Organization Oriented Programming: From Closed to Open Organizations

Olivier Boissier
ENS Mines Saint Etienne, France
MAS/G2I/EMSE
158 cours Fauriel, 42023 Saint-Etienne Cedex, France
Contact : Olivier.Boissier@emse.fr
Tel : 33 4 77 42 66 14
Fax : 33 4 77 42 66 66

Outline

1. Introduction
2. Organization Modeling Language
3. Organization Infrastructure
4. Organizational Deliberative Agent
5. Conclusion and Perspectives

Organization

- Organization is a supra-agent pattern of **emergent** cooperation or **predefined** cooperation of the agents in the system, that could be defined by the designer or by the agents themselves, for a purpose.

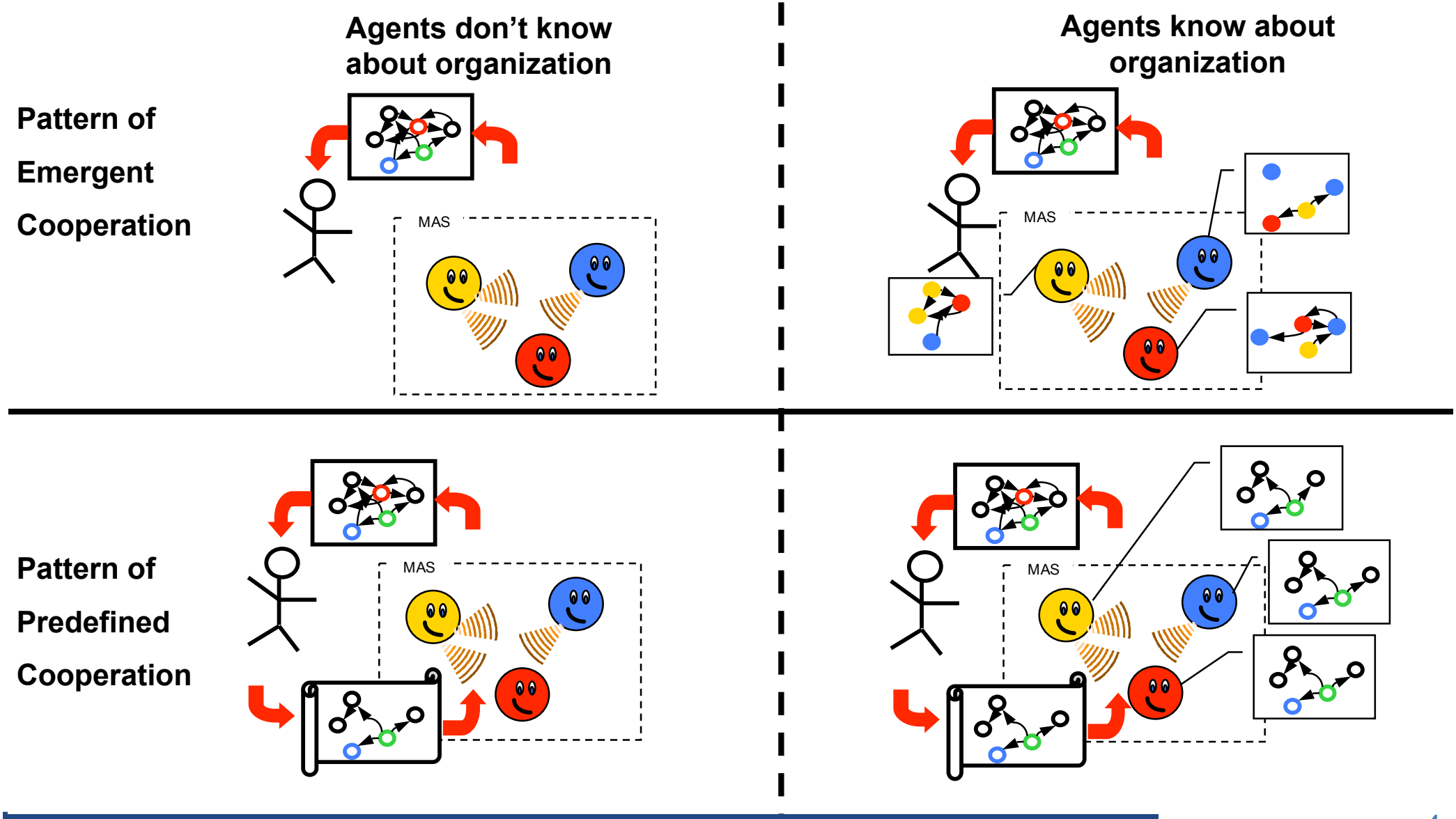
→ Pattern of emergent/potential cooperation

- Organizational entity, institution, social relations, commitments

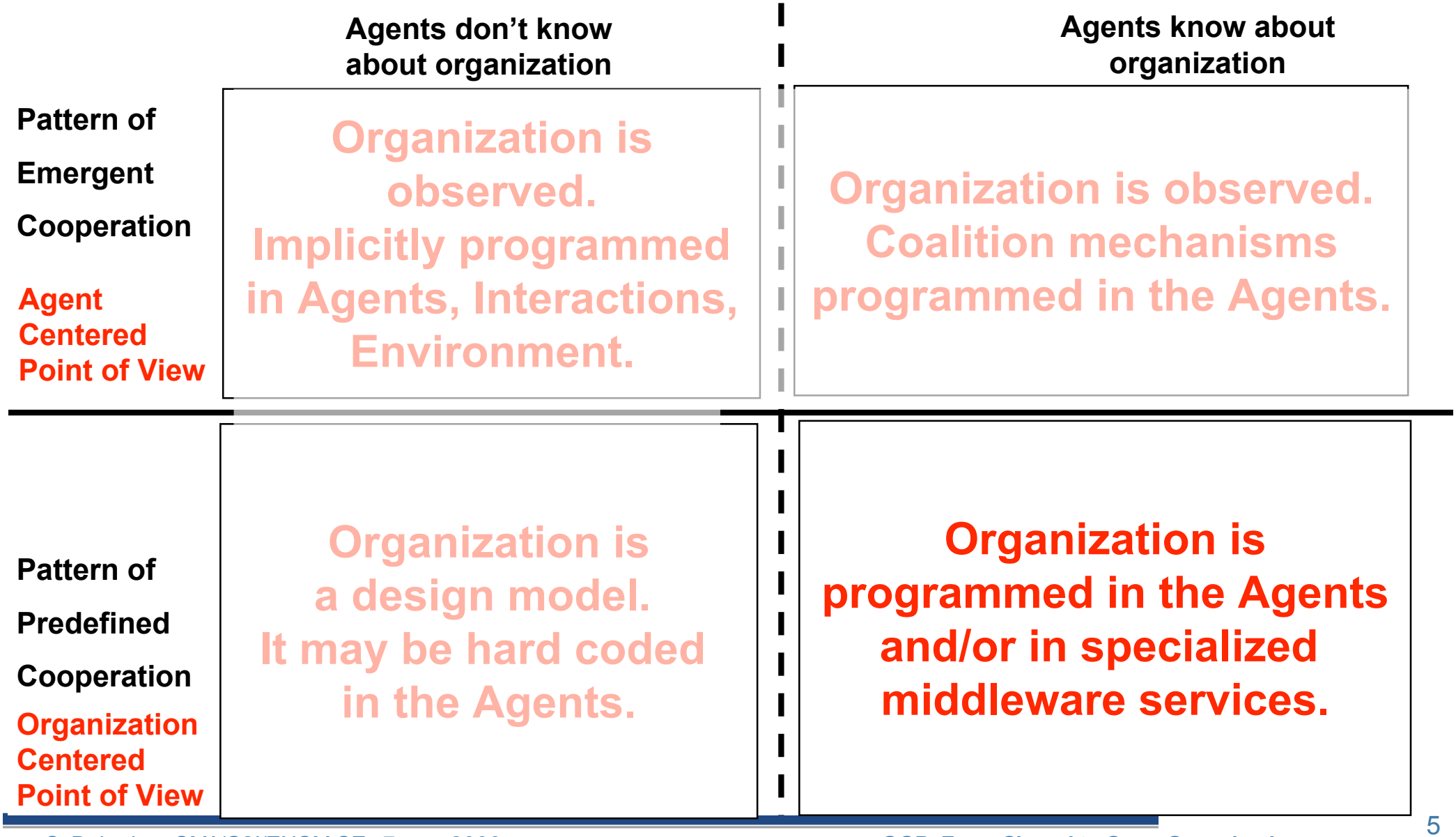
→ Pattern of predefined cooperation

- Organizational structure, norms, …

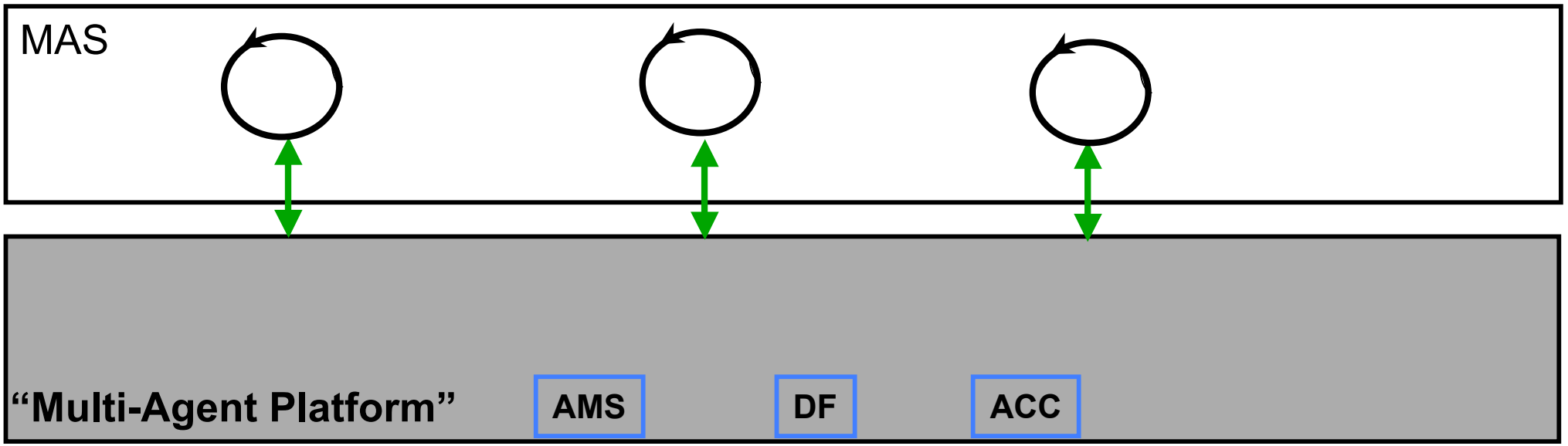
Multi-Agent Organizations (global picture)



Organization Oriented Programming (OOP)



OOP : Multi-Agent Platform

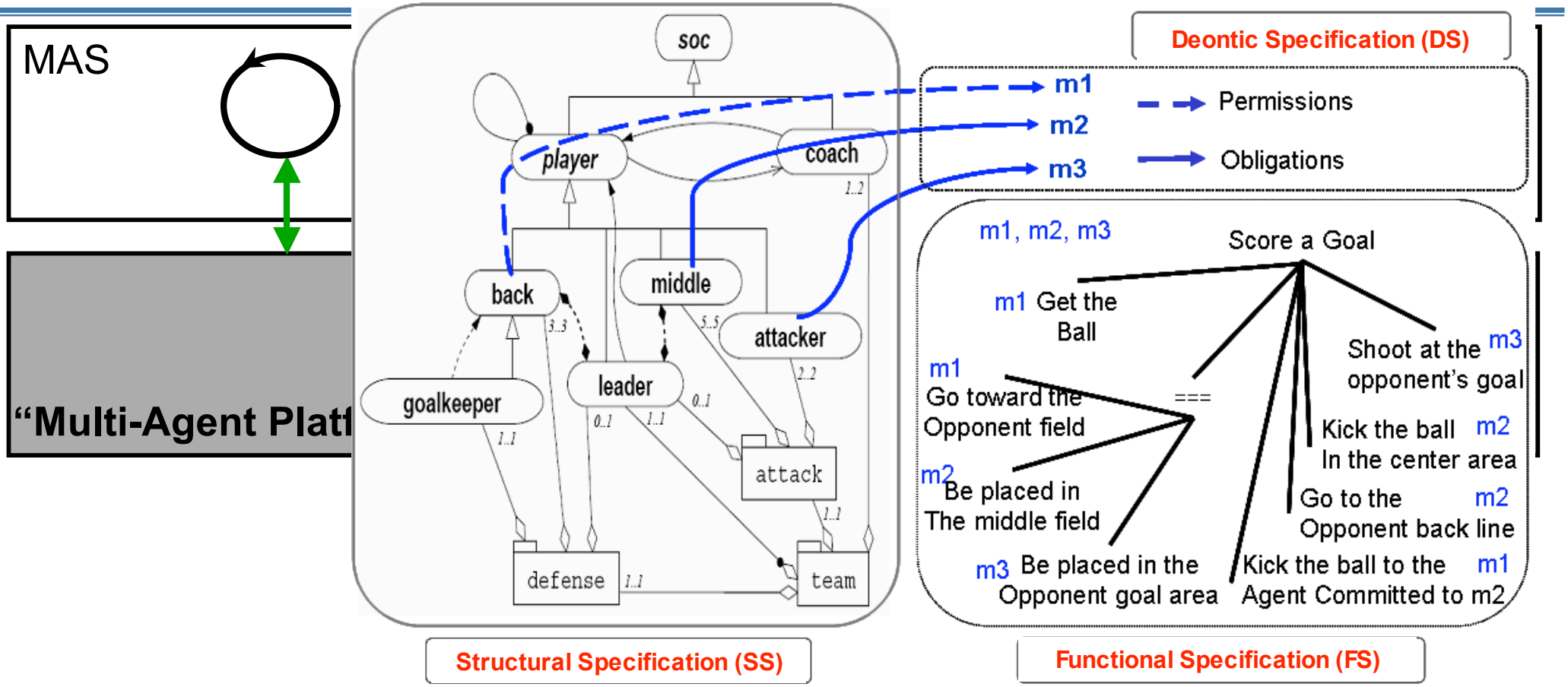


Infrastructure/Platforms for MAS in which domain agents operate on top of a middleware layer

- Supporting the implementation of agents
- Providing fundamental global generic services

e.g. JADE, FIPA-OS, SACI, …

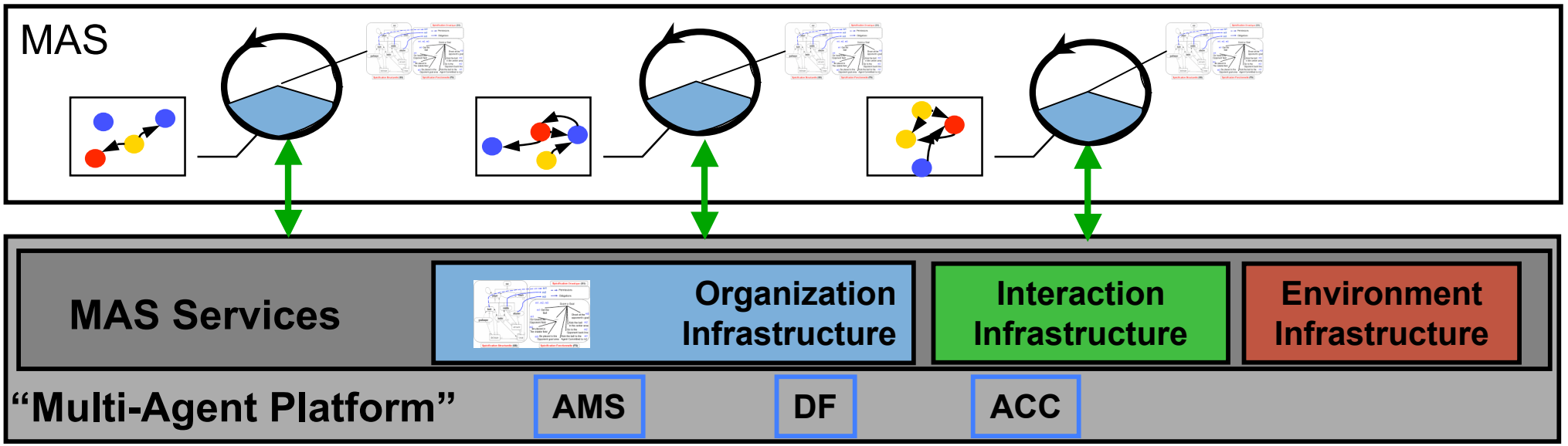
OOP: Organization Modeling Language



Organization Modeling Language (OML): Declarative specification of Multi-Agent Organization(s), collecting and expressing specific constraints and cooperation patterns imposed on the agents

e.g. AGR [Ferber 98], Teamwork [Tambe 98], Islander [Esteva 01], Moise+ [Hubner 02], …

OOP: Org. Implementation Architecture



Org. Specification written with Organization Modeling Language (OML)

Organization Implementation Architecture (OIA) helps the management of the **Organizational Entity**

- into the agents (**Organizational Deliberative Agent**) e.g. Jason-MOISE [Hubner 06], Autonomy based reasoning [Carabelea 07]
- but also into an **Organization Infrastructure**

e.g. Madkit [Gutknecht 98], Karma [Pynadath 03], Ameli [Esteva 04], S-Moise+ [Hubner 05], SYNAI [Gateau 07], …

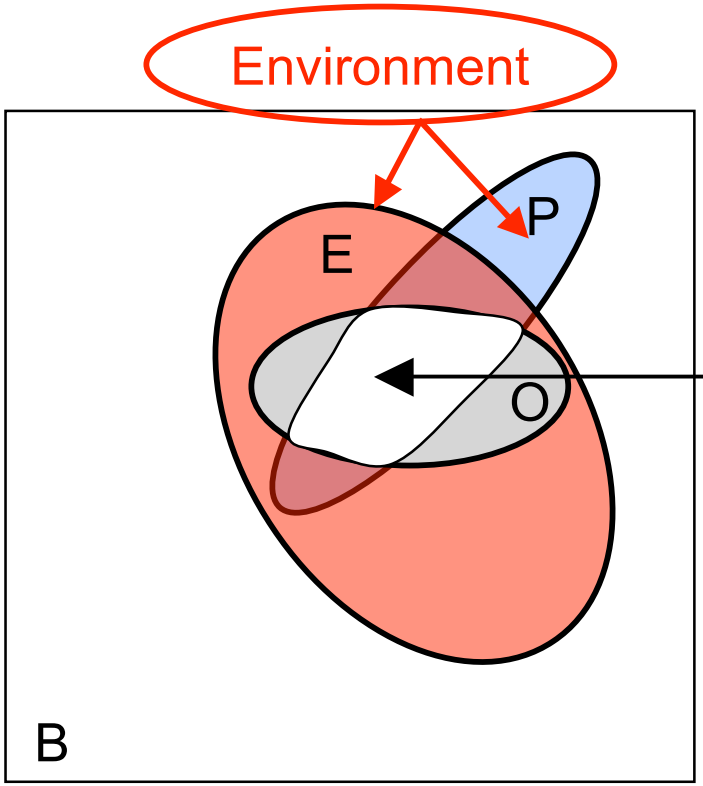
Outline

1. Introduction
2. Organization Modeling Language
3. Organization Infrastructure
4. Organizational Deliberative Agent
5. Conclusion and Perspectives

Organization Modeling Language

- Agents can ‘‘reason’’ about the organization
  - Declarative representation of the organization
    - » Possibility to enter into the organization during execution
    - » Possibility to change the organization
    - » Possibility to disobey the organization (organization is no more a regimentation)
  - Multiple dimensions:
    - » Functional (e.g. TAEMS [Decker 96])
    - » Structural (e.g. AGR [Ferber & Gütknecht 98])
    - » Functional and Structural (e.g. STEAM [Tambe 98], MOISE+ [Hübner 03])
    - » Structural and Interaction (e.g.: OPERA [Dignum 03], OMNI [Dignum 05], ISLANDER [Esteva et al. 02])
    - » Normative (e.g.: MOISEInst [Gâteau et al. 05])
- OI can interpret and monitor the agents within the organization

Organizations and Agent's Autonomy



Agents' desired behavior:

P ∩ E ∩ O not too big
- increases performance
- constrains agents' autonomy

P ∩ E ∩ O not too small
- increases adaptation
- keeps agents' autonomy

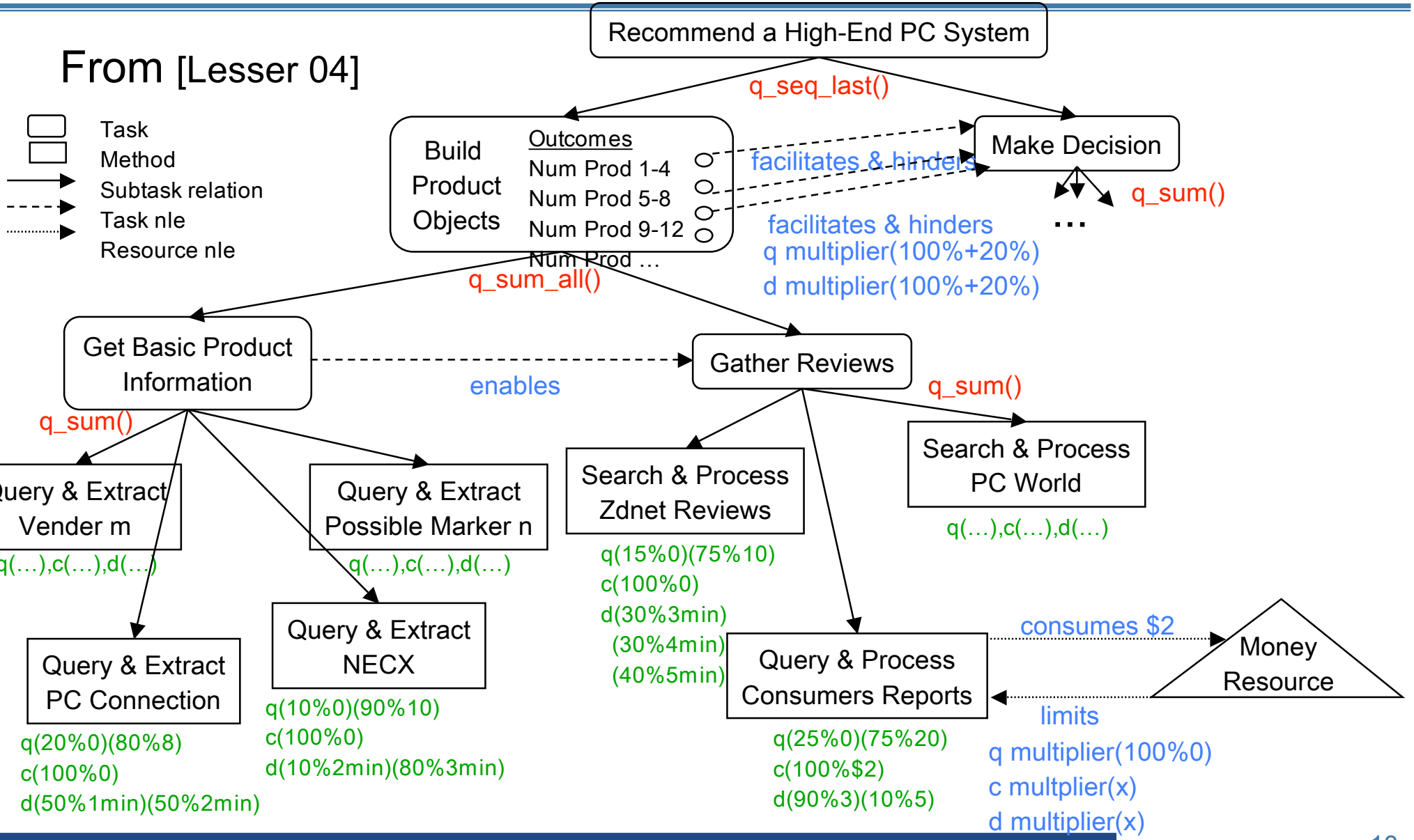
B: agents' possible behaviors
P: agents' behaviors that lead to global purpose
E: agents' possible behaviors constrained by the environment
O: agents' possible/permitted/obliged behaviors constrained by the organization

TAEMS

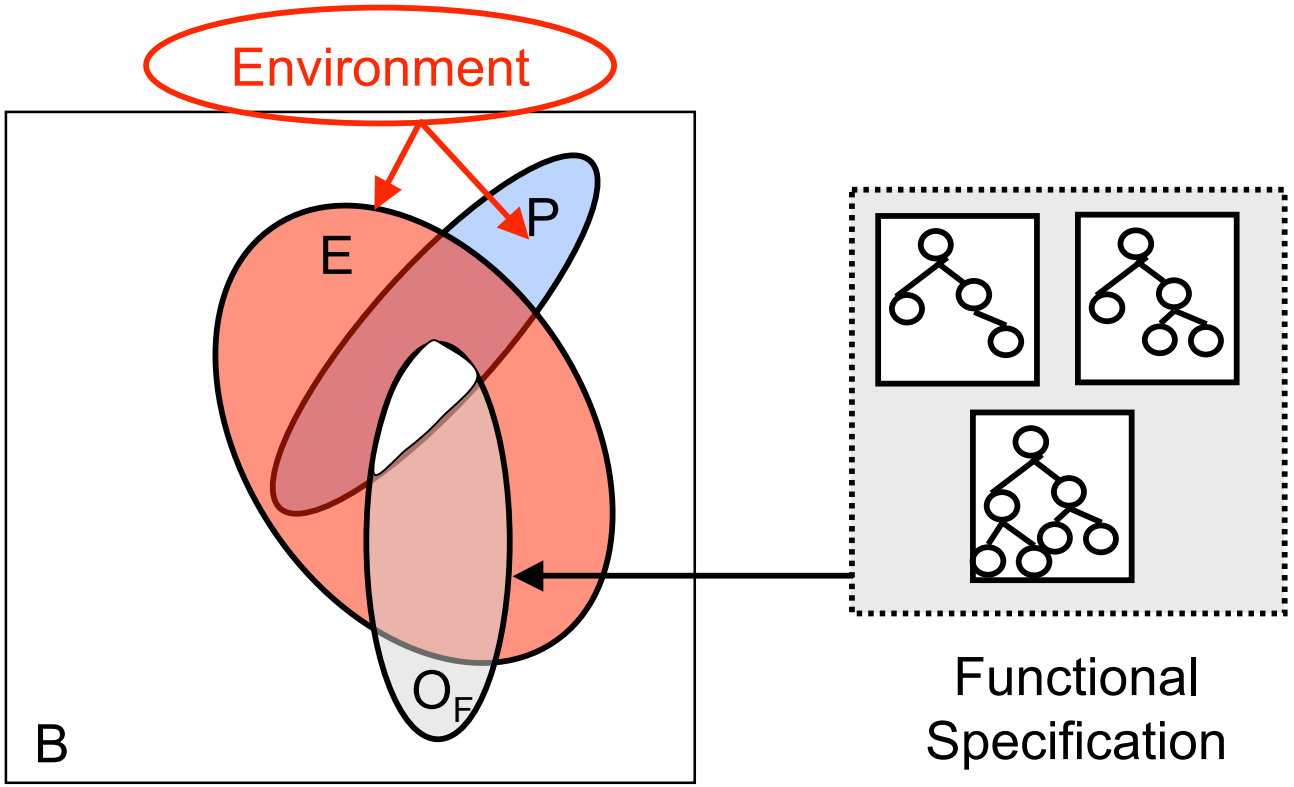
- **T**ask **A**nalysis, **E**nvironment **M**odeling and **S**imulation [Decker 96]
- Main ideas:
  - Task interrelations define potential areas of coordination among agents.
  - Agents must coordinate to maximize the sum of quality achieved for each task group before its schedule.
- TAEMS proposes a Domain independent language for defining models of hierarchical task structures for worth oriented environment.
- It has been used in DVMT, GPGP, JAF, DECAF, …

TAEMS Example

From [Lesser 04]



TAEMS Dimensions [Decker 96]



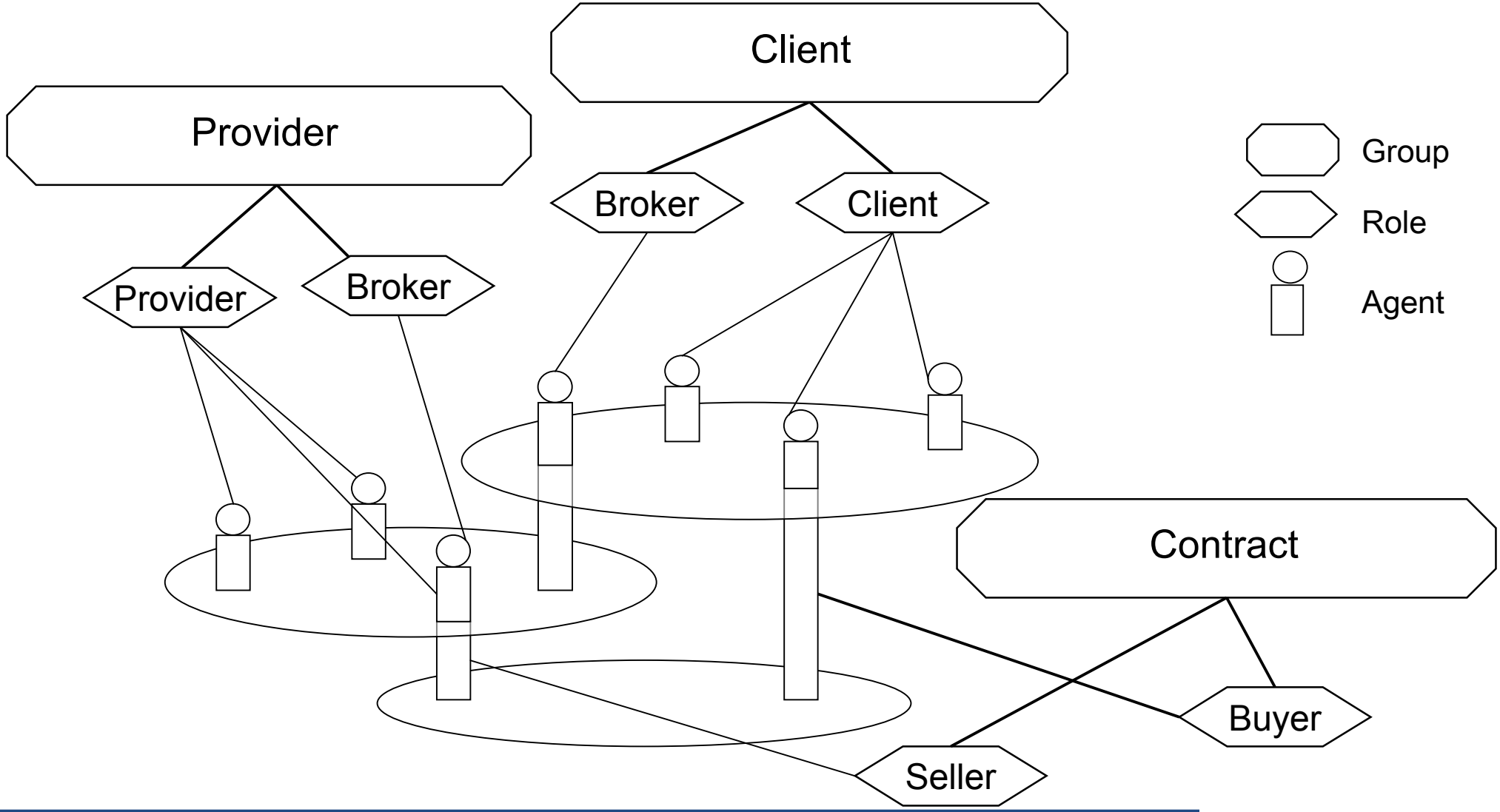
B: agents' possible behaviors
P: agents' behaviors that lead to global purpose
E: agents' possible behaviors constrained by the environment
O_F: agents' possible/permitted/obliged behaviors functionally constrained by the organization

AGR

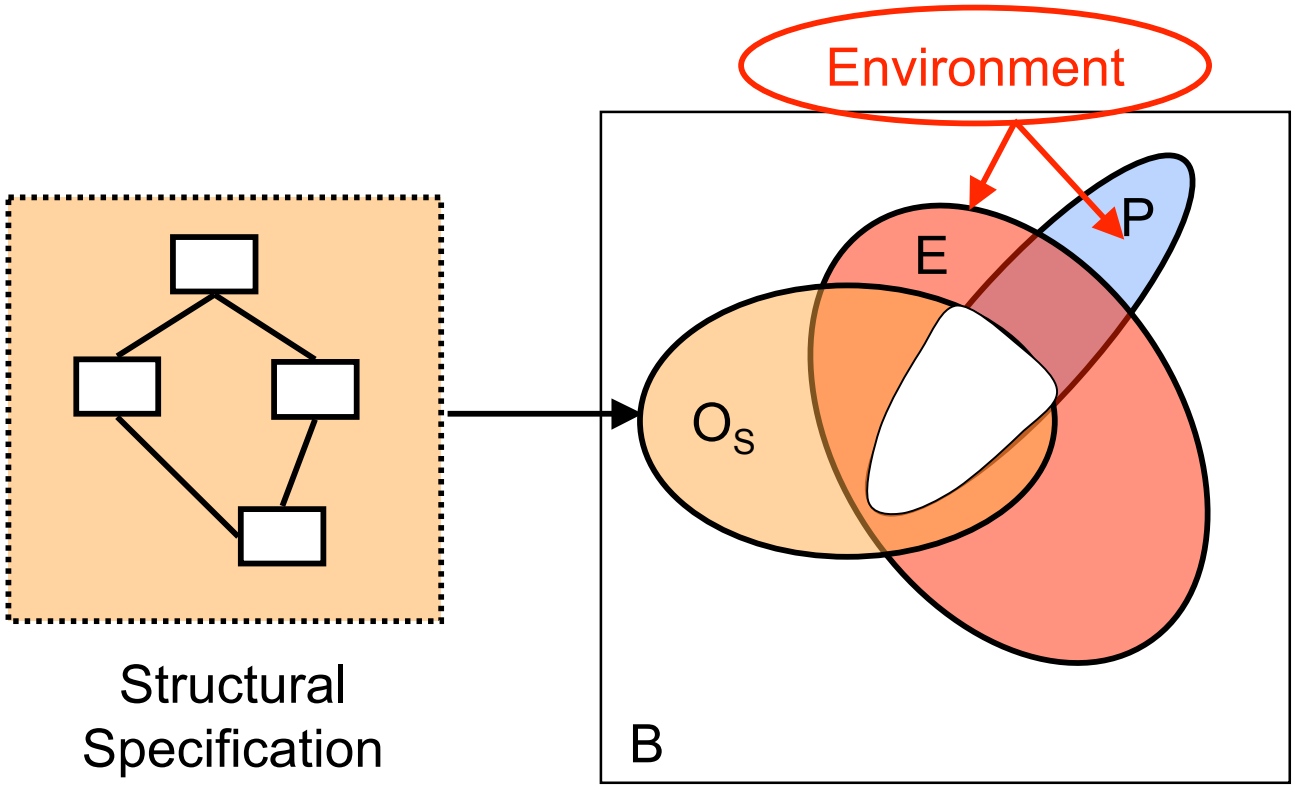
- **A**gent **G**roup **R**ole [Ferber & Gütknecht 98]
- Main concepts
  - Agent: active entity that plays roles within groups.
  - Group: set of agents sharing common characteristics
  - Role: abstract representation of the status, position, function of an agent within a group
    - » Agents may have several roles and may belong to several groups.
    - » Two agents can't communicate with each other if they don't belong to the same group
- Used within the

platform

AGR Example


Client
Provider
Broker
Client
Provider
Broker
Group
Role
Agent
Contract
Buyer
Seller

AGR Dimensions [Ferber & Gütknecht 98]

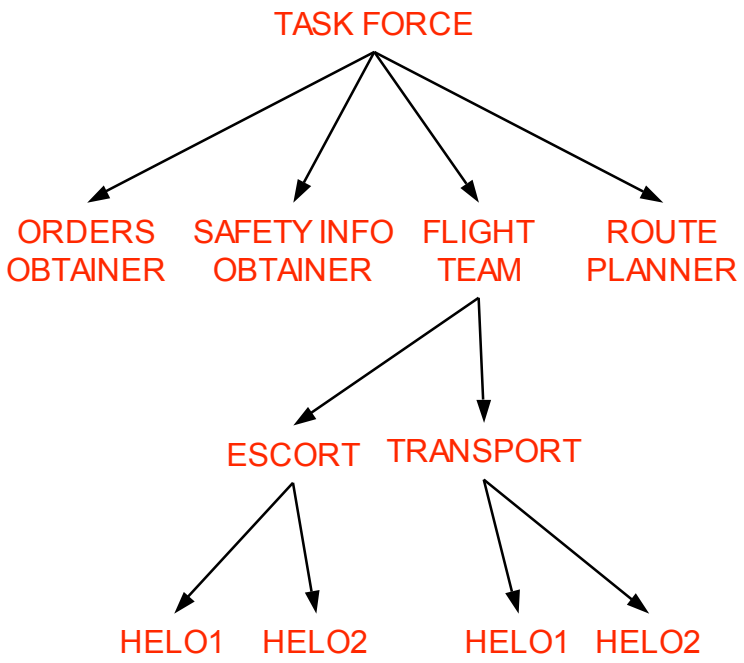


B: agents' possible behaviors
P: agents' behaviors that lead to global purpose
E: agents' possible behaviors constrained by the environment
O_S: agents' possible/permitted/obliged behaviors structurally constrained by the organization

STEAM

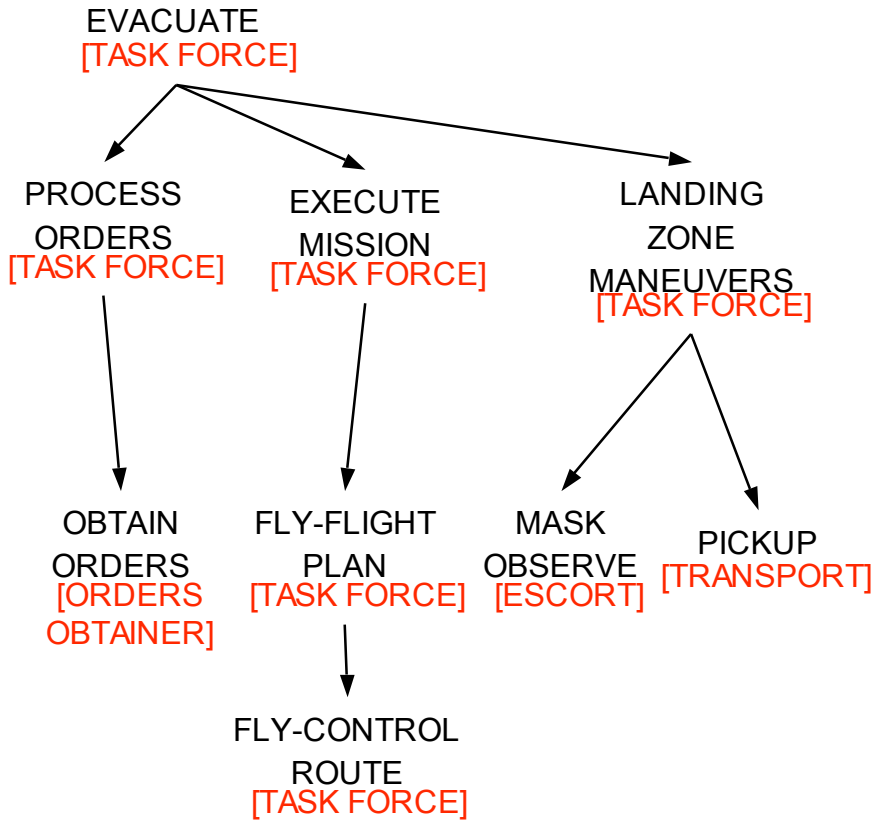
- **S**hell for **TEAM**work [Tambe 98]
- Main features
  - enhanced SOAR architecture
  - Joint intentions theory [Levesque 90, Jennings 95]
  - Shared plans theory [Grosz 96, Rich 97]
- Main principles :
  - Team synchronization
  - Reorganize if there is a critical role failure
  - Reassign critical roles based on joint intentions
  - Decision theoretic communication
- Different applications: Attack, Transport, Robocup soccer

STEAM TEAM SPECIFICATION



Organization: hierarchy of roles that may be filled by agents or groups of agents.

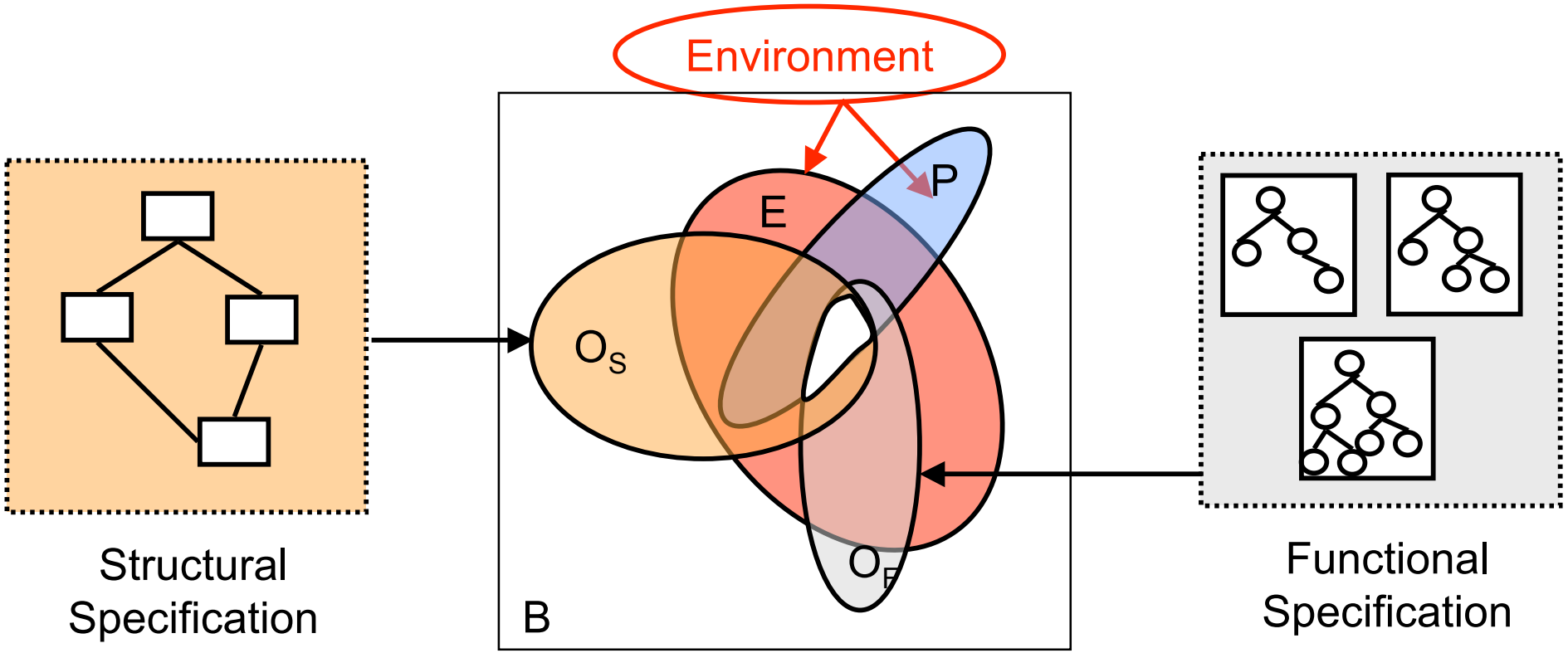
From [Tambe 00]



Team Plan:

- initial conditions,
- term. cond. : achievability, irrelevance, unachievability
- team-level actions.

STEAM Dimensions [Tambe 98]

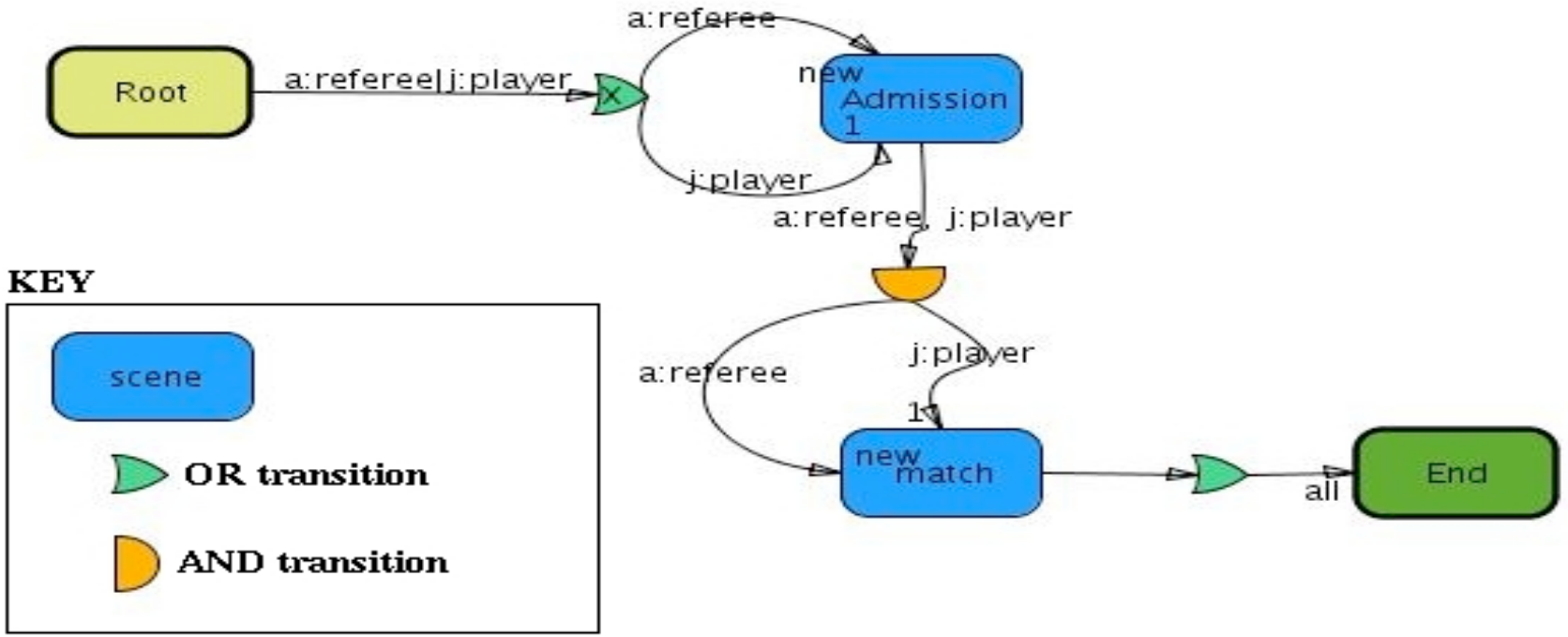


B: agents' possible behaviors
P: agents' behaviors that lead to global purpose
E: agents' possible behaviors constrained by the environment
O_S: agents' possible/permitted/obliged behaviors structurally constrained by the organization
O_F: agents' possible/permitted/obliged behaviors functionally constrained by the organization

E-Institutions

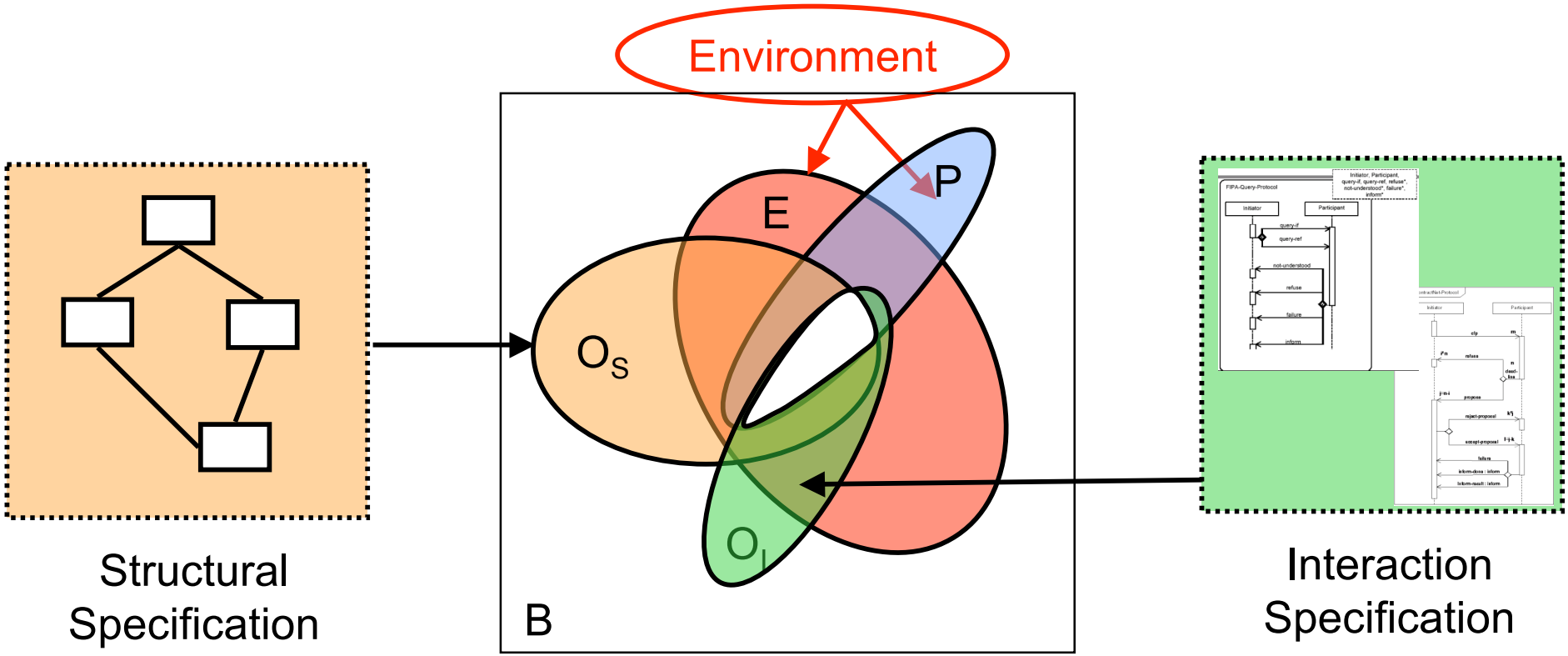
[Esteva et al. 02]

```
(define-institution
        soccer-server as
        dialogic-framework = soccer-df
        performative-structure = soccer-pf
        norms =  ( free-kick  coach-messages … )
)
```



Performative Structure

E-Institutions Dimensions [Esteva et al. 02]

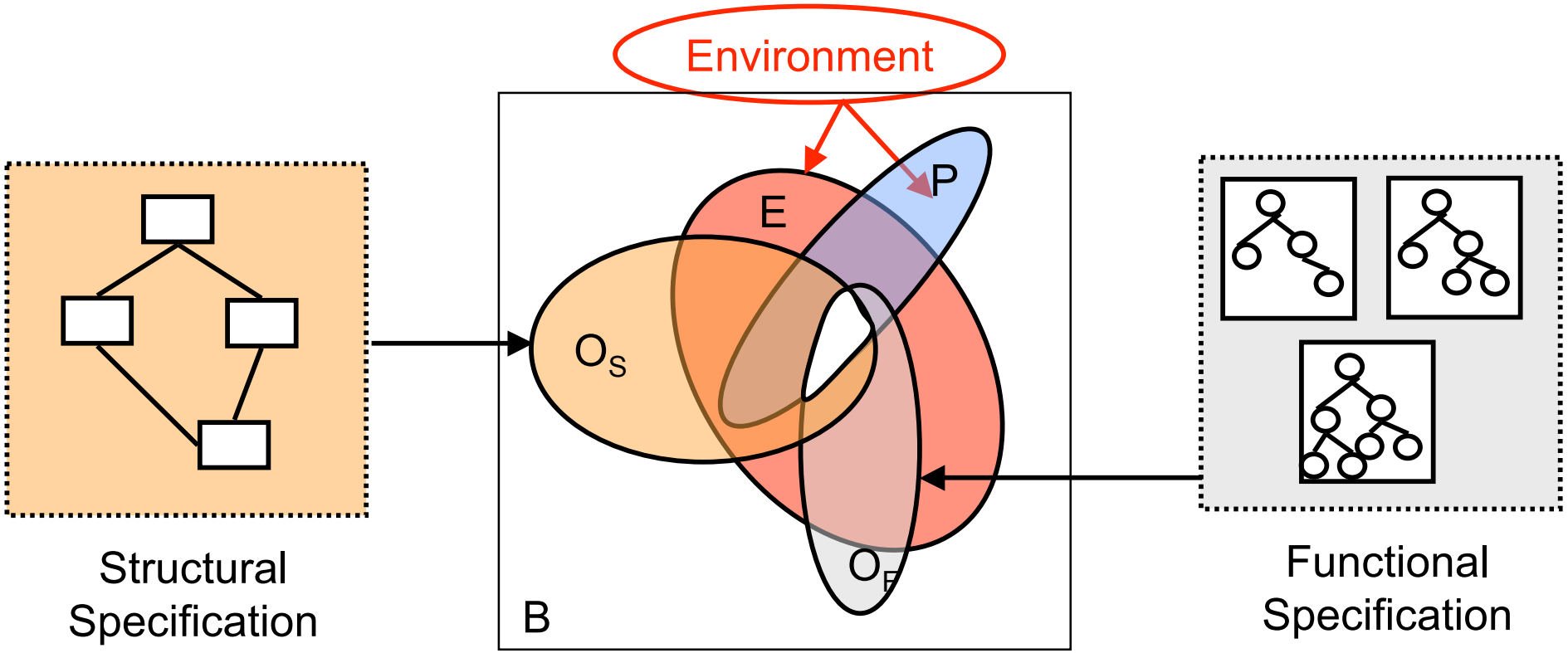


B: agents' possible behaviors
P: agents' behaviors that lead to global purpose
E: agents' possible behaviors constrained by the environment
O_S: agents' possible/permitted/obliged behaviors structurally constrained by the organization
O_I: agents' possible/permitted/obliged behaviors interactionally constrained by the organization

MOISE+

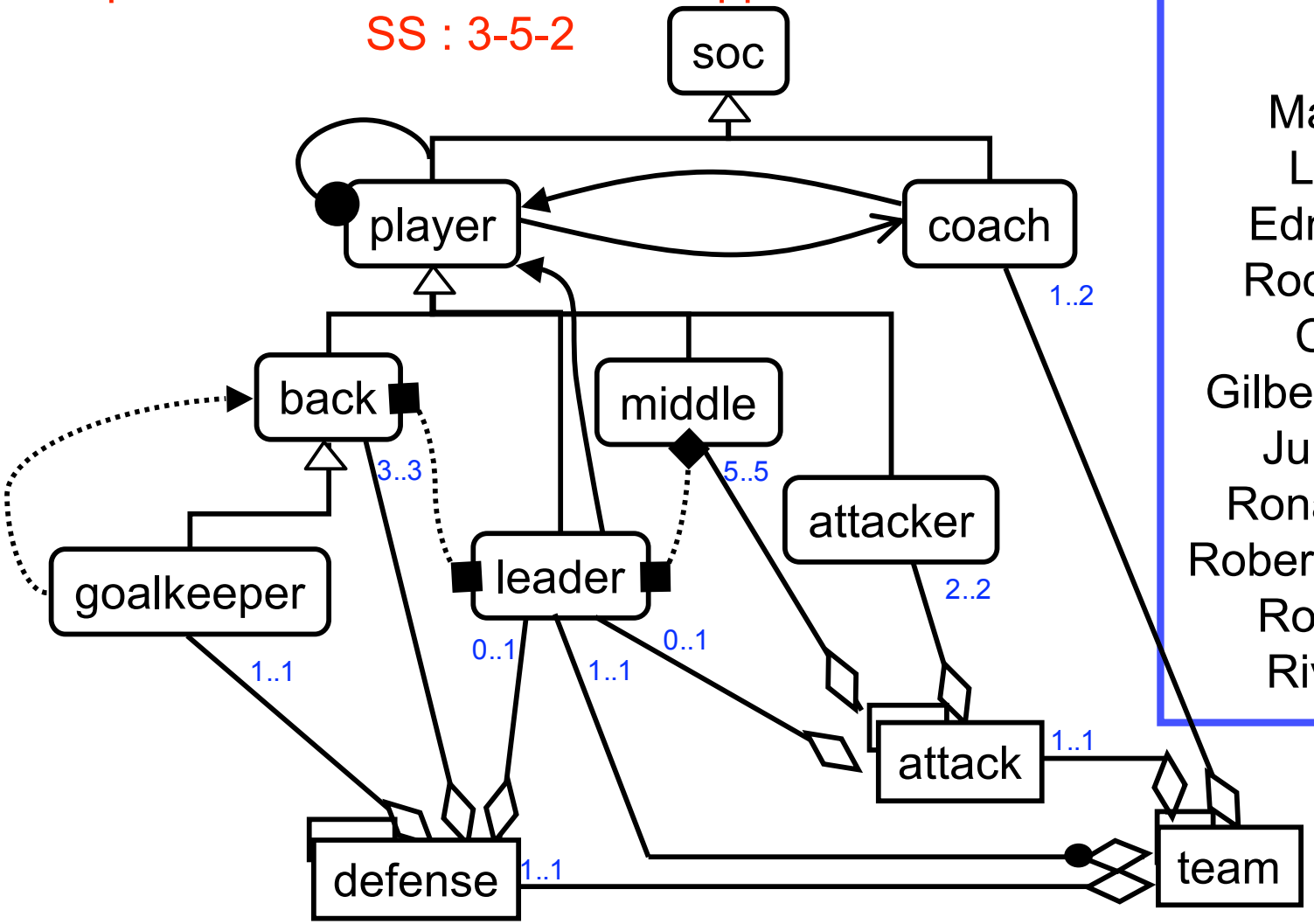
- **M**odel of **O**rganization for mult**I**-agent **S**yst**E**ms [Hannoun 02, Hübner 03]
- http://www.lti.pcs.usp.br/moise
- Distinguishes three main dimensions in the organization of a Multi-Agent System:
  - Structural Specification
  - Functional Specification
  - Deontic Specification

MOISE+ Dimensions



MOISE+ Structural Specification

Graphical view of SoccerGame Application
SS : 3-5-2



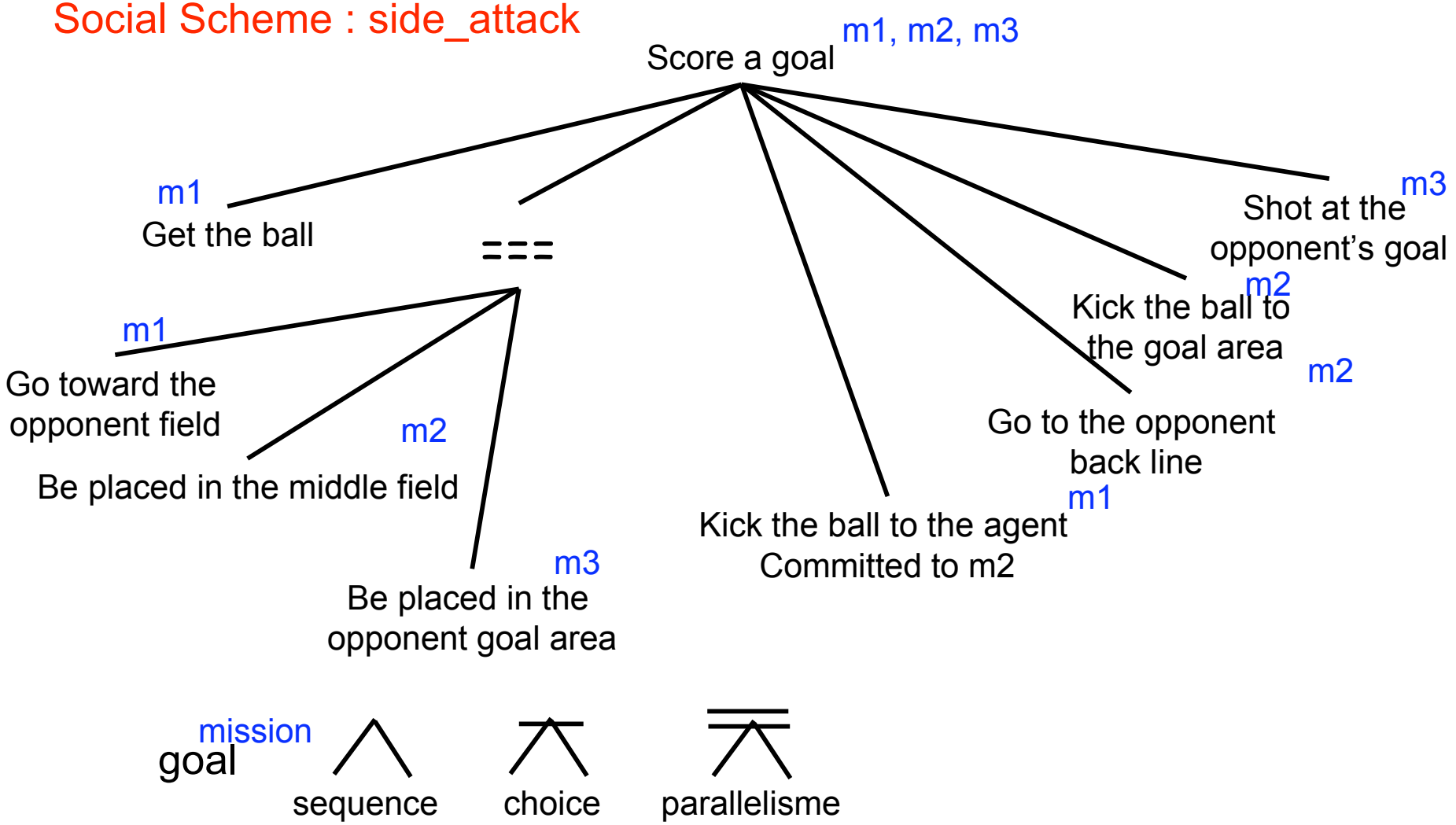
Organizational Entity
from OS 3-5-2

Marcos — goalkeeper
Lucio, Edmilson, Roque Jr. — back
Cafu — leader
Gilberto Silva, Juninho, Ronaldinho, Roberto Carlos — middle
Ronaldo, Rivaldo — attacker

- Roles
- Links
- Groups

MOISE+ Functional Specification

Graphical view of SoccerGame Application FS
Social Scheme : side_attack

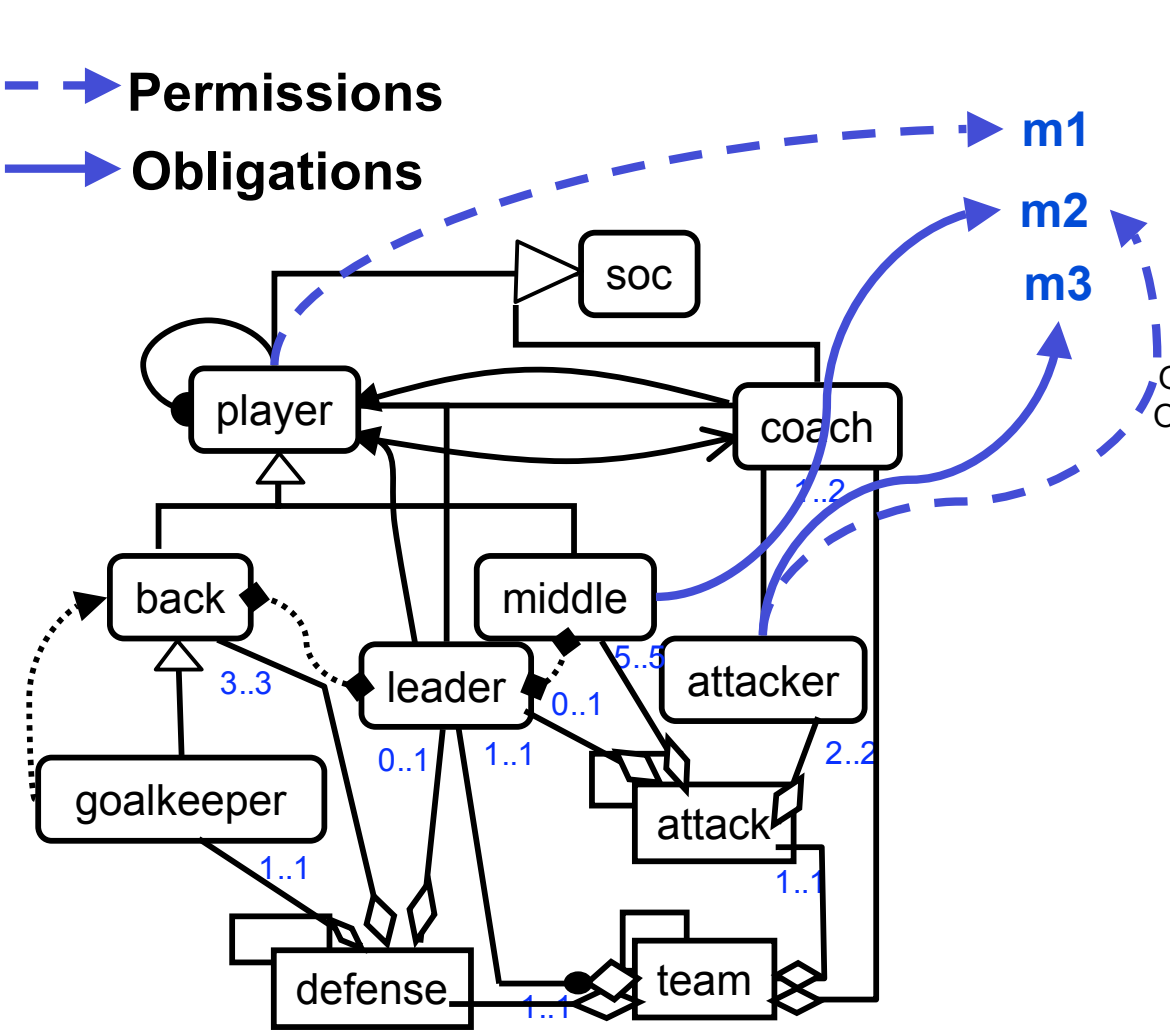


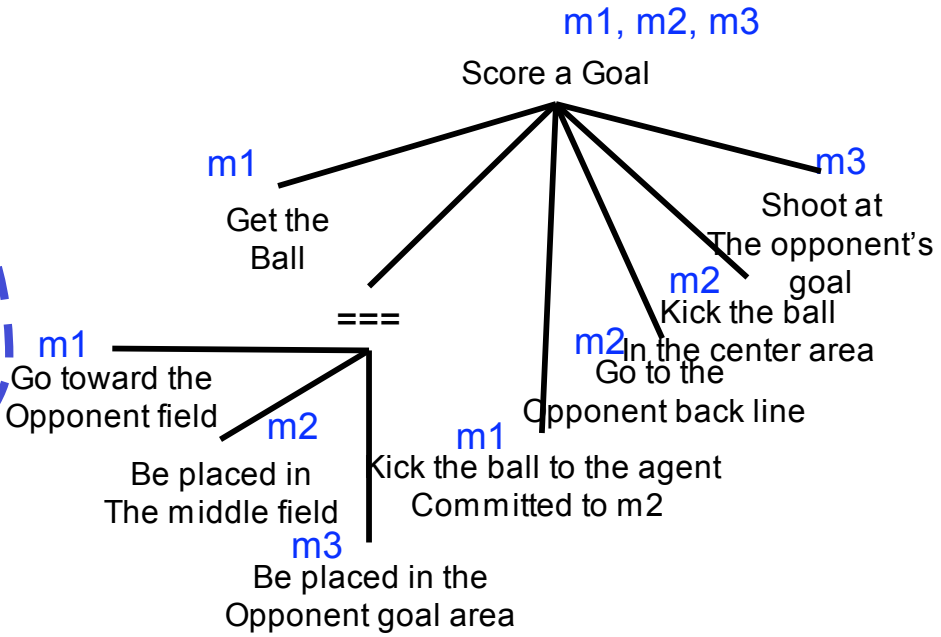
MOISE+ Deontic Specification

- Explicit relation between the functional and structural specifications
  - Permissions and obligations to commit to missions in the context of a role
  - To make explicit the normative dimension of a role

Role	Deontic Relation	Mission	Temporal Constraint (cf. [carron 01])
Back	Permission	m1	In [0 30]
Middle	Obligation	m2	during [Attacker]
Attacker	Obligation	m3	Any

MOISE+ Deontic Specification

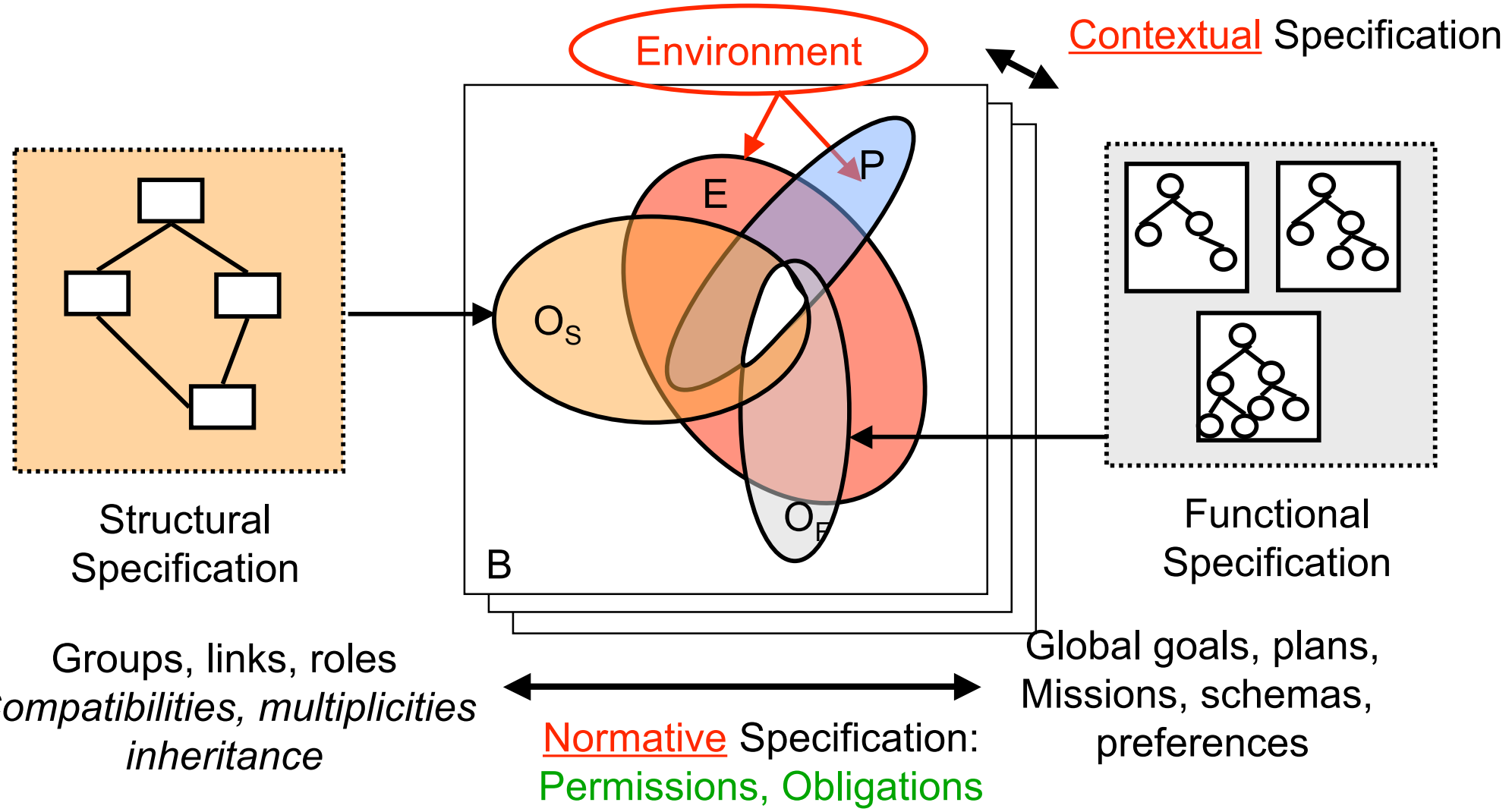




Organisational Entity
Lucio ----- m1
Cafu ----- m2
Rivaldo ----- m3

Graphical view of SoccerGame Application DS

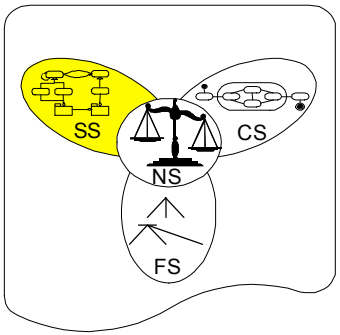
MOISE^{inst} Dimensions [Gateau 07]



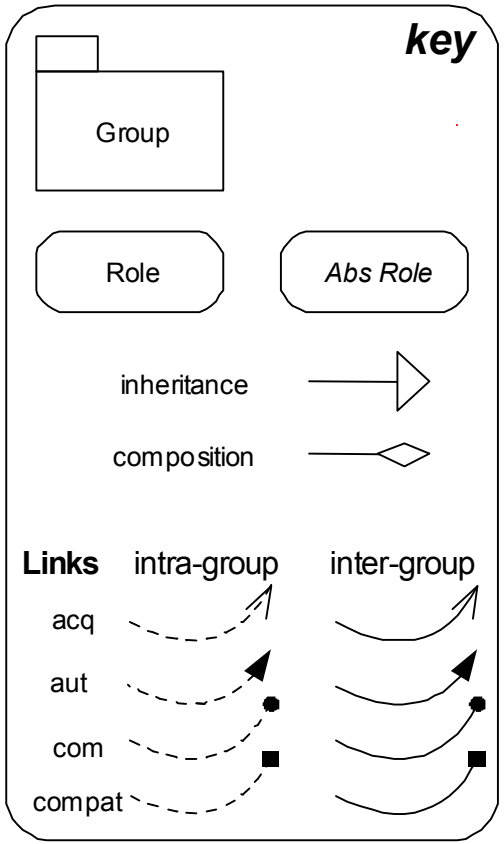
iTV Application

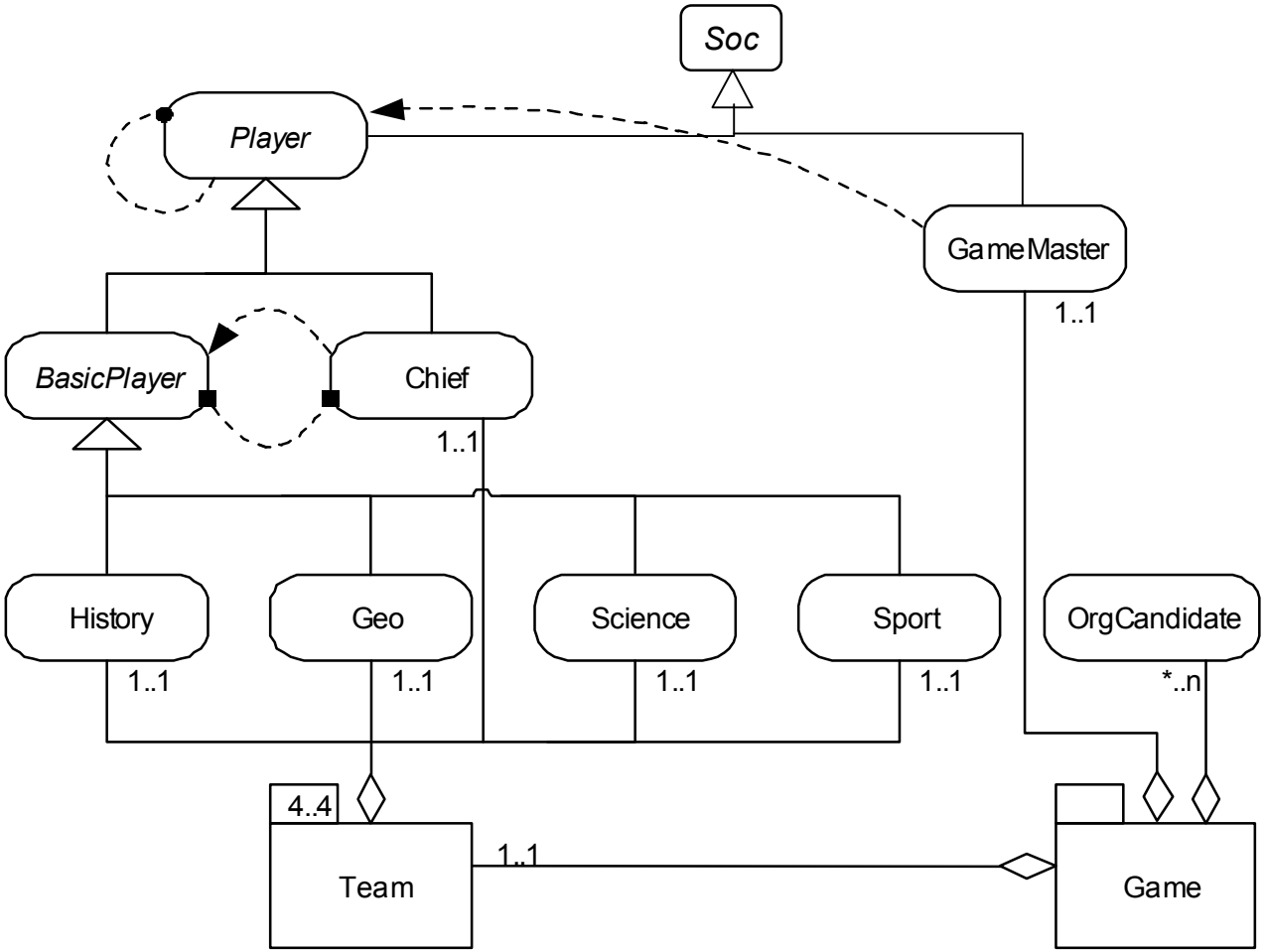
MOISE^{Inst}

- Organizational Specification (OS) along 4 dimensions
- ***Structural Specification (SS)*** *structure of the organization in term of roles, groups and links*



MOISE^{Inst} Structural Specification



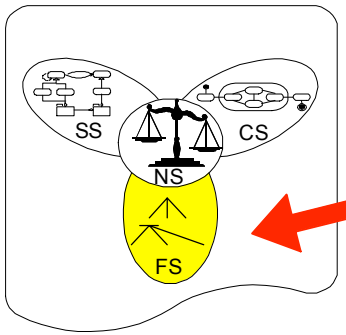


Graphical view of iTV Application Domain SS

MOISE^{Inst}

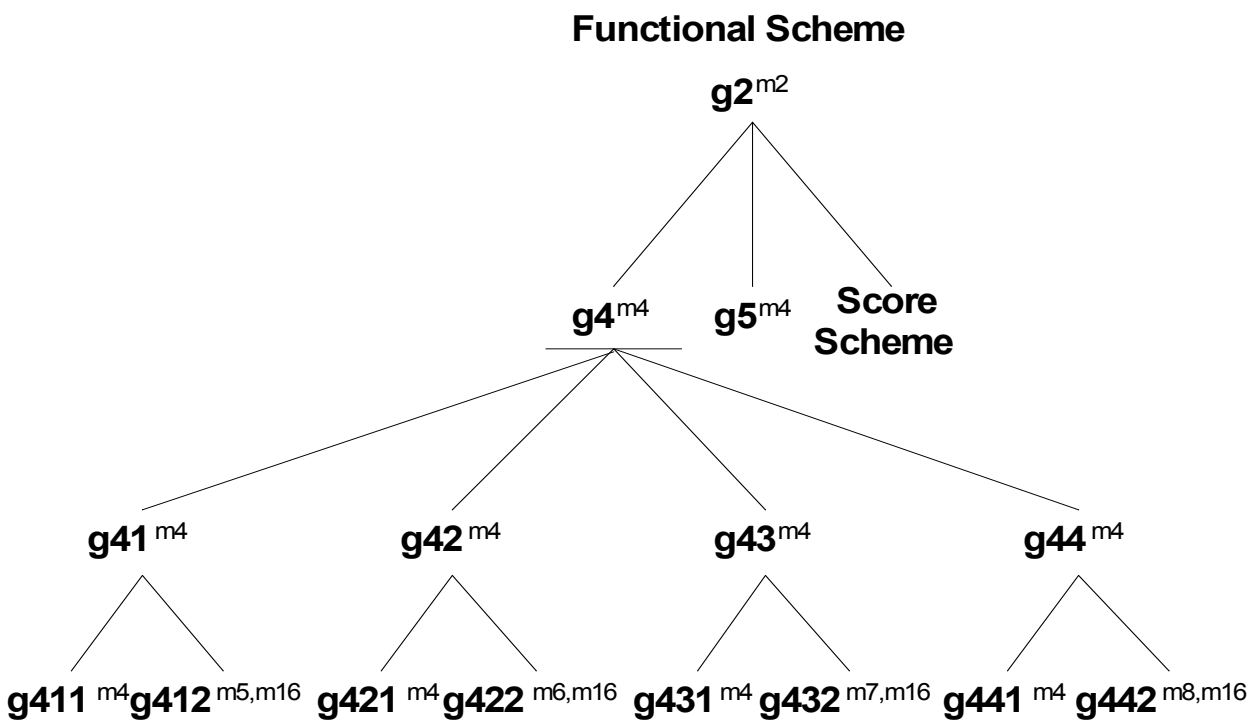
- Organizational Specification (OS) along 4 dimensions

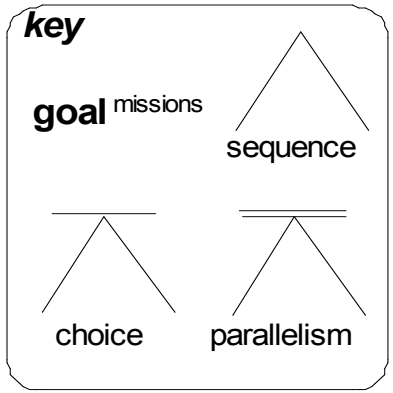
- **Structural Specification (SS)** structure of the organization in term of roles, groups and links



- ***Functional Specification (FS)*** goals to be achieved in the organization

MOISE^{Inst} Functional Specification





g41: "History" topic handled
- g411: "History" question asked
- g412: "History" question answered

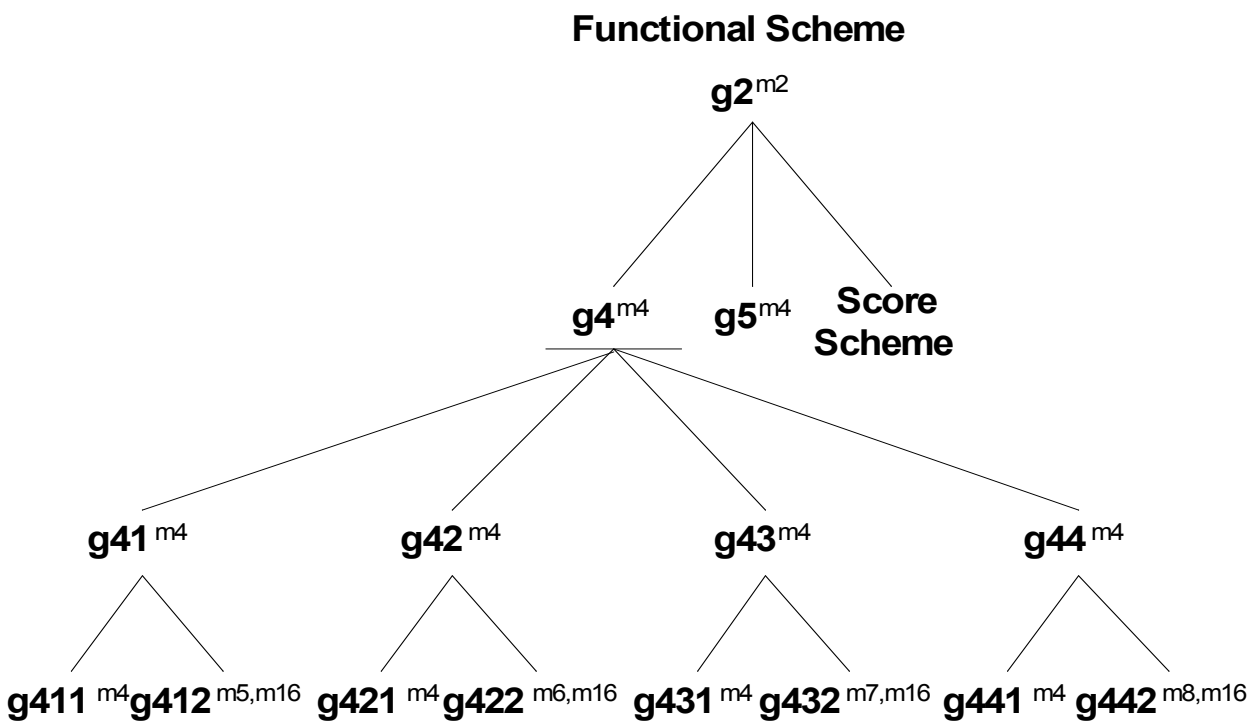
g42: "Geo" topic handled
- g421: "Geo" question asked
- g422: "Geo" question answered

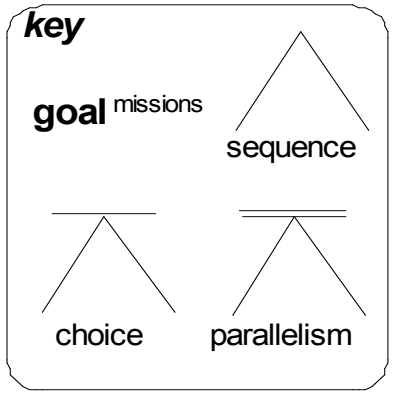
g43: "Sport" topic handled
- g431: "Sport" question asked
- g432: "Sport" question answered

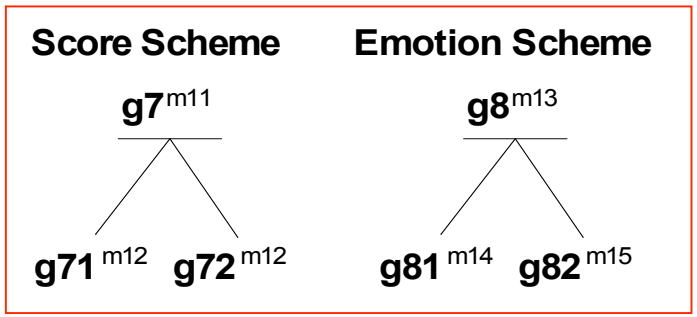
g44: "Science" topic handled
- g441: "Science" question asked
- g442: "Science" question answered

Graphical view of iTV Application FS

MOISE^{Inst} Functional Specification







g41: "History" topic handled
- g411: "History" question asked
- g412: "History" question answered

g42: "Geo" topic handled
- g421: "Geo" question asked
- g422: "Geo" question answered

g43: "Sport" topic handled
- g431: "Sport" question asked
- g432: "Sport" question answered

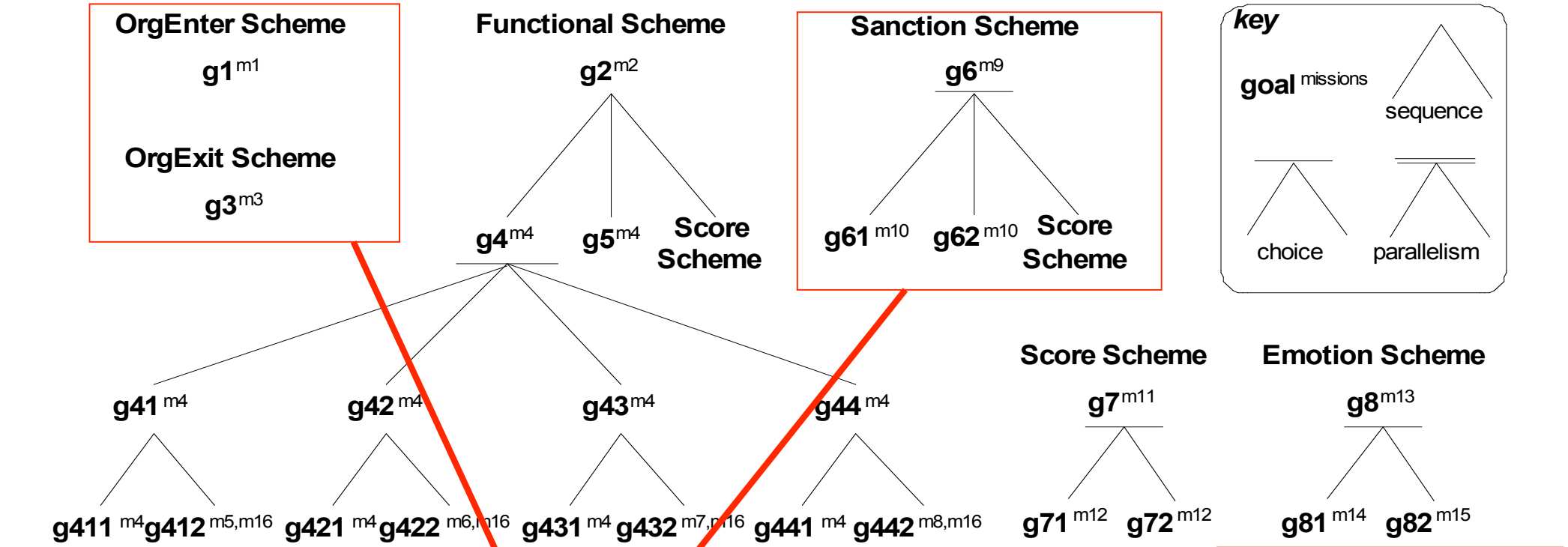
g44: "Science" topic handled
- g441: "Science" question asked
- g442: "Science" question answered

g7: Score changed
- g71: Score increased
- g72: Score decreased

g8: Emotion shown
- g81: Be happy
- g82: Be sad

Graphical view of iTV Application FS

MOISE^{Inst} Functional Specification



g1: Team joined
g2: X pts scored
  g4: Topic handled
  g5: Answer evaluated
g3: Team quit

g41: "History" topic handled
  g411: "History" question asked
  g412: "History" question answered
g42: "Geo" topic handled
  g421: "Geo" question asked
  g422: "Geo" question answered

g43: "Sport" topic handled
  g431: "Sport" question asked
  g432: "Sport" question answered
g44: "Science" topic handled
  g441: "Science" question asked
  g442: "Science" question answered

g6: Sanction applied
  g61: Player ejected
  g62: Team disqualified
g7: Score changed
  g71: Score increased
  g72: Score decreased
g8: Emotion shown
  g81: Be happy
  g82: Be sad

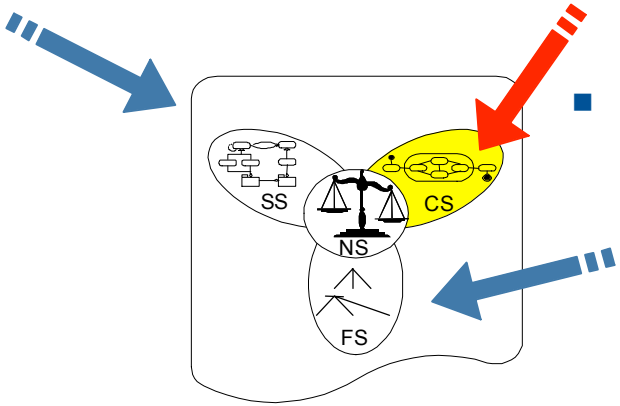
Graphical view of iTV Application FS

MOISE^{Inst}

- Organizational Specification (OS) along 4 dimensions

- **Structural Specification (SS)**
  structure of the organization in term of roles, groups and links

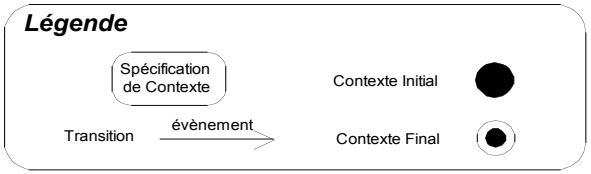
- ***Contextual Specification (CS)***
  all possible "a priori" states of the organization



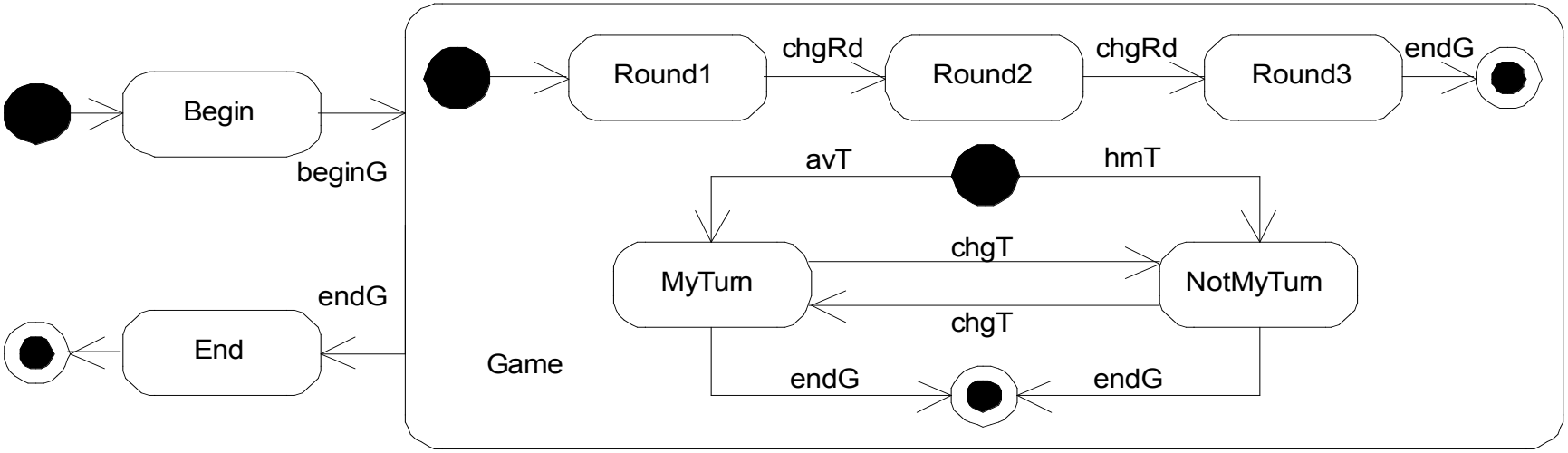
- **Functional Specification (FS)**
  goals to be achieved in the organization

MOISE^{Inst} Contextual Specification

- 'A priori' temporal evolution of the Organization
- **Contexts = States**
  - Particular state in which organization can be
  - Influences the applicability of norms
- **Transitions**
  - Link between states
  - Triggered by events



Graphical view of iTV application CS

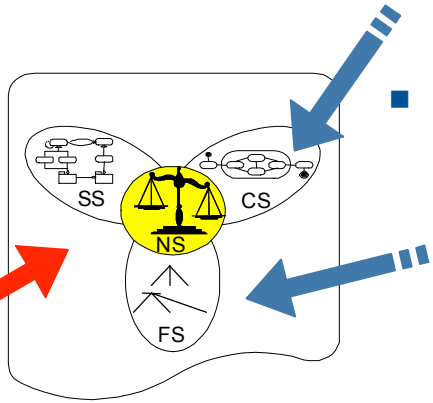


MOISE^{Inst}

- Organizational Specification (OS) along 4 dimensions

- **Contextual Specification (CS)**
  all possible “a priori” states of the organization

- **Structural Specification (SS)**
  structure of the organization in term of roles, groups and links



- ***Normative Specification (NS)***
  norms gluing all SS, FS and CS together

- **Functional Specification (FS)**
  goals to be achieved in the organization

MOISE^{Inst} Normative Specification

- Norm defines rights and duties for a bearer (role or a group) to execute a mission in a particular context and during a given time supervised by an issuer which can apply a sanction if the norm is not respected.

<norm> ::= '('**:id** <normId> **:weight** <int> '::'
[**:conditions** <condition>] **:context** <contextId>
:operator <deonticRel> **:bearer** <sentityId> **:issuer** <sentityId>
:action <deonticAct> [**:relation** <relation> **:deadline** <date>]
[**:sanction** <normId>] ')'

- Conditions are conjonction/disjunction of predicates bearing on:
  - Application, Organization states (e.g. number of agents, cardinalityMax, …), Status of the norms (violated, respected)

MOISE^{Inst} Normative Specification

Functioning of the game:

- Obligation for the "*GameMaster*" role to ask questions and to verify answer -"*m4*" mission- during all the game -"*Game*" context-:

```
(Norm :id N4 :weight 1
    :operator O :issuer Supervisor :bearer GameMaster
    :context Game :action do(m4))
```

- Obligation for the "*Chief*" role to answer questions -"*m16*" mission- during the third round -"*Round3*" context-:

```
(Norm :id N9 :weight 1
    :operator O :issuer GameMaster :bearer Chief
    :context Round3
    :action do(m16) :relation < :deadline answer_delay)
```

- …

iTV Application NS

MOISE^{Inst} Normative Specification

Management of the organization:

- Obligation for the "*OrgCandidate*" role to join a team -"*m1*" mission- at the beginning of the game -"*Begin*" context- in order to play a role in it:

  (Norm :id N1 :weight 1
  :condition (number(Team)!=cardinalityMax(Team))
  :operator O :issuer GameMaster :bearer OrgCandidate
  :context Begin :action do(m1))

- Interdiction for an agent playing "*OrgCandidate*" role to join a team -"*m1*" mission- during the game -"*Game*" context-:

  (Norm :id N6 :weight 1
  :operator F :issuer GameMaster :bearer OrgCandidate
  :context Game :action do(m1) :sanction N17)

- …

iTV Application NS

MOISE^{Inst} Normative Specification

Regulation of the organization: "Enforcement/reward Norms" [Lopez y lopez]

- If N6 is not respected then the "*Arbitrator*" role has the obligation to eject -"*m9*" mission- the agent violating the norm N6 - the one wearing "*OrgCandidate*" role-:

```
(Norm :id N17 :weight 1
      :condition (violated(N6))
      :operator O :issuer GameMaster :bearer Arbitrator
      :context Game :action do(m9))
```

- If N8 is not respected then the "*Arbitrator*" role acts on the score -"*m11*" mission- of the team in which the agent violating N8 is wearing the role:

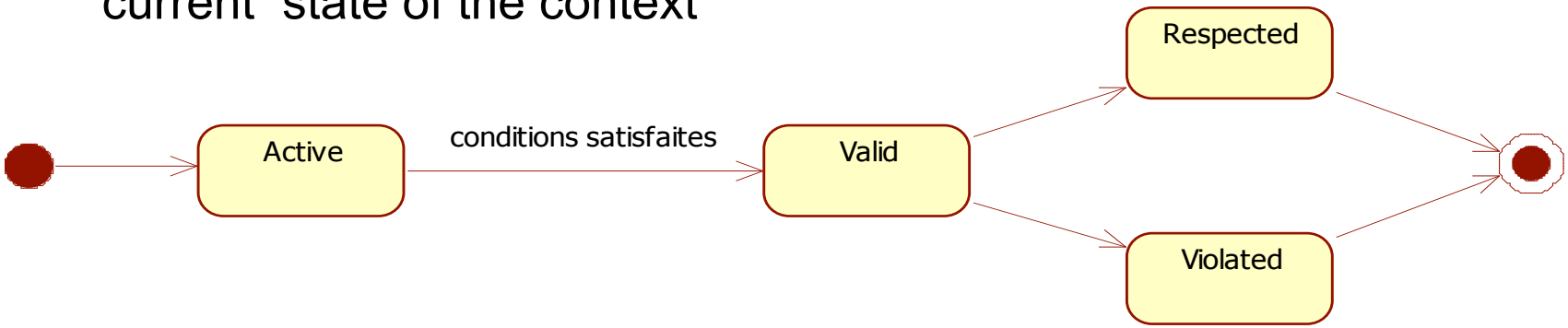
```
(Norm :id N18 :weight 1
      :condition (violated(N8))
      :operator O :issuer GameMaster :bearer Arbitrator
      :context Game :action do(m11))
```

- …

iTV Application NS

MOISE^{Inst} Normative Specification

- Norms Life Cycle
- Active norms
  - Norms applied to **played roles**, to **committed missions** given the current state of the context



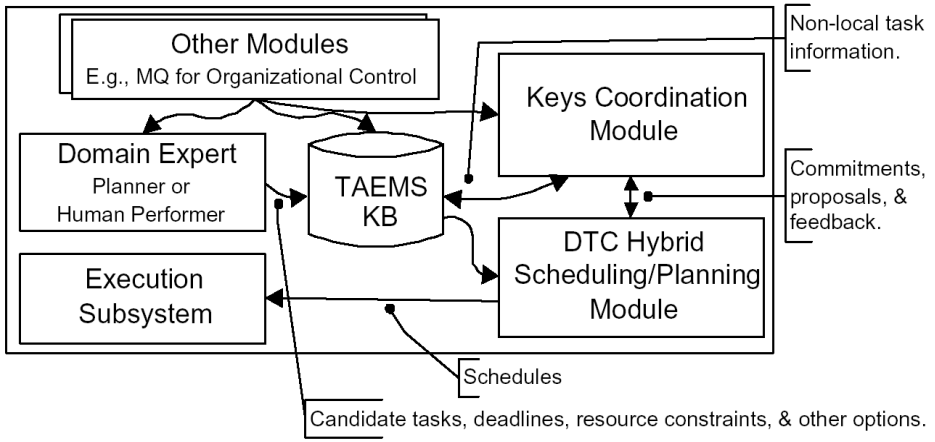
- Respect (violation) of a valid norm depends on:
  - change of state of context
  - time
  - Accomplishment of Mission
  - Deontic operator

Outline

1. Introduction
2. Organization Modeling Language
3. Organization Infrastructure
4. Organizational Deliberative Agent
5. Conclusion and Perspectives

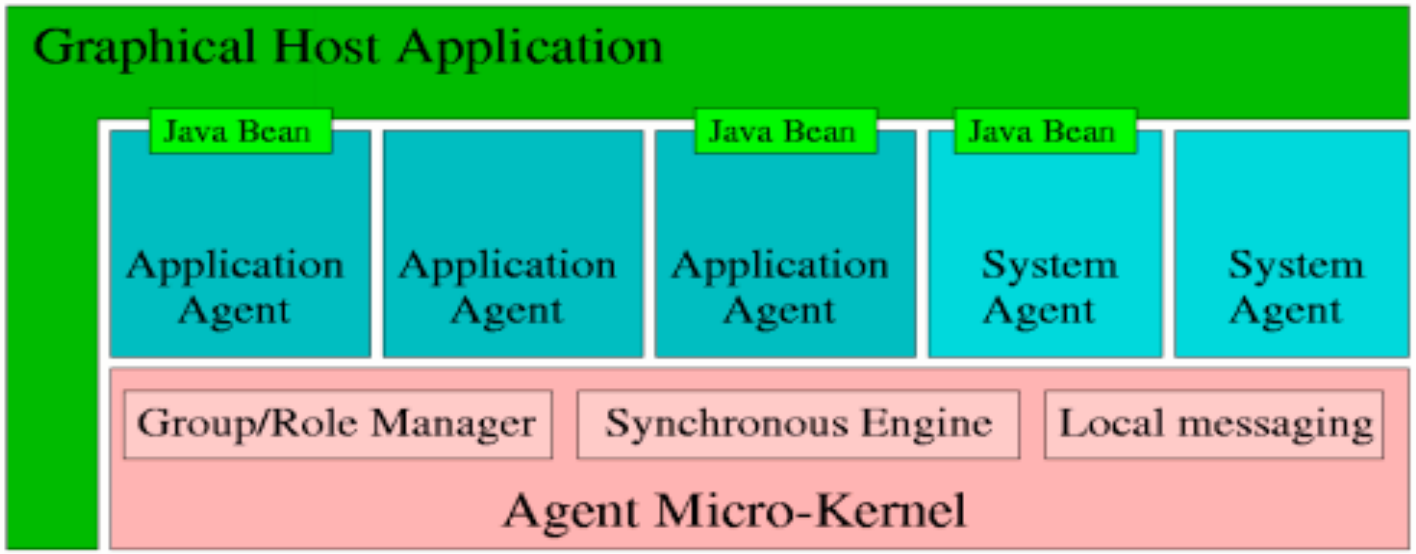
Agents using TAEMS

- Agents using TAEMS:
  - Belief database
  - Local scheduler
  - Coordination module



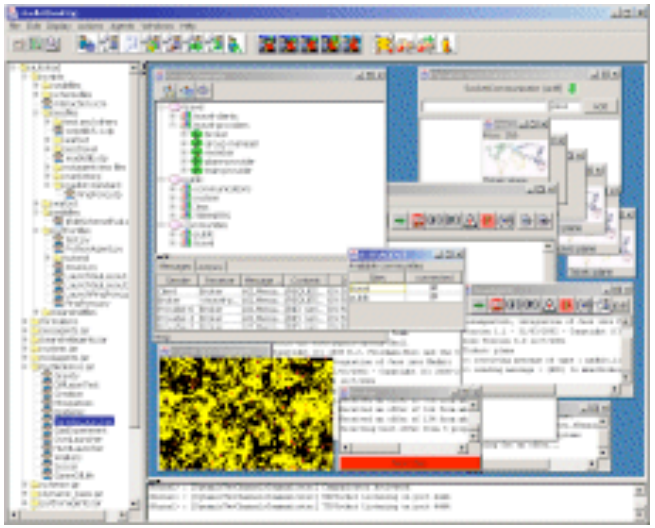
- The scheduler uses information in the database to schedule execution of methods, in a way to maximize quality.
- The coordination module handles communication with other agents and makes/breaks commitments with them in order to complete tasks.

MADKIT



Multi-Agent Development Kit

www.madkit.org



TEAMCORE

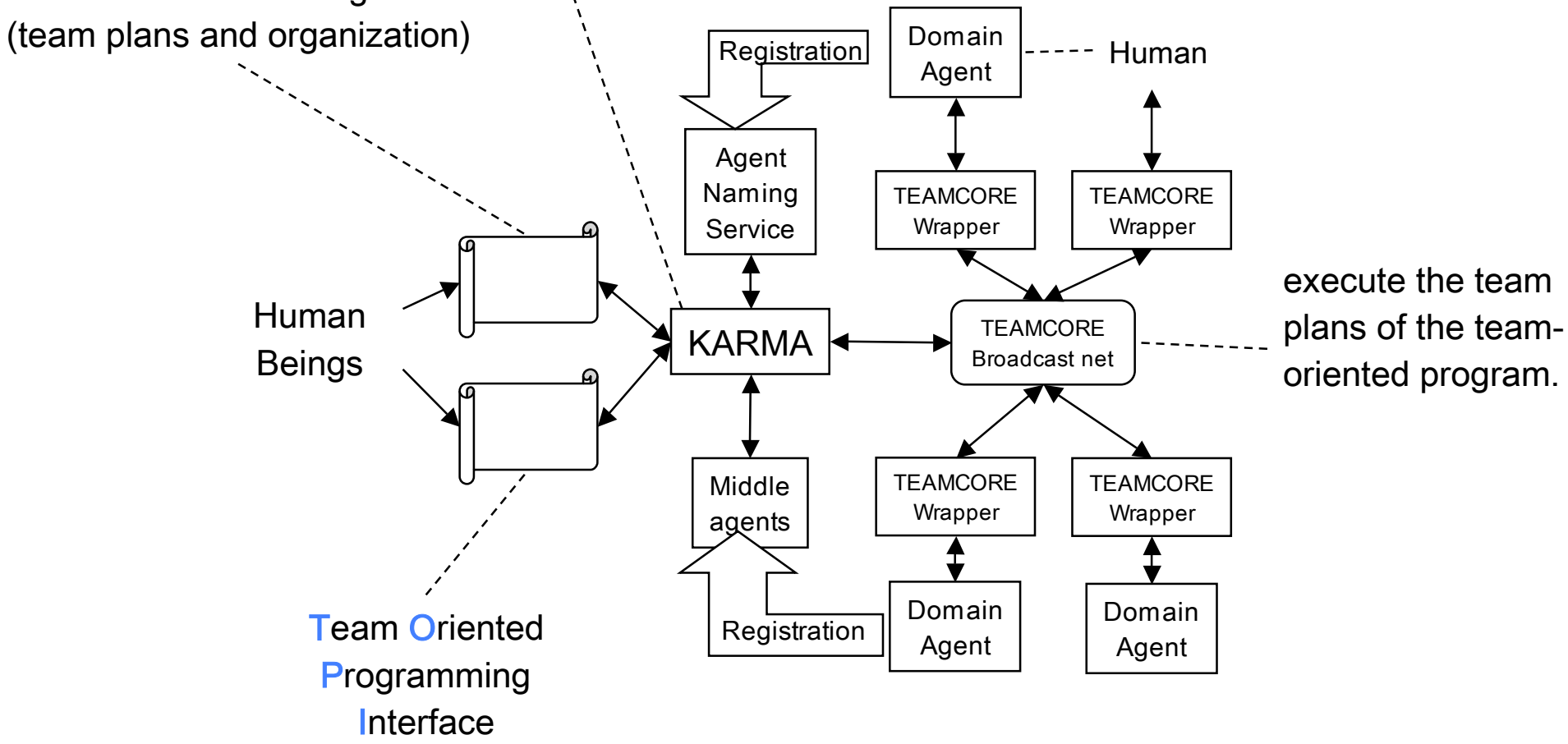
[Pynadath 03]

- Core Team Reasoning (TEAMCORE) focuses on enabling software developers to build large-scale agent organizations
  - Specification and monitoring of the agent organization
    → Knowledgeable Agent Resources Manager Assistant (**KARMA**)
  - Robust teamwork among agents
    → **TEAMCORE Wrappers** based on STEAM Teamwork model

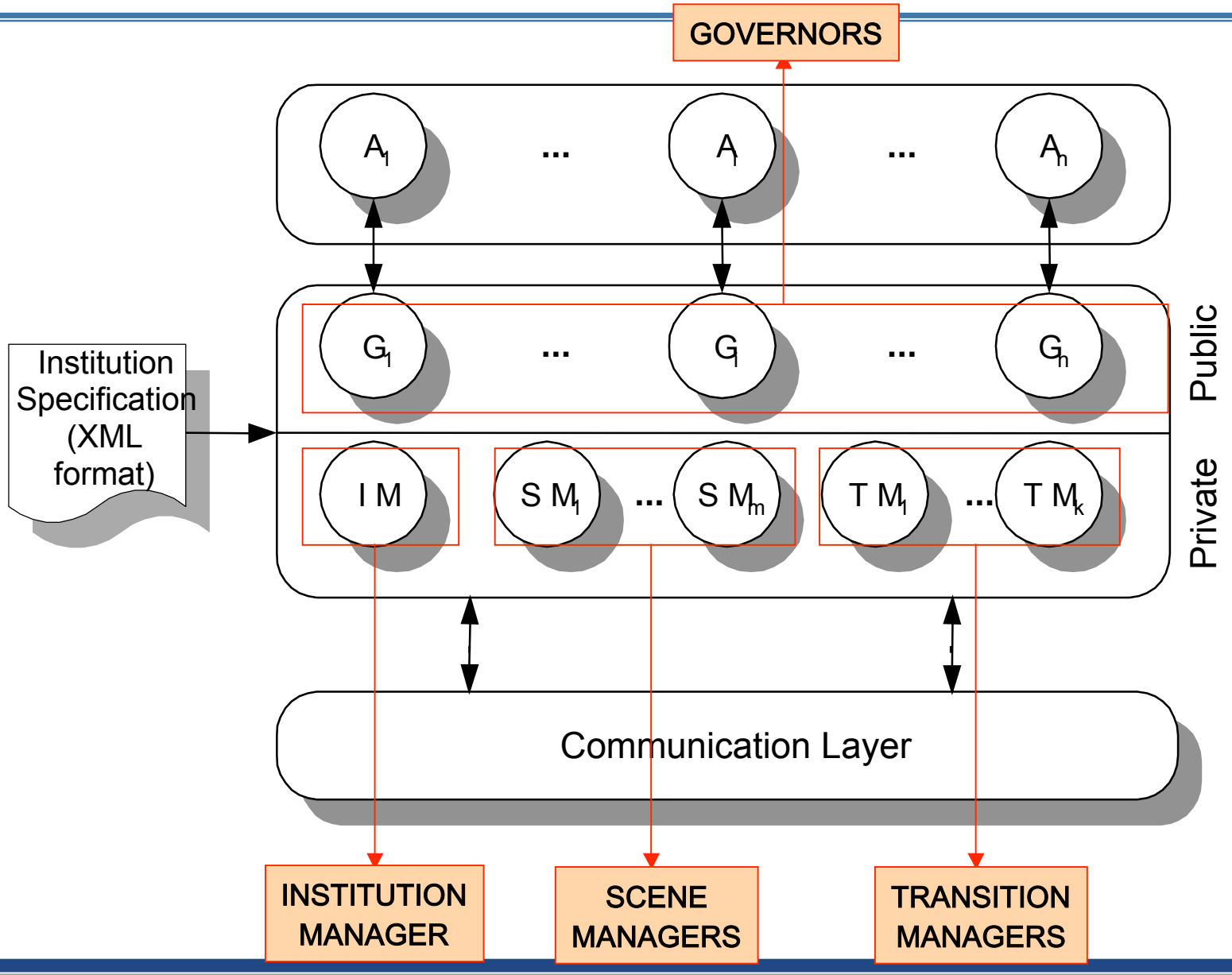
TEAMCORE

requirements for roles
searches for agents with relevant expertise
assists in assigning agents to organizational roles.

From [Pynadath 03]



AMELI

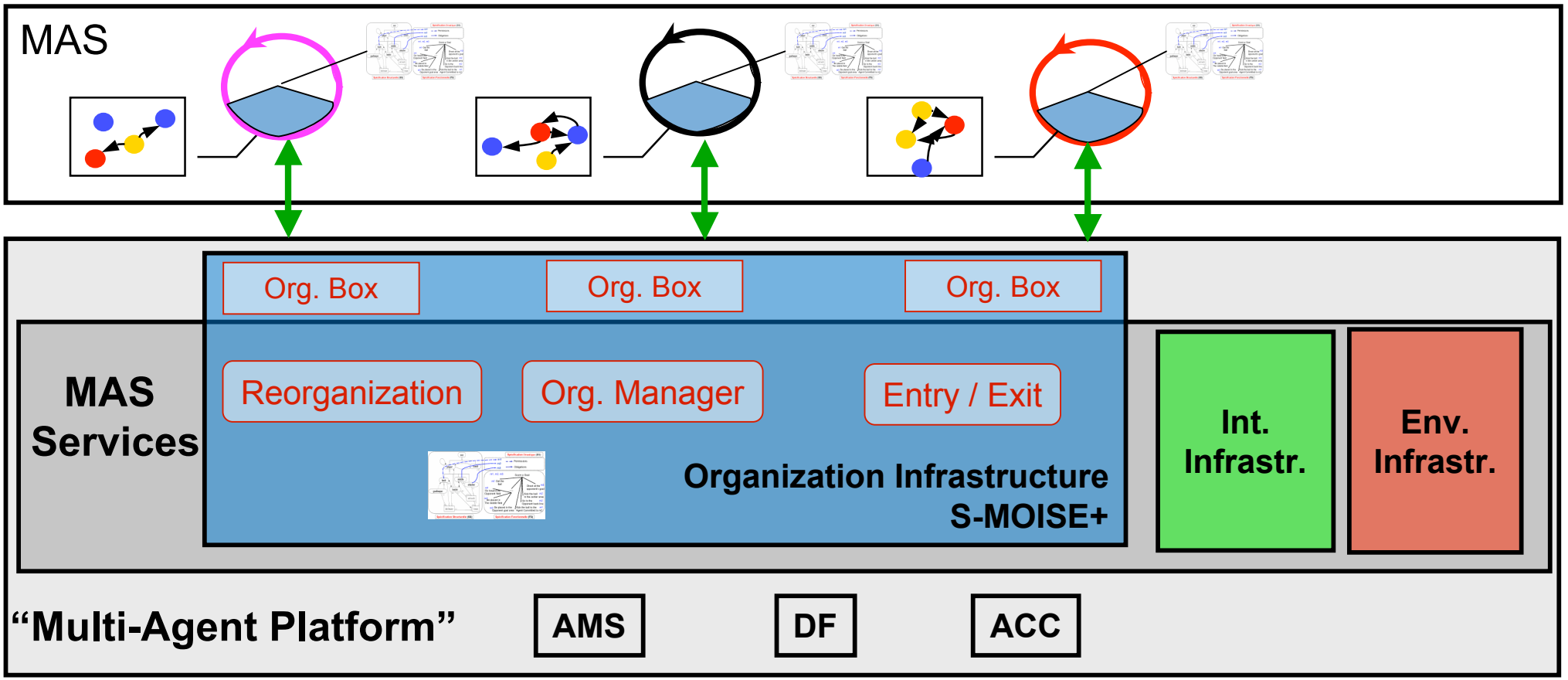


[Esteva 04]

From [Noriega 04]

OI supporting MOISE+

[Hübner 03]



- Organization Modeling Language: MOISE+ [Hubner 02]
- Organization Infrastructure: S-MOISE+ [Hubner 05],
- Organization Deliberative Agent: J-MOISE+ [Hubner 06]

S-MOISE+ OrgBox Services

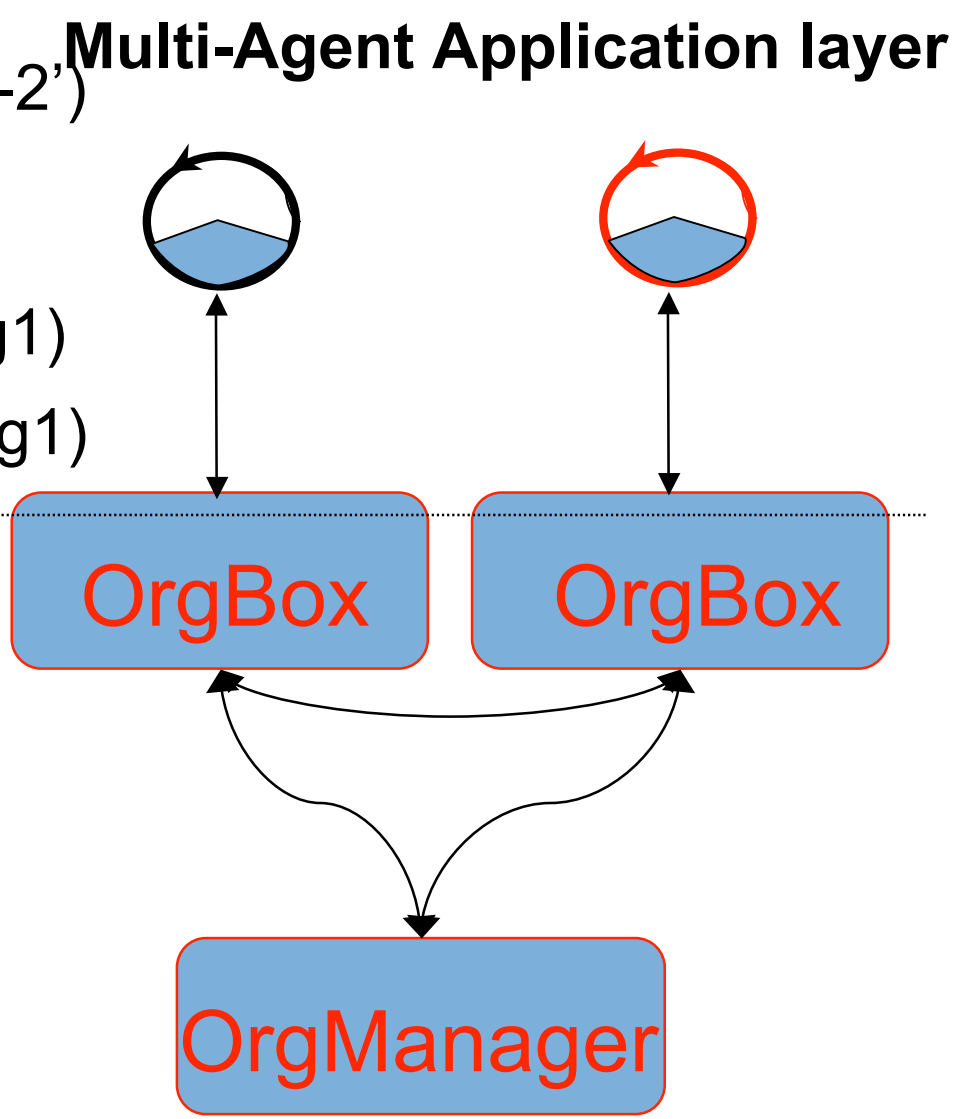
- Communication:
  - sending/receiving messages to/from other agents
  - verification of communication links
- Generation of organizational events:
  - agents may enter the system, commit to a role, create a group
- Informing obligations:
  - OrgBox keeps the agent informed of the missions it is obliged to commit
- Informing possible goals:
  - OrgBox keeps the agent informed of the possible goals it can choose to achieve

S-MOISE+ Organizational Events

- Organization life-cycle
  - Entrance/Exit of an agent
  - Creation/Deletion of an OE
- Structural Organization life-cycle
  - Creation/Deletion of a group
  - Adoption/Release of a role by an agent
- Functional Organization life-cycle
  - Creation/End of a schema
  - Commitment/Release of a mission by an agent
  - Change of a global goal state

S-MOISE+ Events Examples

1. oe1=createOE(‘score a goal’, ‘3-5-2’)
2. g1=createGroup(‘team’,oe1)
3. g1-1=createSubgroup(‘defense’, g1)
4. sc1=createScheme(‘side_attack’, g1)

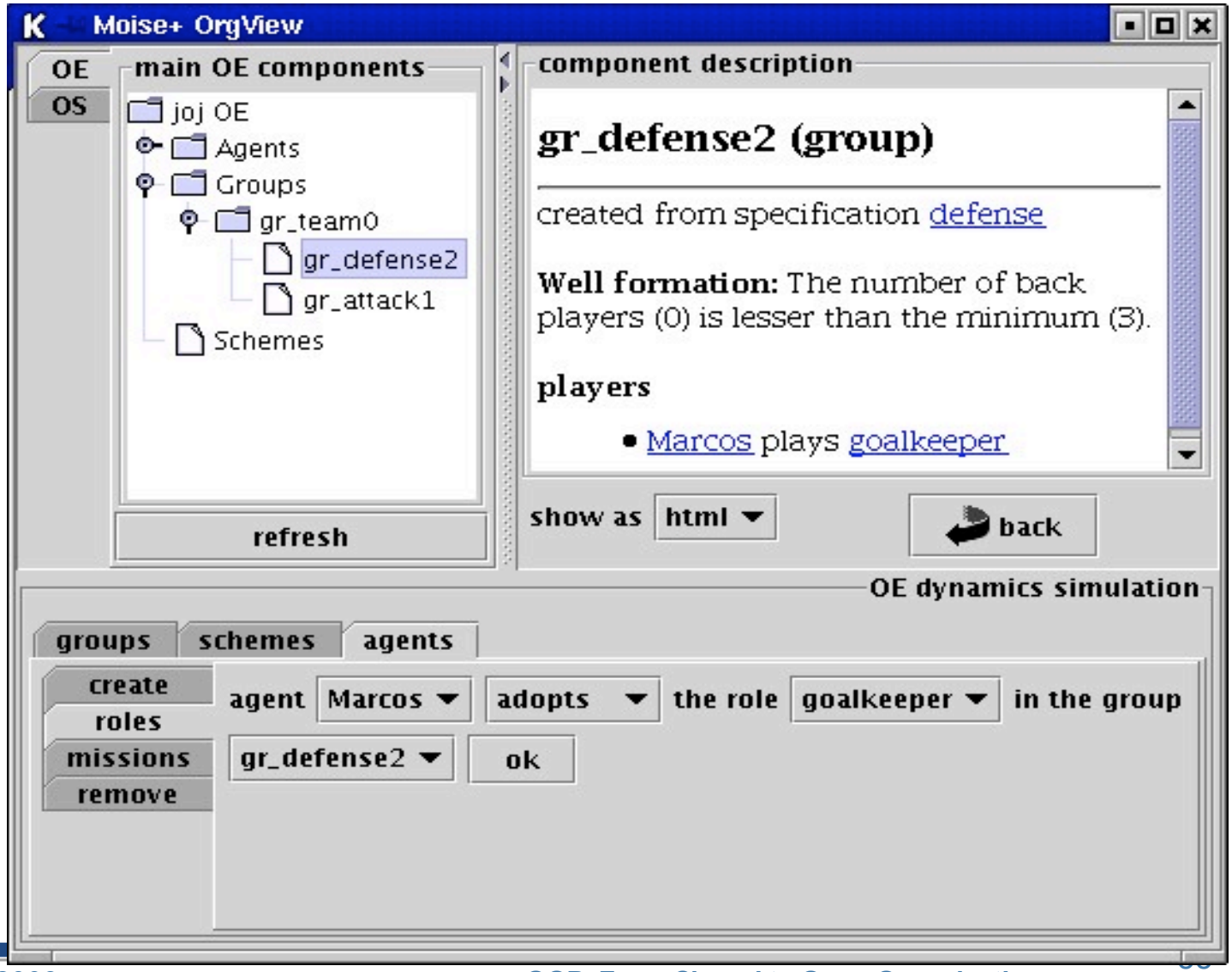


S-MOISE+
Organizational Infrastructure

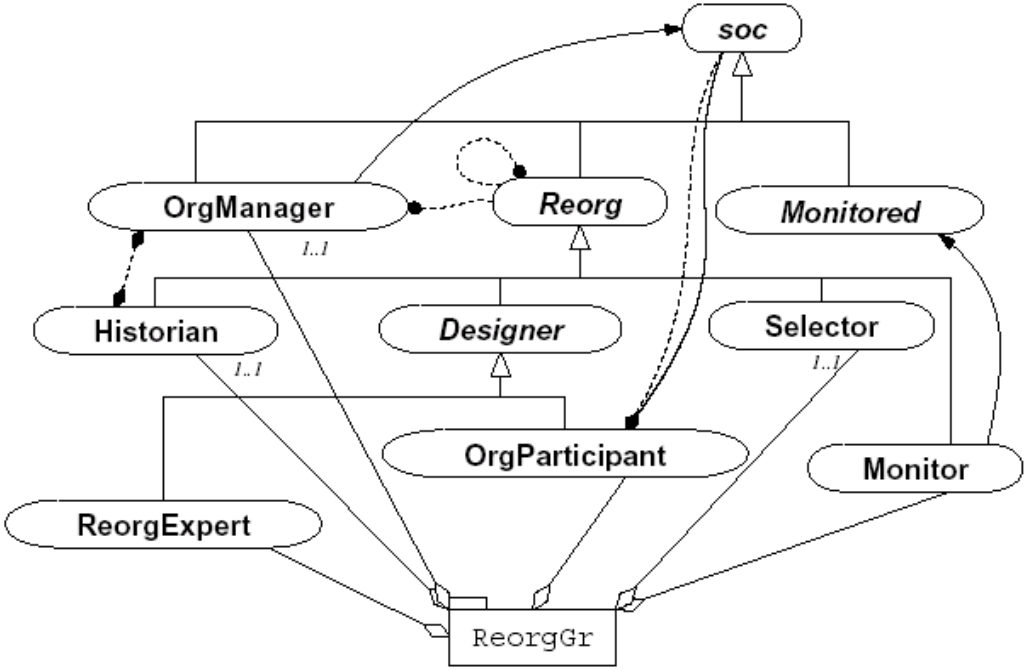
S-MOISE+ OrgManager GUI

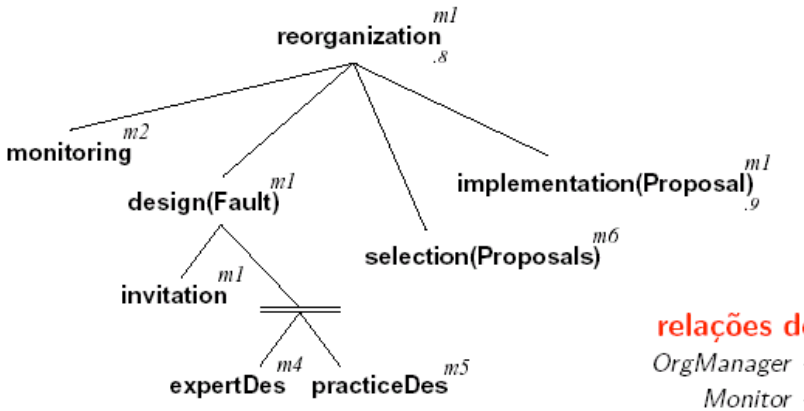
Organizational Entity after the events

The defense group is not **well formed** since there is no agent playing 'back' role



Reorganisation Organization Specification





relações deônticas:

$OrgManager \rightarrow obl(m_1)$

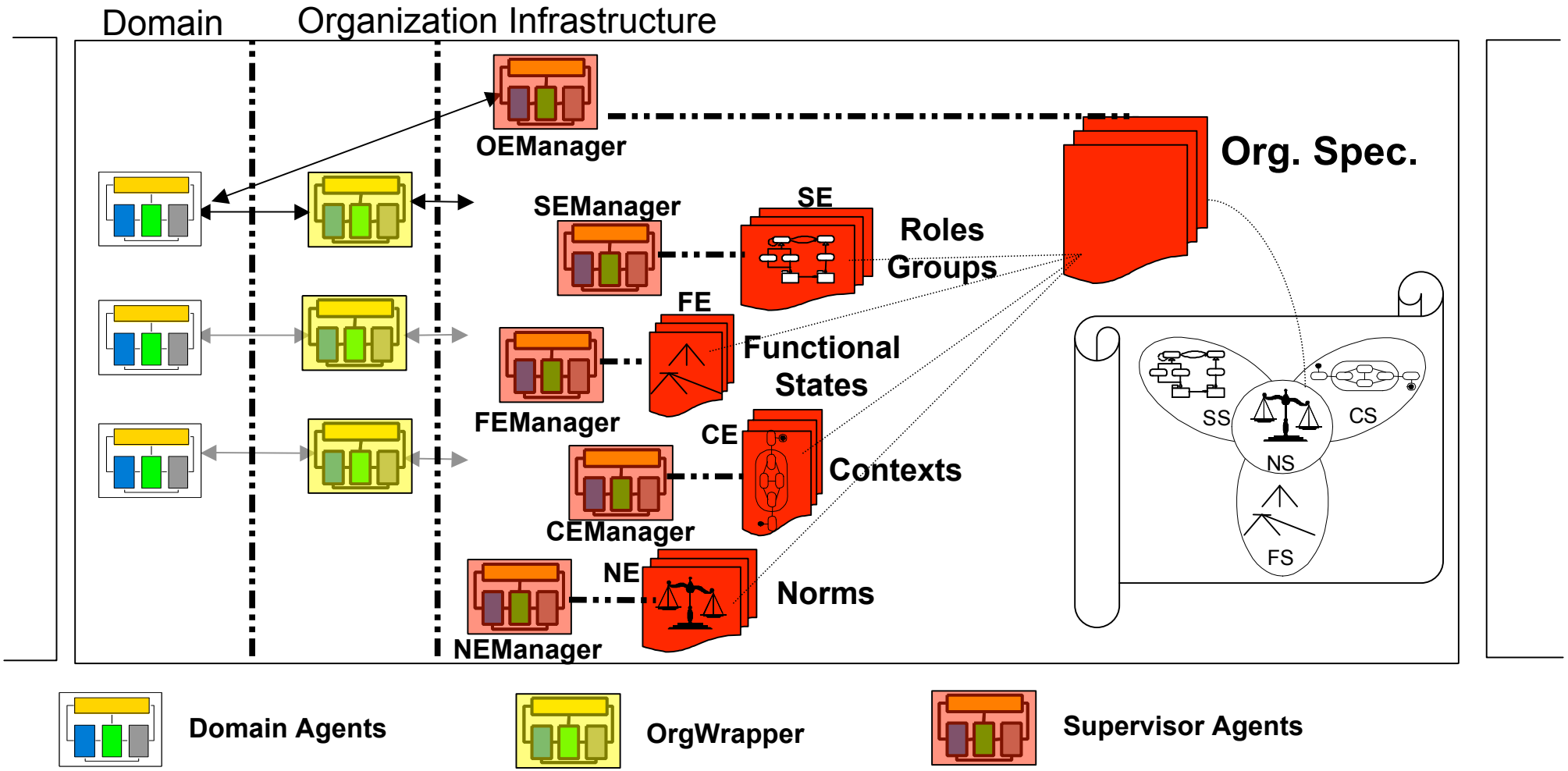
$Monitor \rightarrow obl(m_2)$

$ReorgExpert \rightarrow obl(m_4)$

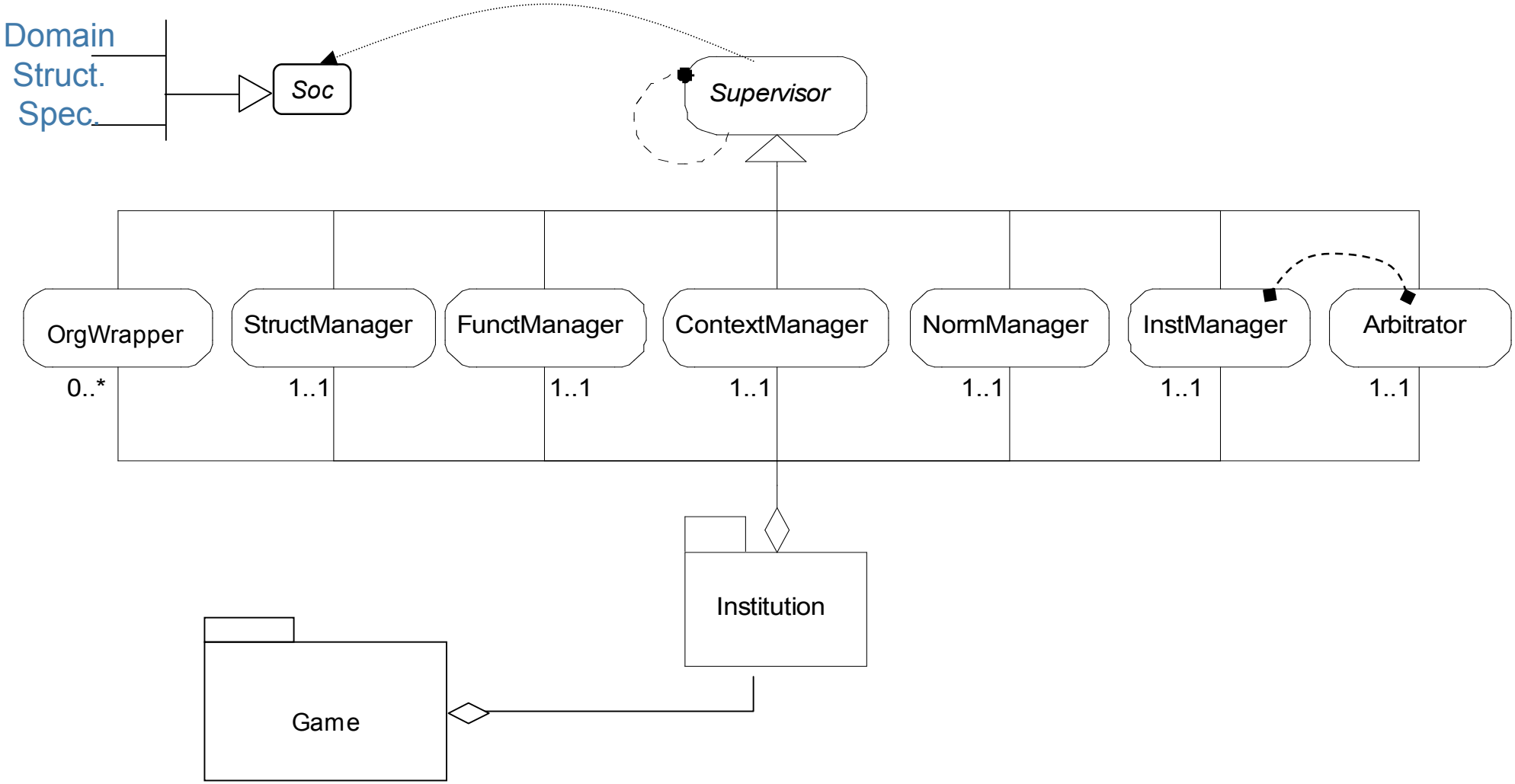
$OrgParticipant \rightarrow per(m_5)$

$Selector \rightarrow per(m_6)$

MOISE^{Inst}-SYNAI Architecture

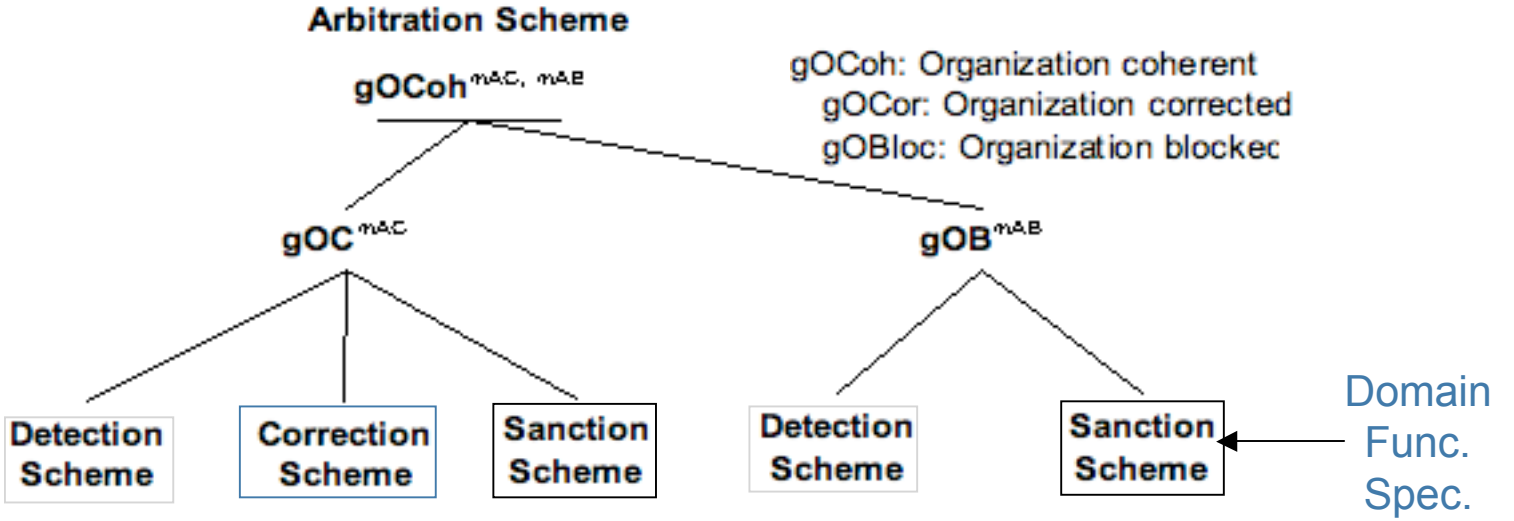


MOISE^{Inst}-SYNAI Regulation SS

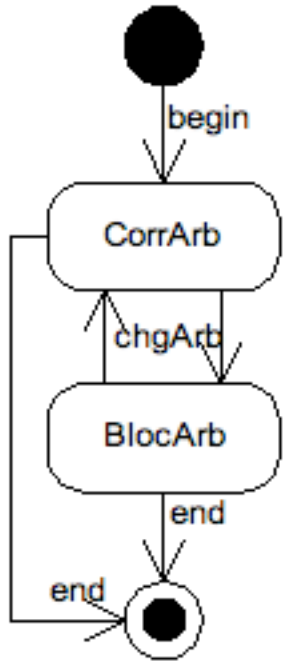


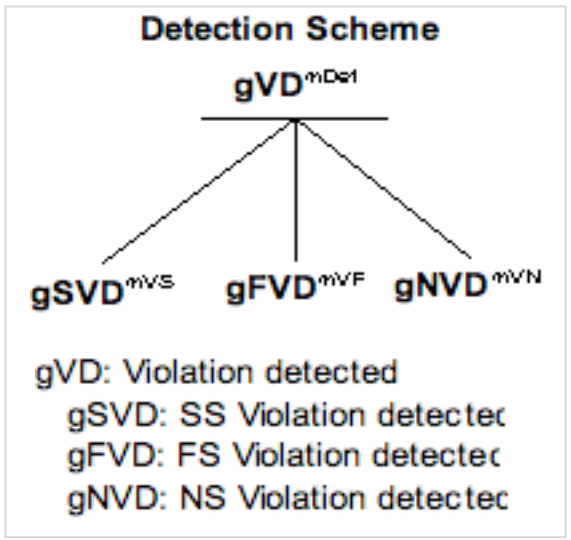
MOISE^{Inst}-SYNAI Regulation FS & CS

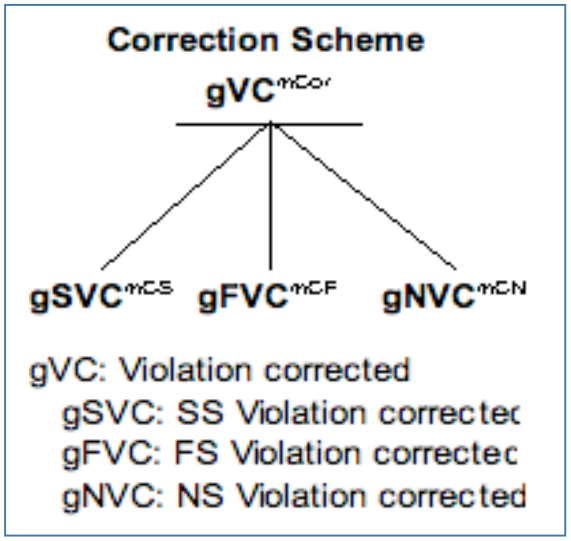
Corrective and Preventive Monitoring Modes



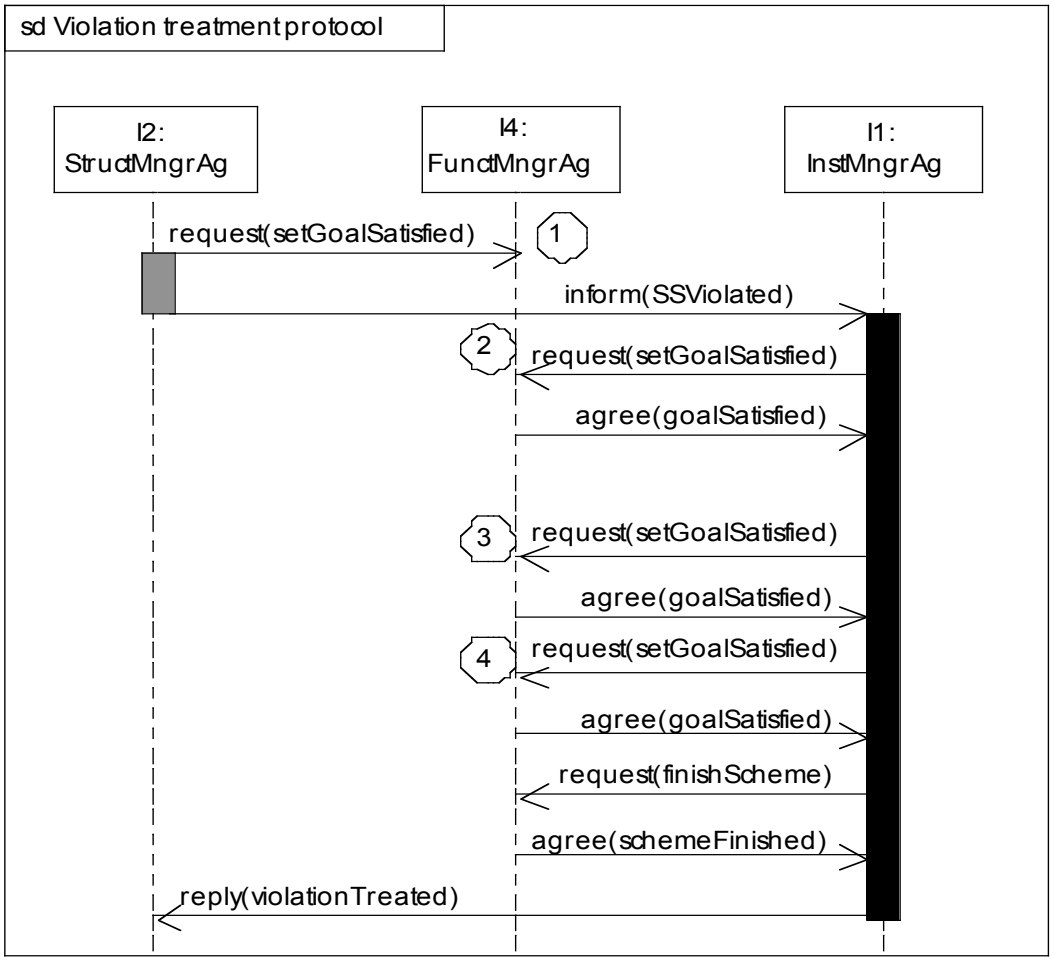
Domain Func. Spec.

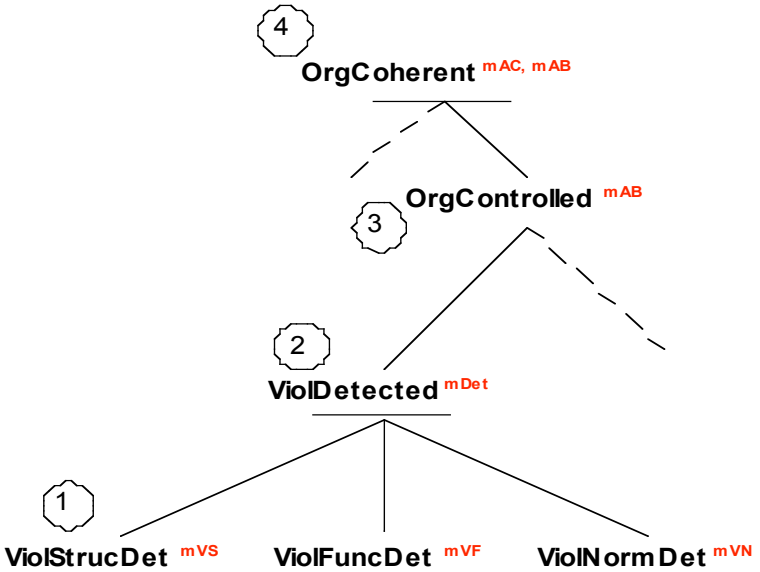






MOISE^{Inst}-Violation Detection





iTV Application

Organization and Rules of the Game.

Avatars

MAS

Domain Agents

SS
CS
NS
FS

Synai

MAS Services

Interaction Services

Environment Services

"Multi-Agent Platform"

AMS

DF

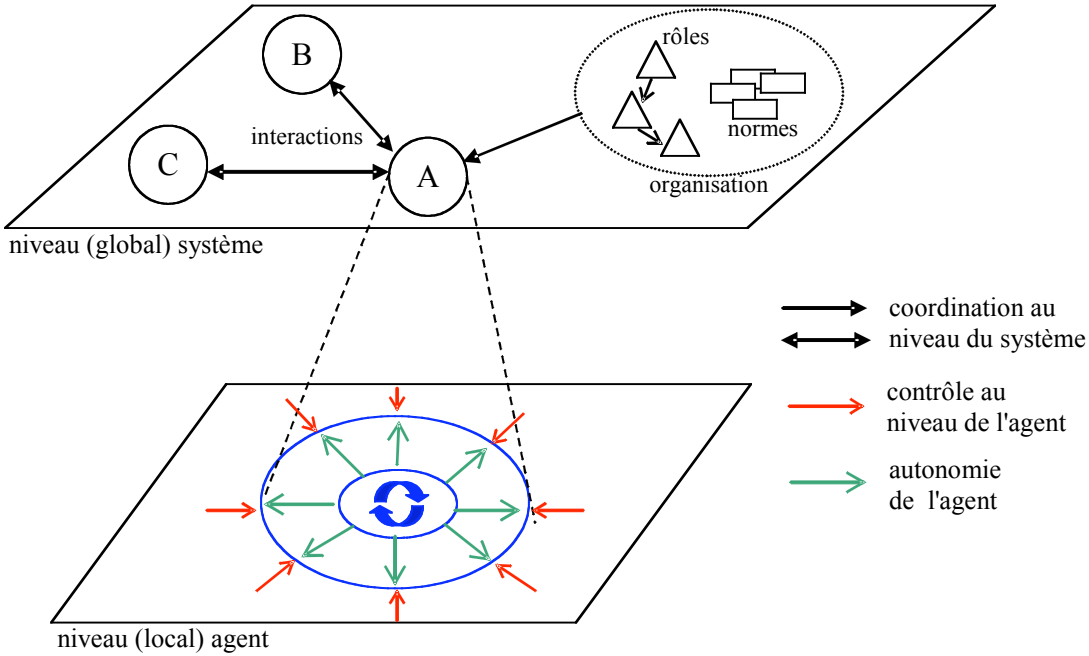
ACC

Outline

1. Introduction
2. Organization Modeling Language
3. Organization Infrastructure
4. Organizational Deliberative Agent
5. Conclusion and Perspectives

Agents in Open Organizations

- Agent centered point of view : Autonomy based reasoning [Carabelea 07]



- Coordination (system) → control (agent) ←→ autonomie
  - Balancing autonomy and control (Chopinaud 2007)

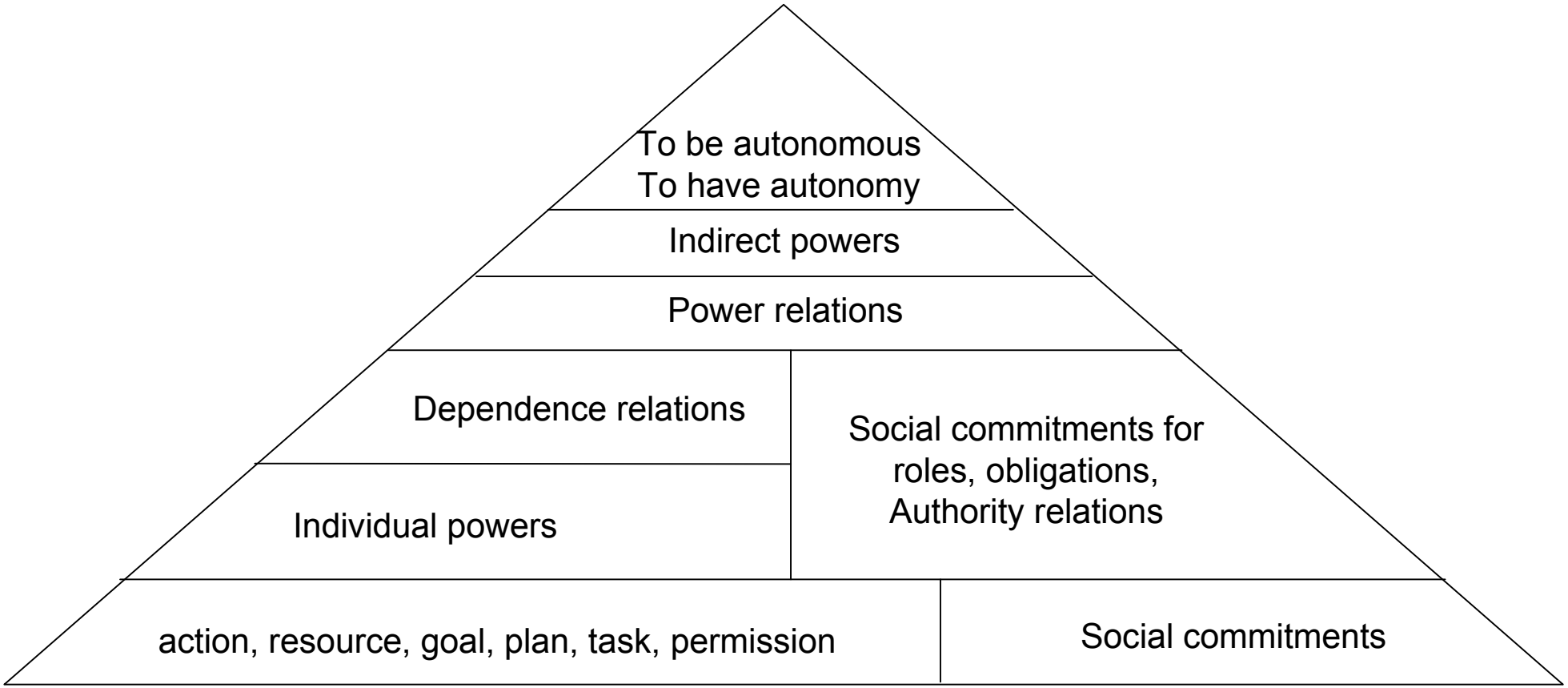
AC-Autonomy based reasoning (1)

Internal perspective: To have autonomy to decide

Constraints	Inter-agent	institutional
Decision	Dependence Theory	Authority Links
	Social Politics (normes) Social Power Theory	
Behaviour	Social Commitments	roles norms attached to roles contract to play a role

External perspective : To be in an autonomous behaviour

AC-Autonomy based reasoning (2)

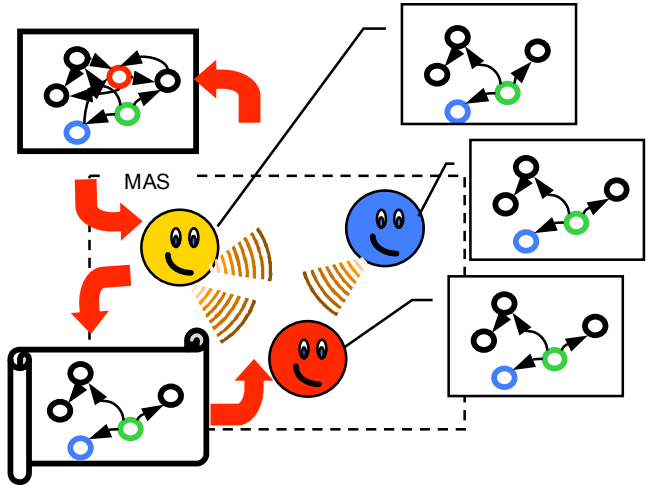


Outline

1. Introduction
2. Organization Modeling Language
3. Organization Infrastructure
4. Organizational Deliberative Agent
5. Conclusion and Perspectives

From Closed to Open Organizations

- What we “have”:
  - Declarative Organization specified with OML
  - Monitoring and Supervision of the agents to ensure coherent organization
  - Building Blocs for “Organizational Deliberative” Agents to ensure adaptation, reorganization,
- What we need:
  - to combine ACPW and OCPW models
  - to combine agent and middleware levels programming of organizational models
  - Organizational Deliberative Agents for emergent organization

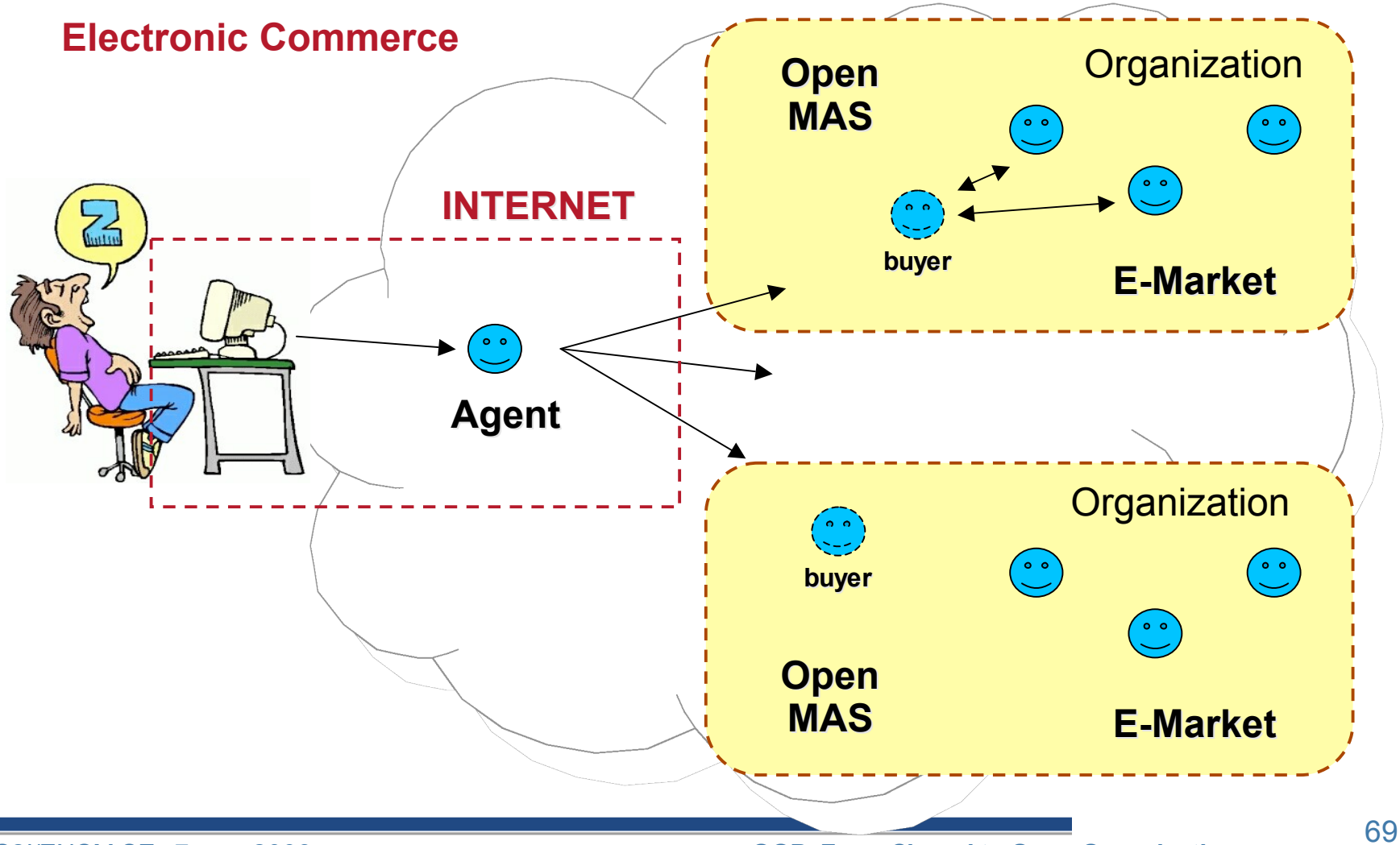


Perspectives

- Organizational Modeling Language
  - Dimensions: are there other dimensions?
  - Evaluation
    - » robustness, flexibility, consistancy
    - » design [Hannoun 98] and run time
- Organization and Agent's Autonomy
  - deontic and normative aspects explicit in the model (e.g.: MOISE+, MOISE^{Inst}, OMNI)
  - Autonomy based reasoning
- Organization Infrastructure
  - Organizations life cycle : formation, dissolution, exit/entering of agents
  - Reorganization, Monitoring and supervision
  - Instrumenting Organization to give back the power to the agents
- Agents in Multiple Organizations
  - interoperability, conflicts, preferences, agent-centered autonomy based reasoning

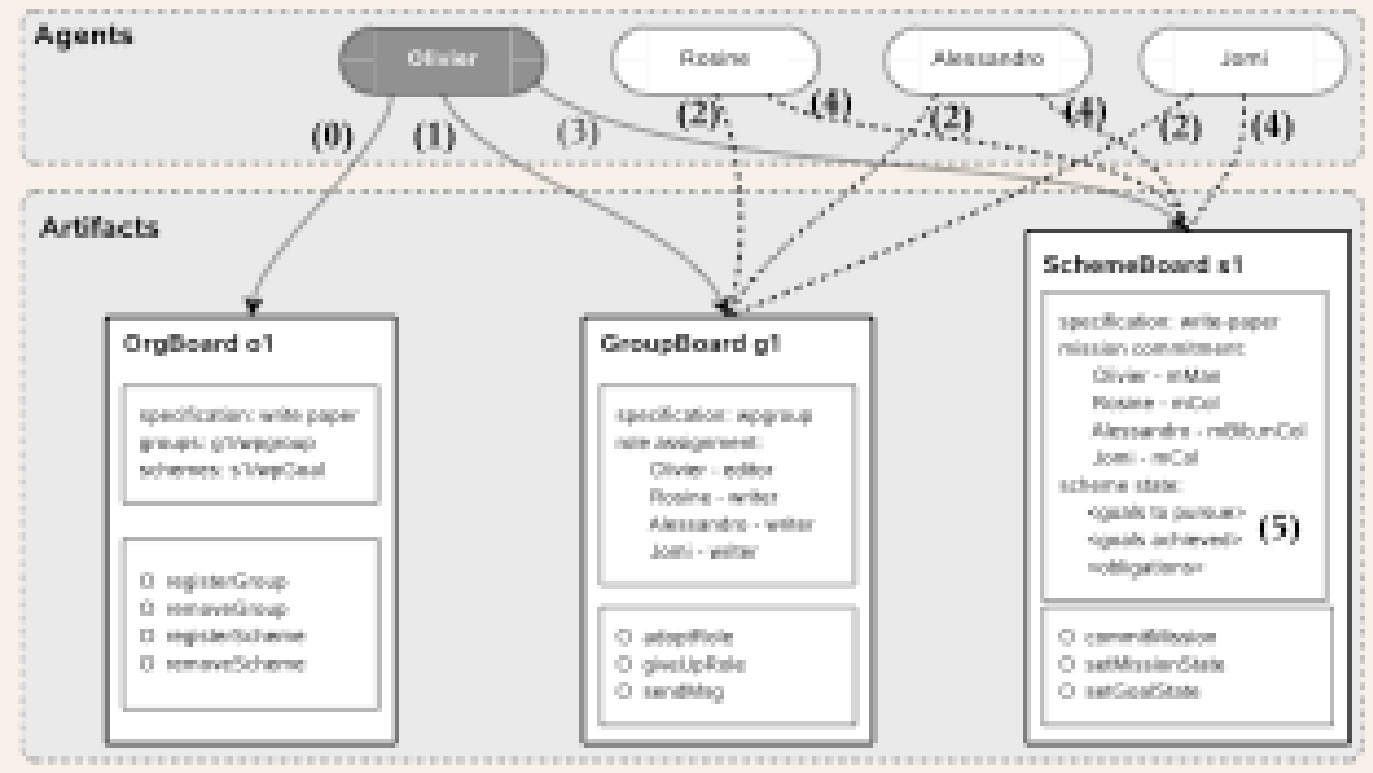
Agents in Multiple Organizations

Organizational Models Interoperability [Coutinho 06]



Instrumenting Organizations

Organizational Artifacts for MAS (ORA4MAS) [Kitio 07]



ACKNOWLEDGEMENTS

THANK YOU FOR YOUR ATTENTION

- USP-COFECUB cooperation program

- Jaime Simão Sichman, University of São Paulo, Brazil
- Jomi Fred Hübner, University of Blumenau, Brazil
- Alessandro Ricci DEIS Univ. Bologne, Italy
- Rosine Kitio, Cosmin Carabelea, Benjamin Gâteau, Mahdi Hannoun, Thibault Carron, ENS Mines Saint-Etienne, France