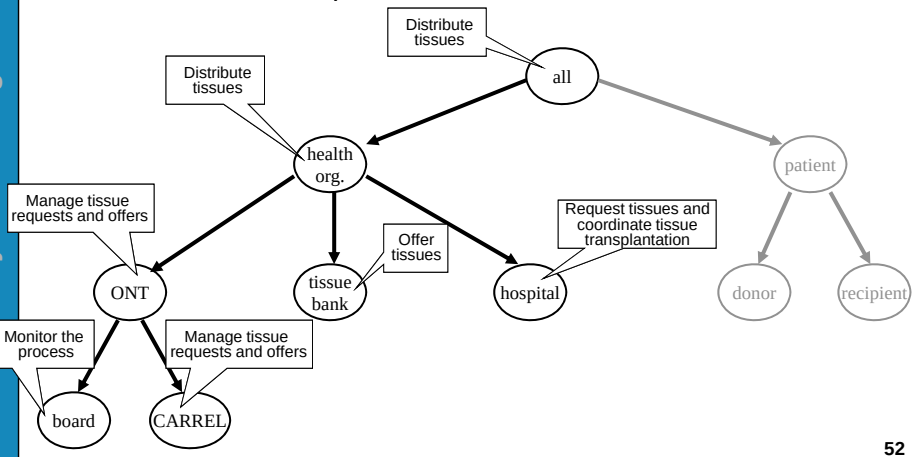
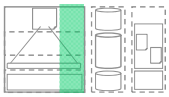
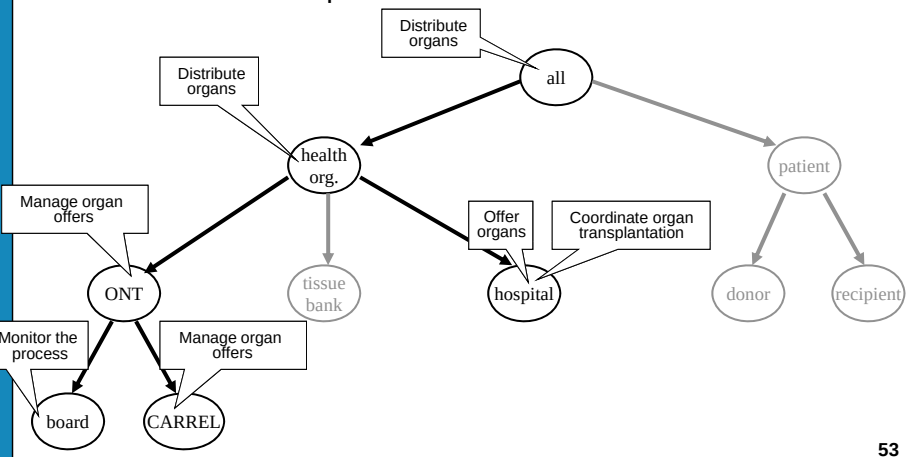


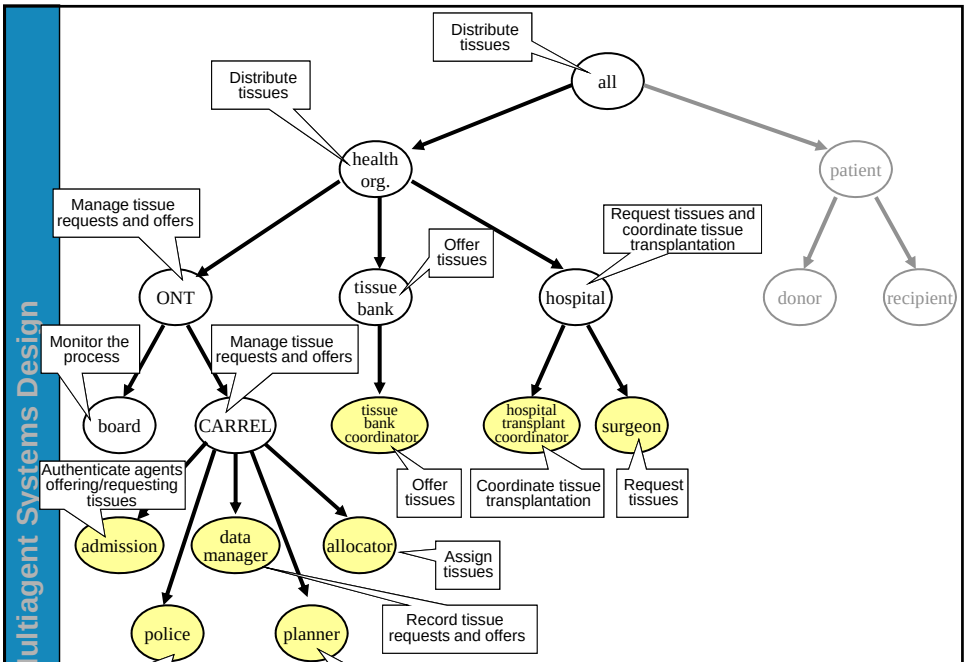
HARMONIA

All levels: Roles (I)



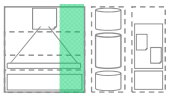
- Role definition guided by goal distribution
  - Origin: Objectives in Statutes
- Distribution of responsibilities



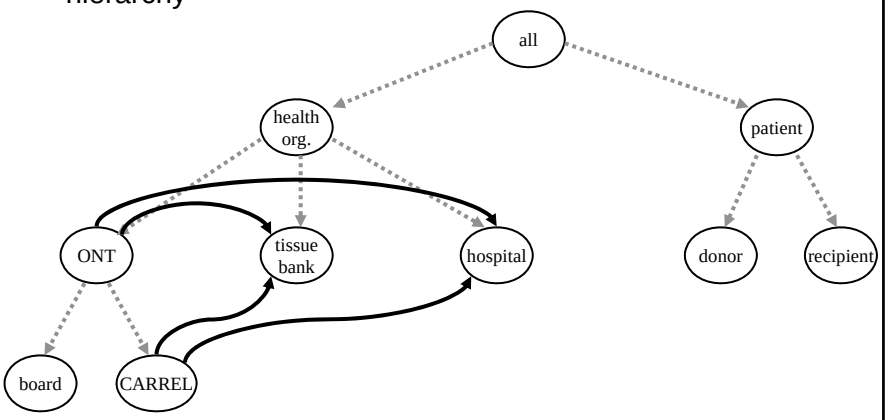


HARMONIA

All levels: Roles (II)

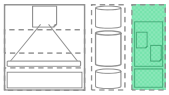


- Role hierarchy extended with power relations to model the distribution of responsibilities not defined in the hierarchy

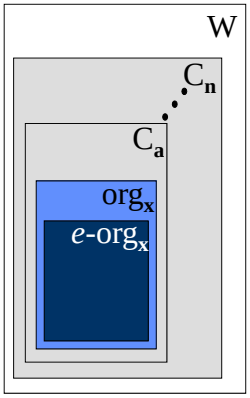


HARMONIA

All levels: Context (I)

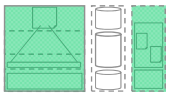


- Statutes make reference to a surrounding context
- Links with the idea of nested contexts
  - $e\text{-org}_X$ is a context defining a vocabulary and a normative system
  - there are super-contexts that have an influence in $e\text{-org}_X$ definition
- formal view: influence as interpretation in the subcontext
  - counts-as operator $\Rightarrow_S$ as a link between interpretations
- influence in several levels of abstraction
  - vocabulary (terms, predicates)
  - values, norms, rules and procedures



HARMONIA

All levels: Context (II)



ABSTRACT LEVEL

D(appropriate(distribution))

O_{ONT}(appropriate(distribution))

CONCRETE LEVEL

Spanish National Health System

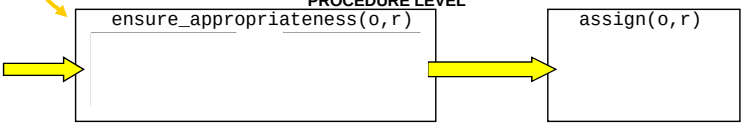
O_{ONT}(ensure_appropriateness(organ,recipient) < do(assign(organ,recipient)))

O_{CARREL}(ensure_appropriateness(organ,recipient) < do(assign(organ,recipient)))

RULE LEVEL

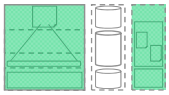
[assign(organ,recipient)]done(ensure_appropriateness(organ,recipient))

PROCEDURE LEVEL



HARMONIA

All levels: Context (II)



ABSTRACT LEVEL

D(appropriate(distribution))

O_{ONT}(appropriate(distribution))

CONCRETE LEVEL

Spanish National Health System

O_{ONT}(ensure_appropriateness(organ,recipient) < do(assign(organ,recipient)))

O_{CARREL}(ensure_quality(organ) < do(assign(organ,recipient)))

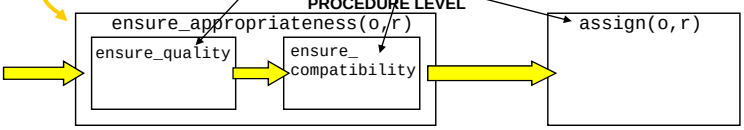
O_{CARREL}(ensure_compatibility(organ,recipient) < do(assign(organ,recipient)))

RULE LEVEL

[assign(organ,recipient)]done(ensure_quality(organ))

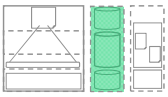
[assign(organ,recipient)]done(ensure_compatibility(organ,recipient))

PROCEDURE LEVEL

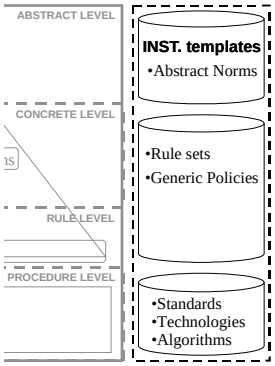


HARMONIA

All levels: Background Knowledge



- The Background Knowledge is a repository containing templates that can be adapted to create new e-organizations
  - At the abstract level, it provides a collection of abstract norms and the related ontology and abstract roles
  - At the concrete and rule levels, it provides templates for some generic policies
    - e.g., the security policy
      - concrete norms, rules and ontology
  - At the procedure level it provides a link with the standards, technologies and algorithms needed to implement the policies



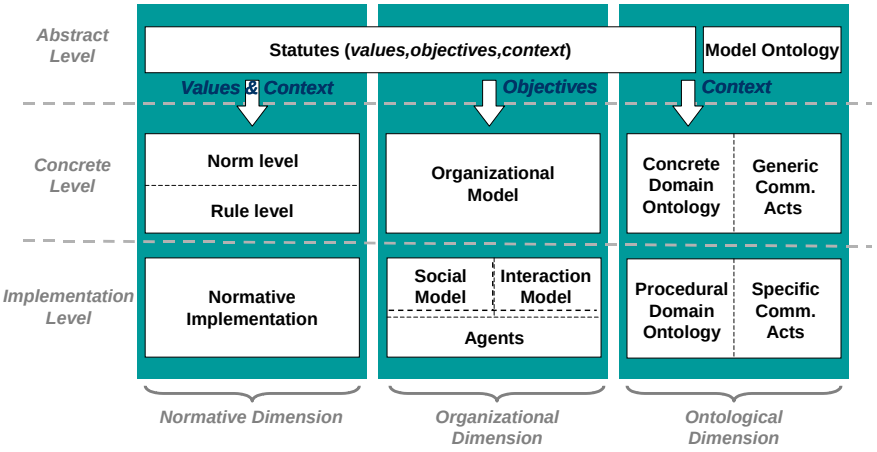
- Idea for future: Institutional templates to be *parameterized, adapted* or *implemented* to build e-Institutions.

OMNI

J. Vázquez-Salceda, V. Dignum and F. Dignum

- OMNI: Organizational Model for Normative Institutions [5]
  - Integration of HARMONIA's Normative concepts [1] with **OperA**'s Organizational concepts [6]
  - integrated framework for both
    - closed systems with fixed participants and interaction protocols,
    - open, flexible systems that allow and adapt to the participation of heterogeneous agents with different agendas.
- Layered Approach
  - Abstract Level: Requirement analysis
  - Concrete Level: Analysis and design process
  - Implementation Level: Design specification in a given multi-agent architecture
- Top-down
  - Methodological guidance for design
- Bottom-up
  - Trace of origin and motivation for rules and protocols

OMNI
Levels and dimensions



OMNI
Dimensions

- Normative Dimension
  - Norms and rules that guide agent behaviour
  - Includes a model of the environment regulations
  - Comes from HARMONIA
- Organizational Dimension
  - Captures the organizational structure and requirements
  - Comes from **OperA**, with norm language coming from HARMONIA
- Ontological Dimension
  - Content: concepts and relationships
  - Communication Language
  - Comes from **OperA**

OMNI
Abstract Level

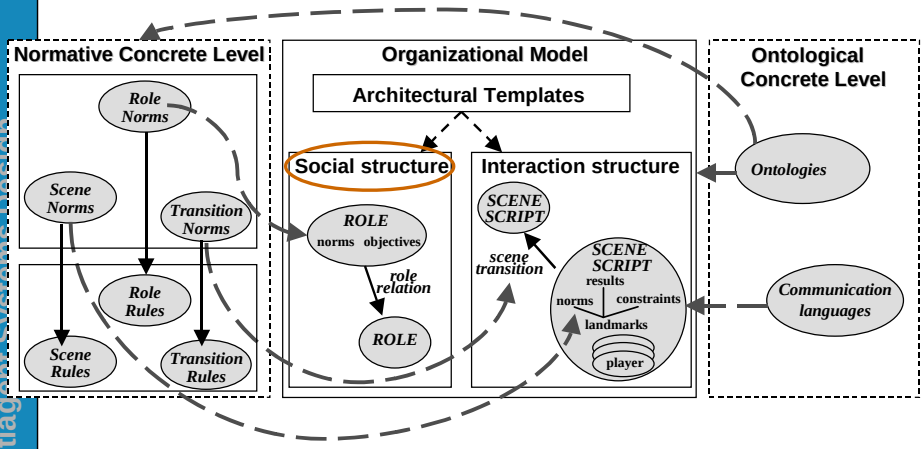
- Statutes
  - Main objective(s) of the organization,
    - Guides organizational design
    - Input for the Organizational Model
  - Values that direct the fulfilling of this objective
    - Guides normative design
    - Input for the Norm level
  - Context
    - Guides the ontological design
    - Influences also the normative design
- Generic Terms
  - In-contextual concepts
- Model Ontology
  - concepts of the framework itself
  - E.g. norm, rule, role, group, violation, landmark…

OMNI
Concrete Level

- Analysis and design process
  - Based on abstract values and objectives
- Refinement in three dimensions
  - Organizational Model
    - Social Structure
      - roles, groups, dependencies
    - Interaction Structure
      - scene scripts, connections, transitions
  - Normative Structure
    - role, scene and transition norms (deontic)
    - role, scene and transition rules (operational)
  - Communication Structure
    - Concrete ontological concepts, communicative acts, domain ontology

OMNI

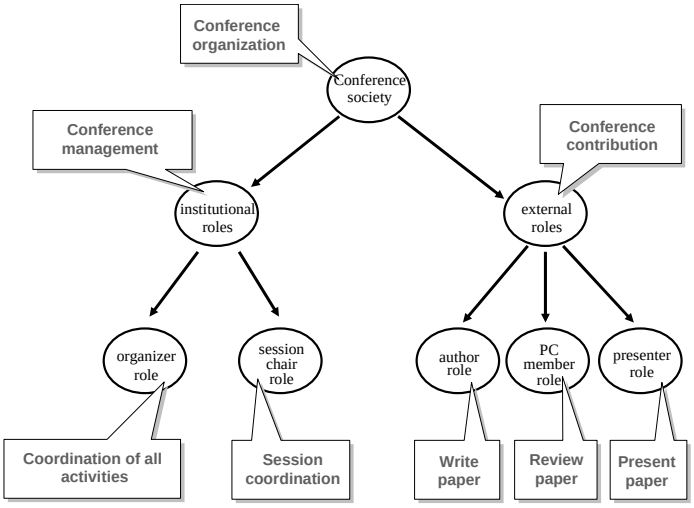
Concrete Level



OMNI

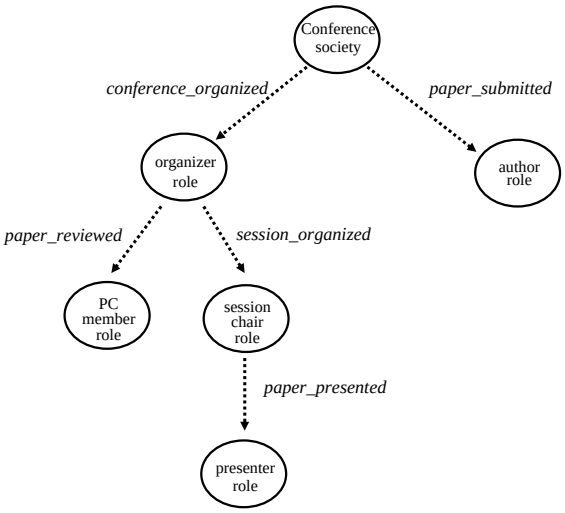
Concrete Level: Social Structure

- Role Model based in goal decomposition coming from objectives in statutes



OMNI

Concrete Level: Social Structure. Role dependencies



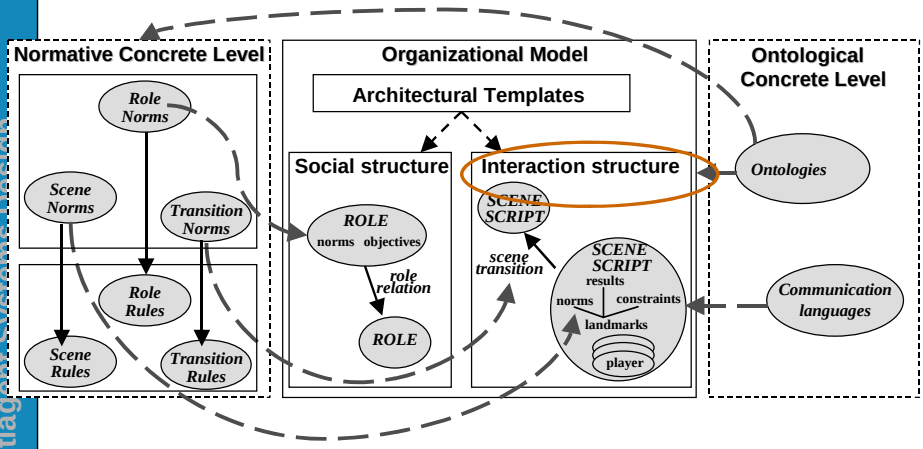
OMNI

Concrete Level: Social Structure. Role example

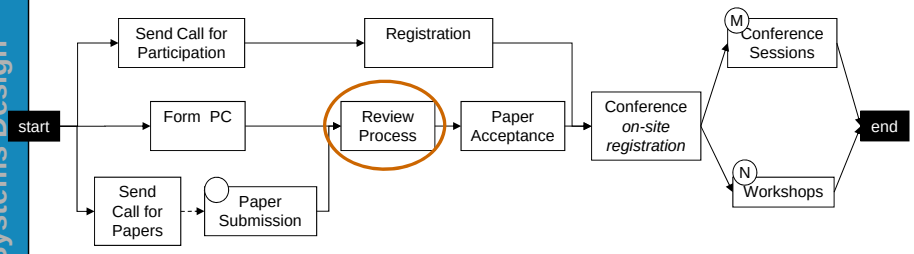
Role: PC Member	
Objectives	paper_reviewed(P, Rep)
Sub-objectives	{ read(P), report_written(P, Rep), review_received(Org, P, Rep) }
Rights	access-confman-program(*me*)
Norms	OBLIGED understand(English) IF DONE assigned (P, *me*, Deadline) THEN OBLIGED paper_reviewed(P, Rep) BEFORE Deadline IF DONE paper_assigned(P,*me*, _) AND direct_colleague(author(P)) THEN OBLIGED review_refused(P) BEFORE TOMORROW
Type	external

OperA *Role descriptions +* **HARMONIA** *norm language*

OMNI
Concrete level

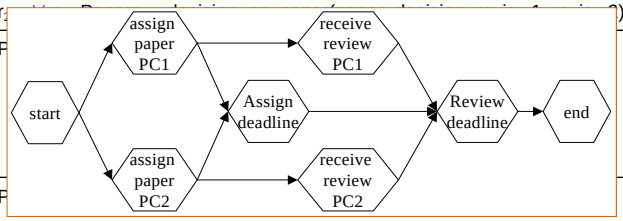


OMNI
Concrete Level: Interaction structure



OMNI

Concrete Level: Interaction Structure. Scene example

Interaction Scene: Review Process	
Roles	PC-Chair (1), PC-member (2..Max)
Results	$r_1 = \forall$ P $\in$Papers, reviews_done(P, review1, review2)
Interaction Patterns	
Norms	OBLIGED(PC, paper_reviewed(P, Rev) BEFORE DeadlineR) OBLIGED (O, decision_on_paper(P, D, Rev1, Rev2) BEFORE DeadlineD)

landmarks

OperA *Scene descriptions +* **HARMONIA** *norm language*

OMNI

Implementation Level

- Norm enforcement
  - *Protocols* and *Rules* : enable agents to comply with organizational norms
- Role enactment
  - *Social Contracts* : commitments regulating the enactment of roles by individual agents.
  - *Interaction Contracts* : specific interactions such as agreed upon by agents
- Ontologies
  - *Specific Communication Acts* : actual communication languages actually as fixed in interaction contracts.
  - *Specific Communicative Acts* : implement the content ontologies.

OMNI
Implementation Level: Social Model

- Role enacting agents (rea)
  - agents realizing expected behavior of role
- Social Contract
  - describes a specific agreement for a rea

social-contract(agent1, PC-member, {})
∀scene: PC-member ∈ roles(scene), rea(agent1, PC-member, scene)

social-contract(agent2, PC-member, {*maximum to review papers is 3*})
∀scene: PC-member ∈ roles(scene), rea(agent2, PC-member, scene)

OMNI
Implementation Level: Interaction Model

- Scene Instantiation
  - protocols realizing landmarks
- Interaction contract
  - describes a specific performance of a scene

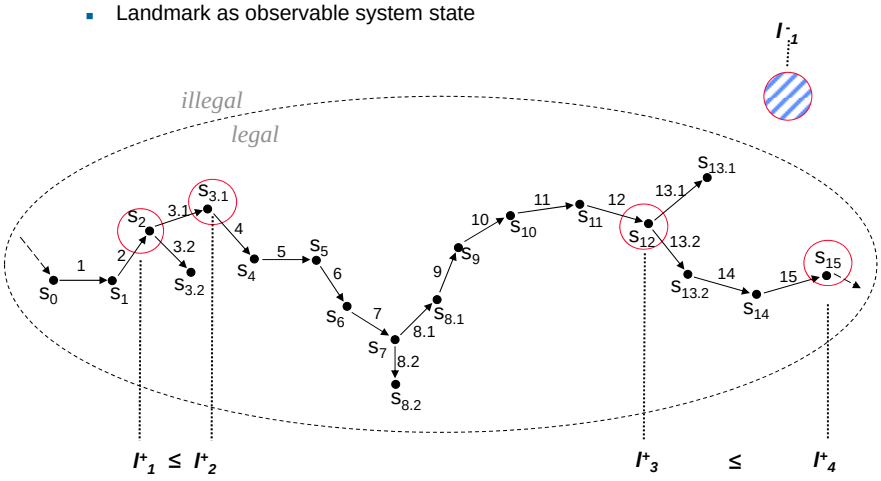
interaction-contract({PC-Chair, pc1, pc2, pc3, pc4}, review-process, {}, P1)

interaction-contract({ PC-Chair, pc3, pc5}, review-process,
{ IF NOT reviews-done BEFORE DeadlineR THEN
PERMITTED(PC-Chair, paper-accepted(P)}, P2)

OMNI

Implementation Level: Norm Enforcement

- Based in **HARMONIA**
- New idea: **OperA**'s Landmarks to monitor norm execution
  - Landmark as observable system state



References

[1] J. Vázquez Salceda. "The Role of Norms and Electronic Institutions in Multiagent Systems", Birkhauser-Verlag, 2004

[2] F. López y López. "Social Power and Norms: Impact on Agent Behaviour". PhD thesis, University of Southampton, 2003

[3] M. Esteva. "Electronic Institutions: from specification to development". PhD thesis, Institut d'Investigació en Intel.ligència Artificial (IIIA), 2003.

[4] J.A. Rodríguez-Aguilar. "On the Design and Construction of Agent-mediated Electronic Institutions". PhD thesis, Institut d'Investigació en Intel.ligència Artificial (IIIA), 2001.

[5] J. Vázquez-Salceda,V. Dignum, F. Dignum. "Organizing Multiagent Systems". Journal of Autonomous Agents and Multi-Agent Systems, vol. 11 issue 3, pp. 307-360, 2005.

[6] Virginia Dignum, "A Model for Organizational Interaction: Based on Agents, Founded in Logic". PhD dissertation, 2004

References

[7] F. López y López and M. Luck. "Empowered Situations of Autonomous Agents". In F.J. Garijo, J.C. Riquelme, and M. Toro, editors, IBERAMIA 2002, volume 2527 of LNAI, pages 585–595, Berlin Heidelberg, 2002. Springer Verlag.

[8] M. d'Inverno and M. Luck. "Understanding Agent Systems". Springer Verlag, 2001.

[9] J.M. Spivey. "The Z Notation: A Reference Manual". Prentice Hall, London, 1992.

These slides are based mainly in [1], [5], [2], [3], and some material from F. Dignum, M. Esteva and M. Sergot