MASTER WEB INTELLIGENCE

Systèmes Multi-Agents

Organization

Olivier Boissier
Olivier.Boissier@emse.fr

23 Septembre 2003

Outline

- Organization in MAS
  - Definitions
  - Motivations
  - History
  - Dimensions
- Organizations with a System Centered Point of View
- Organizations with an Agent Centered Point of View
- Dynamic of Organizations
- Conclusion

Definitions

a) A decision and communication schema which is applied to a set of actors that together fulfill a set of tasks in order to satisfy goals while guarantying a global coherent state [Malone 87]
→ **definition by the designer, or by actors**

b) An organisation is characterized by : a division of tasks, a distribution of roles, authority systems, communication systems, contribution-retribution systems [Bernoux 85]
→ **normative** system

c) An arrangement of relationships between components, which results into an entity, a system, that has unknown skills at the level of the individuals [Morin 77]
→ **emergence**

MAS features

- Needs to insure a global behavior at the system level (cooperation, collaboration, …)
  - To be sure that the global goals of the system are achieved

Despite or Thanks

- Autonomy of the agents : agents act autonomously according to their goals, skills,
  - Different levels of autonomy may be distinguished [Castelfranchi 98]
- Delegation/Adoption of tasks between the agents

Application features

- Increase in
  - Number of agents,
  - Duration and repetitiveness of agent activities,
  - Heterogeneousness of the agents, Number of designers of agents
  - Ability to act, to decide,
  - Action domains of agents, …
- Integration of human communities and technological communities (ubiquitous and pervasive computing)
  - Trust, security, …, flexibility, adaptation

History

- → **90 :** Beginnings
  - 77 : Distributed Hearsay-II (area of interest) [Lesser 79]
  - 81 : An Organizational View on Distributed Systems [Fox 81]
  - 87 : DVMT [Corkill, Pattison 87]
  - 89 : MACE [Gasser 89], Roles [Werner 89]
- → **00 :** Maturation
  - Dependence networks [Castelfranchi 92]
  - CASSIOPEE [Collinot 96], MARSO [MARCIA 97]
  - [Bouron 92], AGR [Ferber Gutknecht 98]
  - Computational Organization Research [Carley 99]
- → **01 :** main dimension in MAS
  - MAAMAW 01
  - Workshops Norms, Institutions

Dimensions [Gasser 01]

- ***Theoretical*** : Abstract and general models of possibilities, limits, and mechanisms of organization ;
- ***Phenomenological*** : Description/analysis/explanation of existing (human, biological, computational, physical, etc.) organizations ;
- ***Technological*** : technologies for solving complex problems, for overcoming « individual » limitations (cognitive, physical, temporal, institutional, etc), and as efficiency optimization strategies

→ **C**omputational **O**rganization **R**esearch

Inspiration sources [Demazeau 02]

- Mathematics, Computer science
  - [Corkill 83], [Bouron 92], [Boissier 93]
- Mechanics, Thermodynamics
  - Sigma [Baeijs 98], Friends [Van Aeken 99]
- Sociology,
  - [Pattison 87], [Bond 92], [Gutknech 98], [Costa 96], [Hannoun 99], …
- Social Psychology
  - [Sichman 95]
- Ethology
  - [Drogoul 93], …

Organization typology [Baeijs 96]

- Centralised
  - Simple hierarchies : centralized decision,
  - multi-level hierarchies : decision on different levels
  - recursive structures : …
- Decentralized
  - multiple hierarchies :
  - Market : contractual dimension
- Unstructured
  - Groups : shared goal, task division, heterarchical decision, several information exchanges
  - Teams : common environment in which agents interact,
  - SIG : interest sharing
  - Communities of practice : grouping of individuals in an independent manner of existing organizations

Where is the organization ?

- In the eye of the Designer → Design of organization
  - Organization = explicit specification
  - Subjective point of view (Human centered)
- In the eye of the Observer → Emergence of organization
  - Organization = result of the functioning, description
  - Implicit representation through one of A,E,I dimension
  - Objective point of view (Human centered)
- In the Agents → Combination of Design and Emergence

Explicit Representations [Castelfranchi 98]

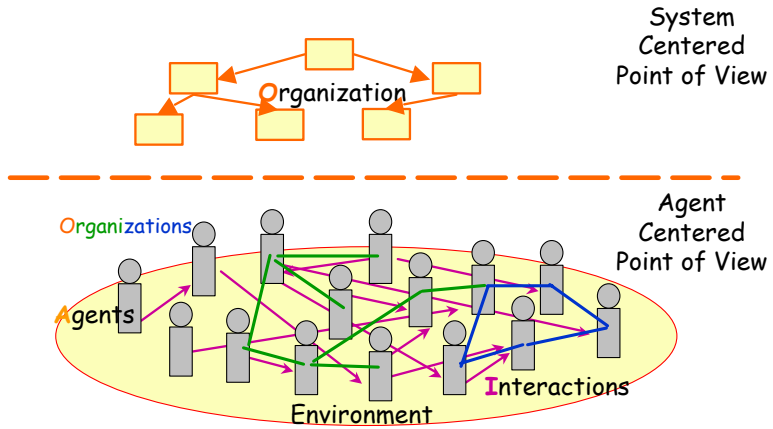
- Dependence, power relations
- Accointances,
- Communication,
- Commitments (delegation and adoption relations which exist between agents),
- Rules and pre-established norms bearing on actions and interactions.

Aim of the organization

- **Social**, aide to cooperation
  - Who to cooperate with, why cooperate, force cooperation, …
- **Normative**, control the MAS
  - Deontic modalities (Obligation, Permission, Interdiction),
  - Normative, what's the limits ?
    Quid of the agents autonomy ?

Dimensions

System vs Agent



Outline

✓ Organization in MAS

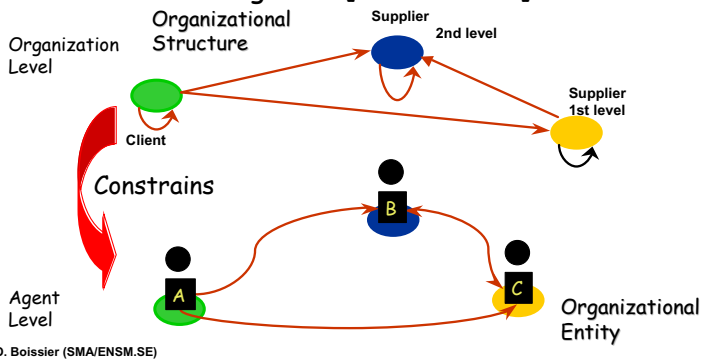
➢ **Organizations with a System Centered Point of View**

- **Main features**
- **Agent Group Role**
- **MOISE+**
- **How to program it ?**

- Organizations with an Agent Centered Point of View
- Dynamic of Organizations
- Conclusion

Main features (1)

« The leading concept is the **group** or the **organization** instead of the agent » [Lemaître 98]



Main features (2)

- Make a clear distinction between description of organization and description of agents
  - Two levels : organization and agent
- Agents are dynamic, autonomous entities that evolve within organizations
  - Organizations constrain the behaviors of the agents
  - Organizations may be the result of the activities of agents

Main Features (3)

- Organizational models are in the "eye" of the designer
- Multiple Organizational models :
  - Roles
    - [Kendall 98], [Stone-Veloso 98], …
  - Organizational Structure
    - [Pattison 87], [Werner 87], [Le-Strugeon 95],
    - Agent-Group-Role [Gutknecht-Ferber 98]
    - MOISE [Hannoun 99], MOISE+ [Hubner 02]
  - Norms
    - [Verhagen 00], [Dignum 96], Social Laws [Shoham 92], [Conte 99]
  - Institution
    - [Sergot 99], [Esteva, Sierra 01], …
- Organizational models may be an aide and tool for the designer
  - Methodology : CASSIOPEE [Collinot 96], AALAADIN [Ferber], MESSAGE [Garijo 01], GAIA [Wooldridge 00]

AGR

Agent/Group/Role Model

- Developed by [Ferber, Gütknecht 98]
- Previously known as AALAADIN
- Used within the Madkit platform
- Agent
  - Active entity that plays roles within groups. An agent may have several roles and may belong to several groups.
- Group
  - Set of agents sharing common characteristics, i.e. context for a set of activities.
  - Two agents can't communicate with each other if they don't belong to the same group

AGR

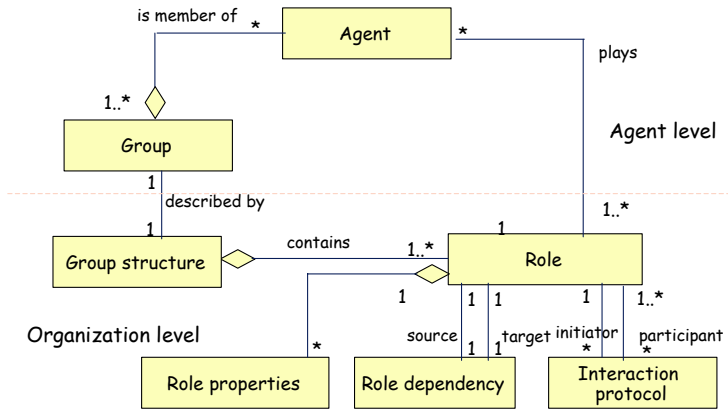
Role

- Abstract representation of the status, position, function of an agent within a group.
- Roles are local to group
- Several agents can play the same role.

- A role is a description of an expected behavior of an agent
- A role describes constraints that agents playing that role should satisf
- Roles are interrelated through interaction description and relation/dependencies between roles

AGR

Complete meta-model

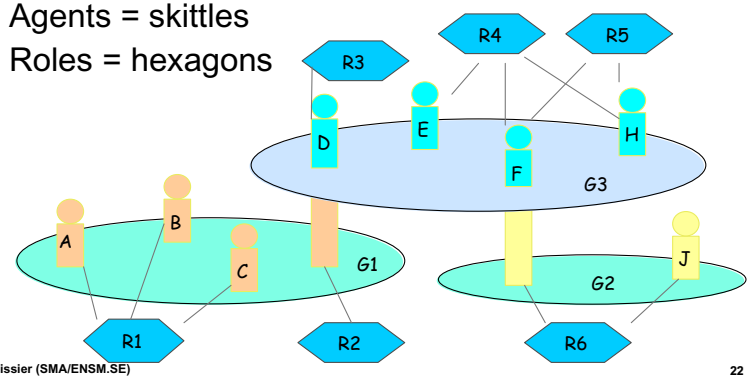


Abstract Concepts

- Group Structure
  - Abstract definition of a group
  - Contains description of roles, relations between roles, interaction specification
  - Taxinomy of group structures
- Organizational Structure
  - Set of group structures and description of their relations

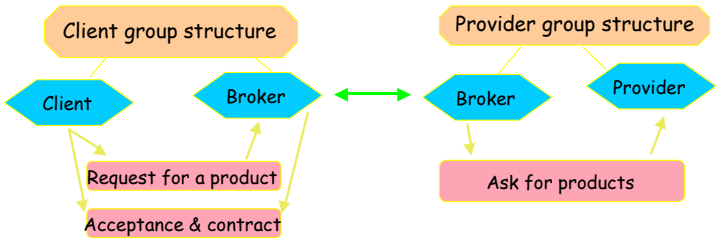
Agent Level Notations

- Groups = ovals
- Agents = skittles
- Roles = hexagons

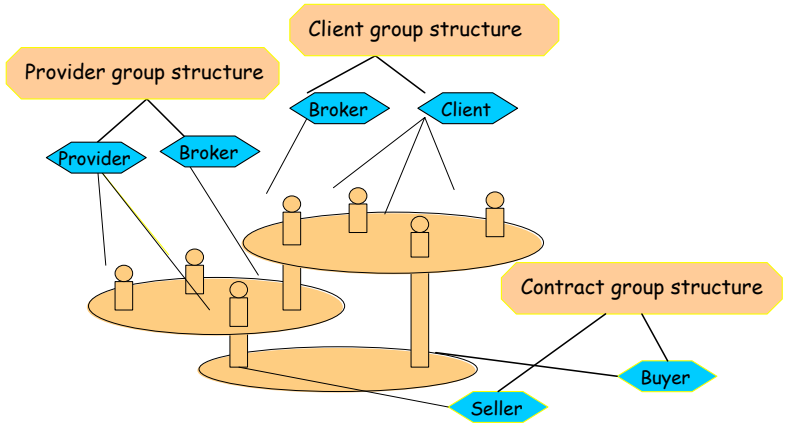


Organizational level Notations

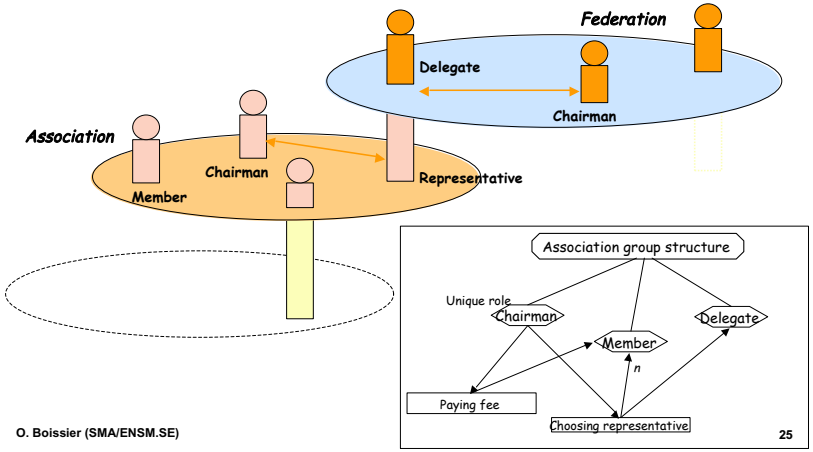
- Group Structures = octogons
- Roles = hexagons
- Interactions = rounded rectangles
- Constraints between roles = arrows



Agent & Organizational Levels



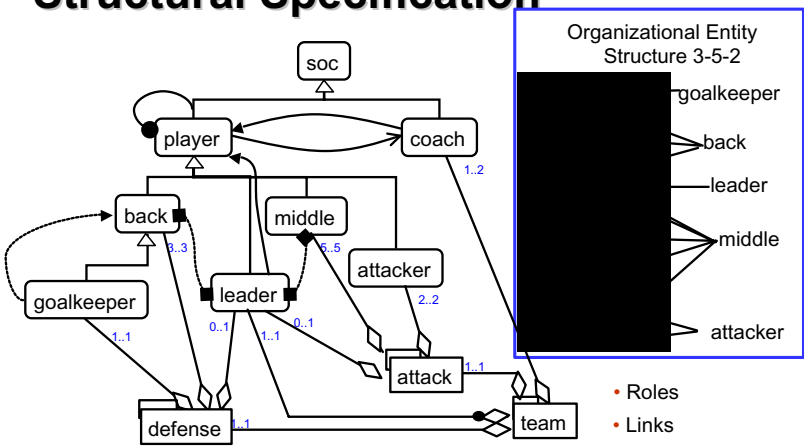
Hierarchies representation



MOISE+

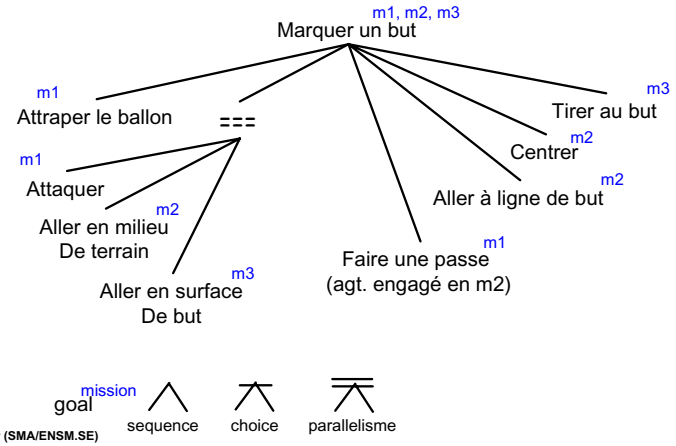
- Developed by [Hubner 02]
- http://www.lti.pcs.usp.br/moise
- Three specifications :
  - Structural specification
  - Functional Specification
  - Deontic Specification

Structural Specification



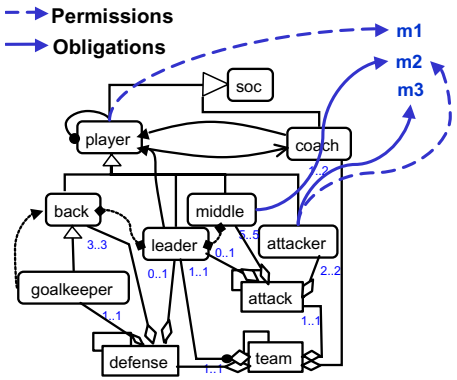
- Roles
- Links
- Groups

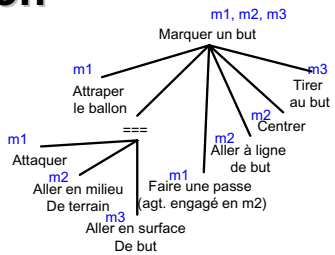
Functional Specification



MOISE+

Deontic Specification





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

How to program SCPW Org. Models in MAS ?

- "Agent Centered Programming"
  - Agents Reasoning on Norms [Boela 00, Castelfranchi 99, Ossowski 99]
    - Representation of norms, of the organization, …
    - Deliberation on respect/violation of norms, of the organization, …
    - Reaction to violation of norms, organizations by other agents

How to program SCPW Org. Models in MAS ?

- "System Centered Programming"
  - Definition of "services" in the MAS Middleware for realizing organizations
    - Filters [Minsky 91]
    - Institutions [Dignum 01, Oliveira 99, Dellarocas 00, Esteva 01]
      - Exception Handling, diagnostic, repearing, …
    - Team Oriented Programming [Tambe 00] : shell for execution of Team specifications
    - Policy FIPA : how to constrain agents by services
      - Policy Constraints : permission or obligation, contract, related to conversations, processing,
      - Policy Domain : agents + policy constraints
      - Policy Mechanisms = enforcement mechanisms (guards, sanctions, exceptions, reputation)

Outline

✓ Organization in MAS

✓ Organizations with a System Centered Point of View

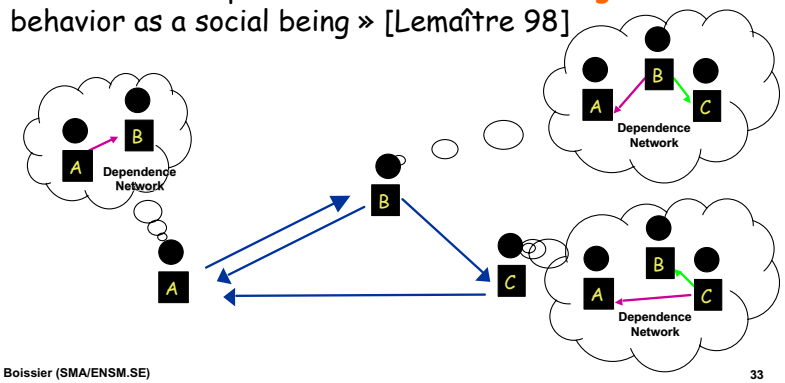
➢ **Organizations with an Agent Centered Point of View**

- **Main features**
- **Social Reasoning Mechanism**

- Dynamic of Organizations
- Conclusion

Main features (1)

« The social concepts are all focused on the agents' behavior as a social being » [Lemaître 98]



Main features (2)

- No distinction between description of organization and description of agents
- Organization are inside the agents, no global representation
- Agents are dynamic, autonomous entities that evolve without any explicit constraint
  - on their behaviors
  - on their communications,

Main features (3)

- Organizational model is in the "eye" of the Agents,
- Organizational model may have a "Social" aim :
  - Joint Intentions [Cohen-Levesque 91]
  - Social Commitment [Singh 97, Castelfranchi 92]
  - Dependence networks [Castelfranchi, Sichman 95], Power relations [Castelfranchi 92]
  - Temporal dependencies [Allouche 00]
  - Goal Dependencies [Ferber 89]
- Or a "Normative" aim :
  - Commitment – Conventions [Jennings 93]
  - Obligations – Permissions [Dignum 96]

SRM

Social Reasoning Model [Sichman 95]

- Class of problems where :
  - Huge networks of processing resources that are heterogenous, autonomous, distributed
  - Openness
  - Remote execution of services,
  - Composition of services,
- in which one should insure :
  - Interconnection and interoperability of its elements,
  - Adaptation of its elements to possible changes in the environment, due to the dynamic entry and exit of services,
  - Existence of an operational model which could allow these elements to cooperate, if they want to.

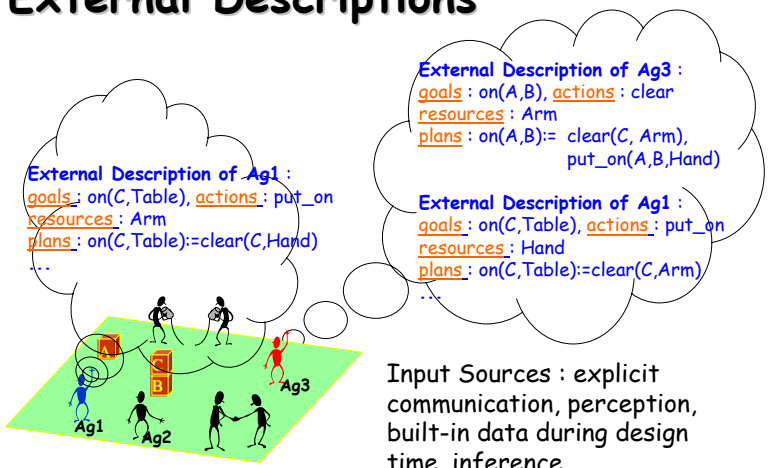
Main features

- Based on Social Power and Dependence theory [Castelfranchi 92]
- Predict, explain occurrence of social interactions, based on the agents' complementarity
- Social reasoning is based on :
  - Explicit representation of the others
  - Explicit reasoning about the others (meta-level, domain independent)
  - Belief revision about the others (in an open scenario, the representation of the others is never correct and complete)
- General Principles :
  - Non-benevolence, sincerity, self-knowledge, consistency

Underlying Hypothesis

- Mentalistic approach
  - Symbolic vs. Decision theoretic approaches
- Absence of domain specific on-line planning
  - Library of plans
- An agent first chooses a goal, then a plan and then the possible partners to whom a cooperation or social exchange proposal is to be sent.

External Descriptions



Input Sources : explicit communication, perception, built-in data during design time, inference

Autonomy – Dependence (1)

Given a goal and a plan whose successful completion achieves this goal, agents may be **autonomous** regarding actions or resources that are used :

- **action-autonomy** [resp. **resource-autonomy**] for a goal, *according to a set of plans*, if there is a plan that achieves this goal in this set and every needed action [resp. resource] in the plan belongs to the agent.
- **social-autonomy** : given a goal if action-autonomy and resource-autonomy for this goal.
- On the contrary, an agent which is not action-autonomous, **action-depends** on an other agent …

Autonomy – Dependence (2)

- **Plan-autonomy** regarding action [resp r-dependance a->r]
  - An agent is a-autonomous [resp. r-autonomous] / plan p if it can execute all the actions needed in plan p
  - $aut\_plan_a(i,g,p,k) \equiv is\_plan(k,g,p) \wedge has\_all_a(i,p)$
- **Plan-dependence**
  - An agent is a-dependent [resp r-dependent a->r] of an agent j for g and plan p belonging to agent k if :

    $dep\_plan_a(i,j,g,p,k) \equiv is_p(k,p) \wedge \exists\, a\ (achieves(p,g) \wedge needs_a(i,p,a) \wedge is_a(j,a))$

Dependence relation (1)

- An agent which is not autonomous for a goal g depends on the other for this goal
- Dependance relation
  - a-dependence [resp r-dependence a->r]
    $dep_a(i,g,k) \equiv is_g(i,g) \wedge has\_plans(k,g) \wedge \neg \exists\, p\ aut\_plan_a(i,g,p,k)$
  - s-dependence : a-dependence or r-dependence
- dependent (third party agent)
  - an agent is a-dependent [resp r-dependent a->r] on an agent j for g regarding plans belonging to agent k if :

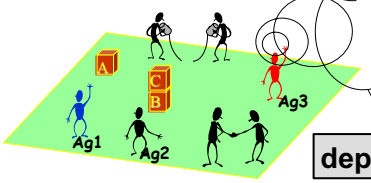
    $dep\_on_a(i,j,g,k) \equiv dep_a(i,g,k) \wedge \exists\, p\ dep\_plan_a(i,j,g,p,k)$
  - s-dependent : a-dependent or r-dependent

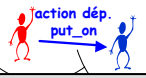
Example

There exists a plan which achieves goal *on(A,B)*, thus *ag3* is not a-aut., for this plan, because it doesn't have action *clear* .

External Description of Ag3 :
goals : on(A,B), actions : clear
resources : Arm
plans : on(A,B):= clear(C, Arm),
put_on(A,B,Hand)

External Description of Ag1 :
goals : on(C,Table), actions : put_on
resources : Hand
plans : on(C,Table):=clear(C,Arm)
...



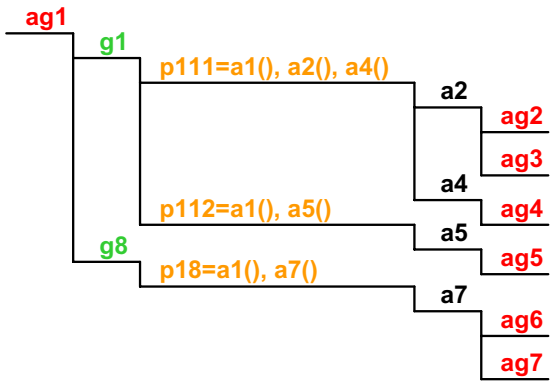


$dep\_on_a\ (ag_3, ag_1, on(A,B), ag_3)$

Dependence Relation (2)

- An agent ag_i *OR-depends* on a set of agents Ag_j when she holds a disjunction set of dependence relations upon any member ag_k of Ag_j. Any member of the set Ag_j is sufficient but unnecessary for ag_i's goal. *OR-dependence mitigates social dependence*.
- An agent ag_i *AND-depends* on a set of agents Ag_j when she holds a conjunction set of dependence relations upon all members of Ag_j. All members of the set Ag_j are necessary for ag_i's goal. *AND-dependence strengthens social dependence*.

Dependence Networks (1)



Dependence Networks (2)

- **Independence**
- **Unilateral** Dependence (agent *i* depends on agent *j* for one of its goals *g*)
- **Bilateral** Dependence (agents *i* and *j* depend on each other for their goals g_1 and g_2)
  - Mutual Dependence MD ($g_1 = = g_2$)
  - Reciprocal Dependence RD : $g_1 \neq g_2$

Goal situations

- A goal situation relates an agent to a goal :
  - NG(*i*,*g*) : the agent *i* does not have the goal *g*
  - NP(*i*,*g*) : the agent *i* has the goal *g* but it does not have any plans to achieve it
  - AUT(*i*,*g*) : the agent *i* has the goal *g*, and at least a plan *p* makes it action-autonomous to achieve *g*
  - DEP(*i*,*g*) : the agent *i* has the goal *g*, and every plan *p* to achieve *g* makes it action-dependent to achieve *g*

→This notion is taken into account for goal, plan and partner (acceptance) choice.

Dependence Situations (1)

A dependence situation relates 2 agents and a goal :

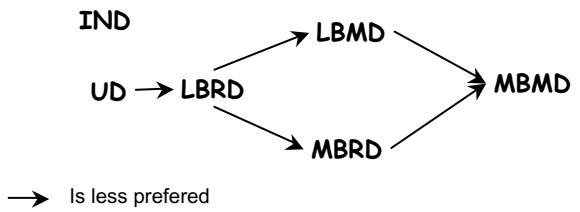
- $IND(i,j,g) \equiv DEP(i,g) \wedge \neg\, dep\_on_a(i,j,g,i)$
- $LBMD(i,j,g) \equiv MD(i,j,g,i) \wedge \neg\, MD(i,j,g,j)$
- $MBMD(i,j,g) \equiv MD(i,j,g,i) \wedge MD(i,j,g,j)$
- $LBRD(i,j,g,g') \equiv RD(i,j,g,g',i) \wedge \neg\, RD(i,j,g,g',j)$
- $MBRD(i,j,g,g') \equiv RD(i,j,g,g',i) \wedge RD(i,j,g,g',j)$
- $UD(i,j,g) \equiv dep\_on_a(i,j,g,i) \wedge \neg \exists\, g'\, (\, is_g(j,g') \wedge dep\_on_a(j,i,g',i))$

→ This notion is taken into account for partner (proposal) choice

SRM

Dependence situations (2)

- Possible ordering of the dependence situations to choose a partner :



Outline

✓ Organization in MAS

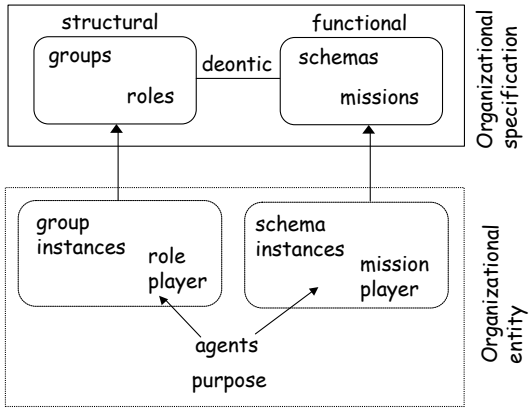
✓ Organizations with a System Centered Point of View

✓ Organizations with an Agent Centered Point of View

➢ **Dynamic of Organizations**

- Conclusion

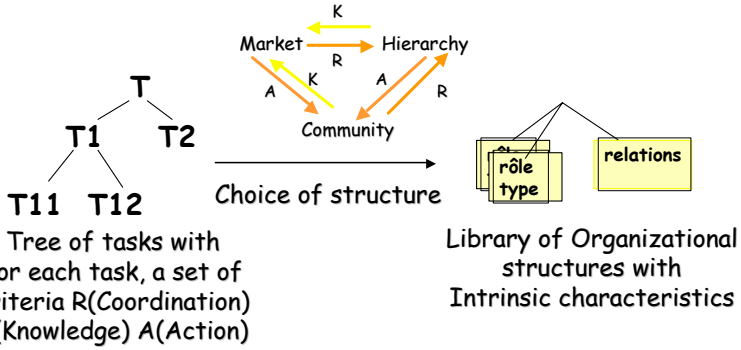
What can be changed ? MOISE+



Different kinds of dynamic

- ‘‘Reorganization’’ via Temporal Organization
  - TOSL [Carron 01] : expression of temporal constraints within the organization
- Reorganization
  - Choice within a library of organizations [Le Strugeon 95]
  - Controled Reorganization [Hubner 02?]
  - Organizational learning [Prasad 96], [Camps 98]
- Emergence

Organization dynamic [Le Strugeon 95]
Choice in a library of organizations



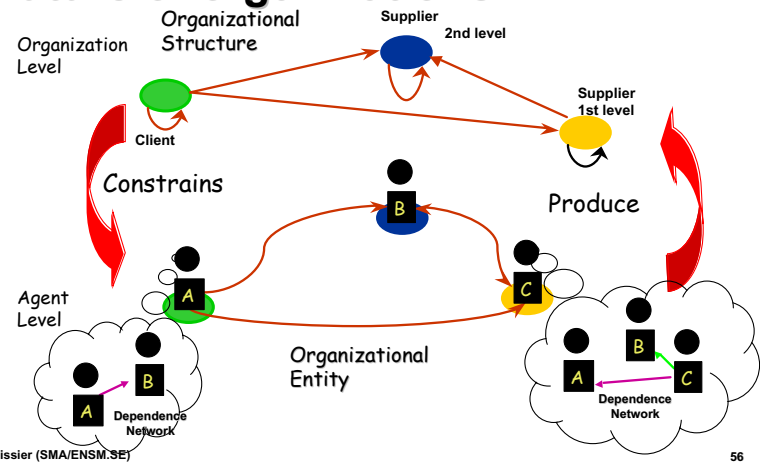
Outline

- ✓ Organization in MAS
- ✓ Organizations with a System Centered Point of View
- ✓ Organizations with an Agent Centered Point of View
- ✓ Dynamic of Organizations
- ➢ **Conclusion**

Conclusion

- Organization is a complex and rich dimension in MAS
  - In the eye of Designer/Observer/Agents,
  - With a Social/Normative aim,
  - Expressed within two Points of View : Agent-Centered vs. System-Centered
  - Programmed within Agents or within the system itself (Organization services in MAS Platforms)
  - That could be Static/Dynamic
- Multi-Agent Oriented Programming for current and future applications needs :
  - To combine ACPW and SCPW Organizational Models
  - To combine ACP and SCP of Orgnizational Models
  - Normative Deliberative Autonomous Agents
  - Dynamic and adaptative organizations

Future of organizations



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