
Guido Boella & Davide Grossi & Leon van der Torre

## AgentLink RoadMap

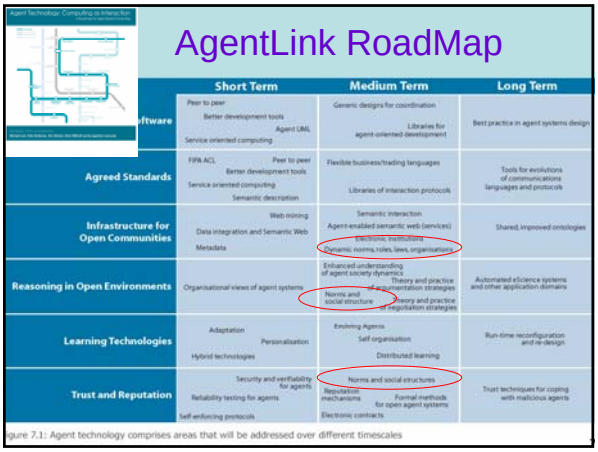



Figure 7.1: Agent technology comprises areas that will be addressed over different timescales

## 2005: Normative MultiAgent Systems

- are multiagent systems with normative systems
- in which agents can decide whether to follow the explicitly represented norms, and
- the normative systems specify how and in which extent the agents can modify the norms.''

G. Boella, L. van der Torre, H. Verhagen, Introduction to normative multiagent systems. *Computational and Mathematical Organization Theory, double special issue on normative multiagent systems,* 2006.

- Many kinds of norms, e.g., legal, moral, social norms



## 2007: Normative MultiAgent Systems

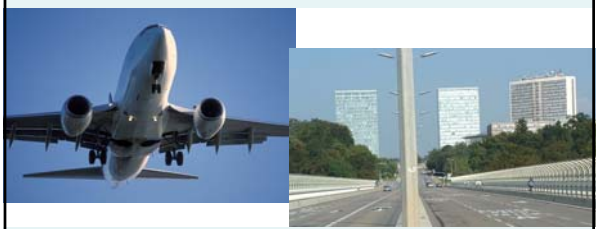
- are multiagent systems organized by means of
- mechanisms to represent, communicate, distribute, detect, create, modify, enforce norms and
- mechanisms to deliberate about norms and detect norm violation and fulfillment.

G. Boella, L. van der Torre, H. Verhagen, Introduction to normative multiagent systems. *Autonomous Agents and Multiagent Systems, special issue on normative multiagent systems,* 2008.



## Dilemmas

- Norms are rules to distinguish right from wrong.





- When may we shoot down a plane hijacked by terrorists?



## Violations

- Norms describe what counts as a violation.


- Budget deficit > 3 % of GDP is a violation?

## Design

- Norms are rules used to control or regulate behavior.

- What are the effects of new norms on behavior?



## Normative Reasoning

Norms are rules used to control or regulate behavior.

Infrastructure for open communities.
Reasoning in open environments.
Trust and reputation.

More than distinguishing right from wrong.
More than describing what counts as a violation.



## Security and Reliability

- Norms make systems more secure & reliable.

- How to prevent over-regulation?

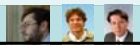


## Trust

- Norms build up trust in international trade.


- Which mechanisms for electronic commerce?







## Virtual Communities

- Social norms are emerging in Second Life.

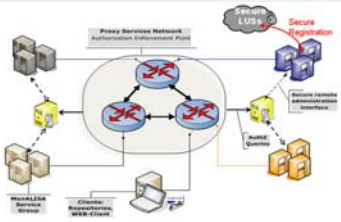
- How to prevent exclusion from communities?





## Autonomous Systems

- *aut-* + *nomos*: making ones own norms.




- How to define global policies about local ones?

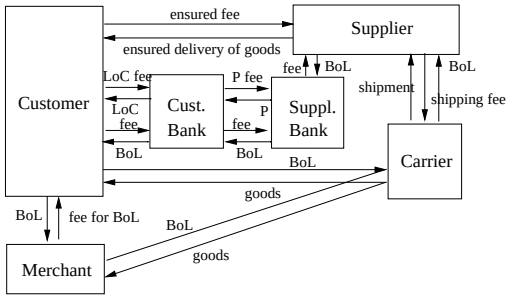
# Applications of NMAS

Norms are rules used to control or regulate behavior.

Risk management for computer security.
Designing trust mechanisms for electronic commerce.
Recognition of emerging social norms in Second Life.
Local and global policies for autonomous systems.

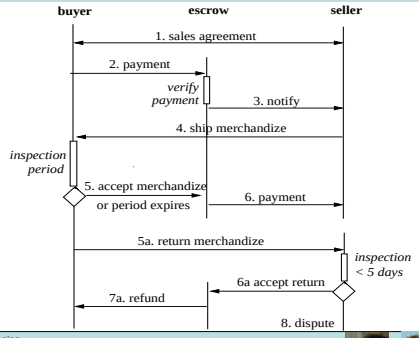


# Example: Letter of Credit






# Trust: ESCROW





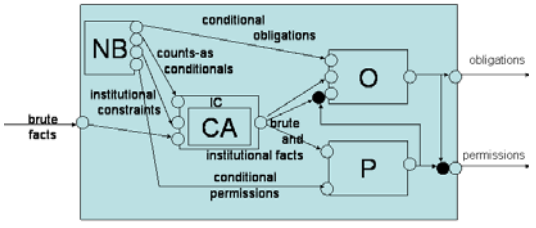

# Norm Model of ESCROW

- Norms describing coordination
  - Agent communication: sales agreement
  - Agent transaction: payment for shipment
- Norms describing fees and compensation
  - ESCROW gets percentage (from seller or buyer)
  - Return merchandize within 5 days
- Norms ensure fulfillment of some obligations
  - Seller is paid for goods, or goods will be returned
  - (under assumption of trustworthiness of ESCROW)
- Some obligations can still be violated:
  - Seller does not ship goods, shipper unreliable, …



# Norm Representation (Substantive)

- Regulative: obligation, prohibition, permission
- Constitutive: counts-as (intermediate concepts)





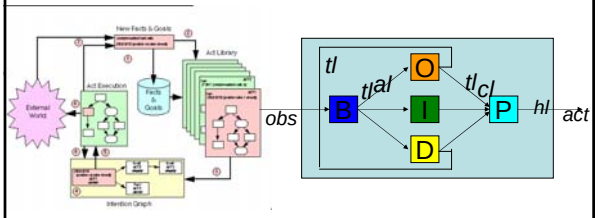

# Norm Representation (Procedural)

- Multiagent structure of a normative system


  - Powers of roles described by counts-as norms, and
  - Their behavior is regulated by procedural norms.

## Decision Making With Norms

- Introducing obligations in agent architectures

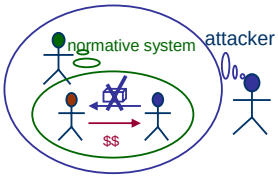



- Introducing obligations in agent programming



## Norm Compliance

- Attacker = agent trying to profit from violation
  - Violation undetected, no sanction, or less than profit




- Anticipate rather than prescribe (mechanism design)



## Profile *NS* of Attacker *A* (for *Op*)

1. *NS* desires *p* ("your wish is my command").
2. Absence of *p* is considered as violation of *A*.
   - Anderson's reduction of deontic logic to modal logic.
3. *NS* desires that there are no violations.
4. If violation, then *NS* is motivated to sanction.
5. *NS* does not like to sanction.
6. *A* does not like being sanctioned.
7. *NS* has the power to count absence of *p* as violation.
8. *NS* has the power to enforce sanction.



## Emergence of Norms

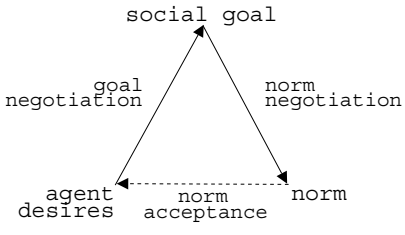
•Immanuel Kant, Metaphysics of Morals, 1785

- "Act only according to that maxim whereby you can at the same time will that it should become a universal law."



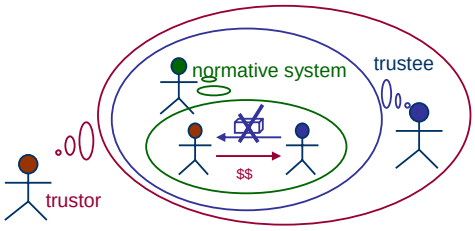

## Emergence of Norms

- Don't do to others, what you don't want them to do to you






## Norm Acceptance



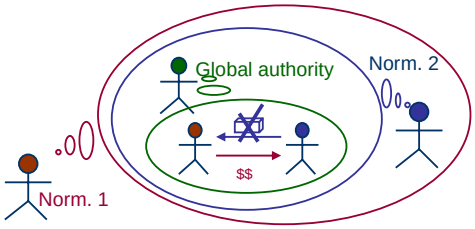

- Decision making of trustor taking profiles of trustee and normative system into account

## Autonomous Systems

- Legal institutions in context of legal institutions
  - Norm dynamics described by counts-as norms
- Strong permissions in norm creation (Bulygin)
- Global policies about local policies
  - vWright: transmission of will by nested norms



## Hierarchical Normative Systems




- Decision making of norm. system 1 taking profiles of norm. system 2 and global authority into account



## Challenges in NMAS

Norms are rules used to control or regulate behavior.

Representation and reasoning with various kinds of norms.
Multiagent structure of normative systems.
Decision making with norms.
Emergence of norms.
Hierarchical normative systems.



## Further Reading

- Normative multiagent systems proceedings:
  - *Computational and Mathematical Organization Theory, double special issue on normative multiagent systems,* 2006.
  - *Normative Multiagent Systems, 18.03. - 23.03.2007, Schloss Dagstuhl, Germany, 2007.*
  - *Autonomous Agents and Multiagent Systems Journal, special issue on normative multiagent systems,* 2008.
- Luxembourg, 15-18 July 2008
  - 9th International Conference on Deontic Logic in Computer Science (DEON2008)
  - 3rd International Workshop on Normative Multiagent Systems (NORMAS2008)

# Norm-types

*what kind of norms for MAS?*

Davide Grossi
University of Luxembourg

**EASSS 2008**



## Outline

| *Types* | *Compliance* | *Implementation* |
|---|---|---|
| constitutive norms | nullity | regimentation |
| regulative norms | violation | regimentation<br>incentives<br>disincentives |



## Part I

| *Types* | *Compliance* | *Implementation* |
|---|---|---|
| constitutive norms | nullity | regimentation |
| regulative norms | violation | regimentation<br>incentives<br>disincentives |



## Barbara



## Normative Inference

Instance of Barbara:

A → **B** "from ***concrete notions*** to ***legal notions***"
**B** → C "from ***legal notions*** to ***normative consequences***"
A → C "from ***concrete notions*** to ***normative consequences***"

*Example:*

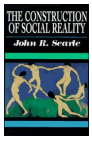
*"Bikes count as **vehicles**."*
*"**Vehicles** are not allowed to access public parks."*
*"Bikes are not allowed to access public parks."*



## Normative Inference

Instance of Barbara:

A → **B** "from ***brute facts*** to ***institutional facts***"
**B** → C "from ***institutional facts*** to ***normative consequences***"
A → C "from ***brute facts*** to ***normative consequences***"

## Types of Norms

Instance of Barbara:

A → **B** ***Constitutive norm*** "what counts as what"

**B** → C ***Regulative norm*** "what ought to be the case / ought to be done"

A → C ***Regulative norm*** "what ought to be the case / ought to be done"

*Example:*

*"Bikes count as **vehicles**."*
*"**Vehicles** are not allowed to access public parks."*
*"Bikes are not allowed to access public parks."*



## TÛ-TÛ Technique



## "On the Noîsulli Islands ...

... in the South Pacific lives the Noît-cif tribe, generally regarded as one of the more primitive peoples to be found in the world today [...]. This tribe [...] holds the belief that in the case of an infringement of certain taboos ---for example, if a man encounters his mother-in-law, or if a totem animal is killed, or if someone has eaten of the food prepared for the chief--- there arises what is called *tû-tû*. The members of the tribe also say that the person who committed the infringement has become *tû-tû*. It is very difficult to explain what is meant by this. [...] *tû-tû* is conceived as a kind of dangerous force [...] a person who has become *tû-tû* must be subjected to a special ceremony of purification."



## *A. Ross "Tû-Tû", Harward Law Rev.*

- *Tû-Tû* works like our less mysterious legal concepts: "right", "violation", "vehicle" ...
- It makes normative inference work:

1. "If a person has eaten of the chief's food he is *tû-tû*."
2. "If a person is *tû-tû* he shall be subjected to a ceremony of purification."
3. "If a person has eaten of the chief's food he shall be subjected to a ceremony of purification."



## ... a basic "technology of presentation"

- For connecting **p** legal facts all to **n** normative consequences you need **p·n** rules.

$$\begin{array}{cccccc} F_1-C_1 & F_2-C_1 & F_3-C_1 & \ldots\ldots & F_p-C_1 \\ F_1-C_2 & F_2-C_2 & F_3-C_2 & \ldots\ldots & F_p-C_2 \\ F_1-C_3 & F_2-C_3 & F_3-C_3 & \ldots\ldots & F_p-C_3 \\ \cdot & \cdot & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & \cdot \\ \cdot & \cdot & \cdot & & \cdot \\ F_1-C_n & F_2-C_n & F_3-C_n & \ldots\ldots & F_p-C_n \end{array}$$

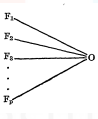
*regulative norms*



## ... a basic "technology of presentation"

- For connecting **p** legal facts all to **n** normative consequences you need **p·n** rules.

*constitutive norms*




*regulative norms*

- Using the *tû-tû technique* you need **p+n** rules.

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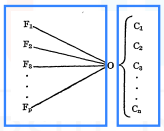


- Using the *tû-tû technique* you need **p+n** rules.
- The *tû-tû technique* supports modularity



## … a basic "technology of presentation"

- For connecting **p** legal facts all to **n** normative consequences you need **p·n** rules.

"***Our legal rules are in a wide measure couched in a "tû-tû" terminology***" (Ross,58)

- Using the *tû-tû technique* you need **p+n** rules!
- The *tû-tû technique* supports modularity



## Part II

| *Types* | *Compliance* | *Implementation* |
|---|---|---|
| constitutive norms | nullity | regimentation |
| regulative norms | violation | regimentation<br>incentives<br>disincentives |



## Following Norms

***Constitutive norms:*** ***Definitions***
"conceptual rules", "definitional norms", etc.

***Regulative norms:*** ***Prescriptions***
"rules of conduct", "imperatives", etc.

"Where the rule is purely regulative, behaviour which is in accordance with the rule could be given the same description or specification [...] whether or not the rule existed [...] But where the rule (or systems of rules) is constitutive, behaviour which is in accordance with the rule can receive specifications or descriptions which it could not receive if the rules did not exist"



## Chess Analogy

***Constitutive norms:*** ***Definitions***
"A check which cannot be escaped is a checkmate"

***Regulative norms:*** ***Prescriptions***
"it is forbidden to touch a piece without moving it"

"Where the rule is purely regulative, behaviour which is in accordance with the rule could be given the same description or specification [...] whether or not the rule existed [...] But where the rule (or systems of rules) is constitutive, behaviour which is in accordance with the rule can receive specifications or descriptions which it could not receive if the rules did not exist"



***Constitutive norms:*** ***Definitions***
"by winning an auction or clicking the buy-now button the customer commits to buy the item"

***Regulative norms:*** ***Prescriptions***
"if the customer commits to buy an item he is obliged to purchase it at the stated price"

What happens if I don't comply?

## Non-compliance

***Non-compliance with constitutive norms:***

"If I don't win the auction nor I click the buy-now button I am not committed to buy the item"

***Non-compliance with regulative norms:***

"if I am committed to buy the item and I do not purchase it, then I am violating the eBay regulations"

"If we do not comply with constitutive norms, the result is not a sanction or a punishment, for it is not a breach or **violation** of any obligation, nor an offence, but **nullity**"



## Compliance

***Compliance with constitutive norms:***

"If I win the auction or click the buy-now button I am committed to buy the item"

***Compliance with regulative norms:***

"if I am committed to buy the item and I purchase it, then I am not violating the eBay regulations"

"Compformity with the conditions specified by a constitutive rule is a step which is like a **move** in a game"



## … to sum up

***Compliance with constitutive norms:***

"If I win the auction or click the buy-now button then I am committed to buy the item"

*If the conditions of a constitutive norm hold, then its consequences follow by necessity.*

***Regulative norms:***

"if I am committed to buy the item then I ought to purchase it"

*If the conditions of a regulative norm hold, then its consequences follow only if the agent chooses to comply.*



## Part III

| *Types* | *Compliance* | *Implementation* |
|---|---|---|
| constitutive norms | nullity | regimentation |
| regulative norms | violation | regimentation<br>incentives<br>disincentives |



## Implementation = Ensuring Compliance

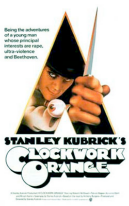
- To design a normative MAS does not only mean to state a set of norms
- It also means to organize the MAS in such a way that compliance is ensured
- What about agents' autonomy?



## Regimentation

- *A regulative norm is regimented whenever it is not possible for the agent to violate it, hence compliance follows necessarily.*

1) Agents' mental states are accessible to the system (closed systems), which can modify non-compliant goals.
E.g. KAoS



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1) Agents' mental states are accessible to the system (closed systems), which can modify non-compliant goals.
E.g. KAoS
2) Agents' mental states are not accessible to the system, which can however constrain their actions.
E.g. Islander/Ameli



## Enforcement

- *A regulative norm is enforced whenever the agent is incentivized to comply with it.*

1) Incentives/disincentives result from system's infrastructures (or artifacts).
E.g., speed control systems



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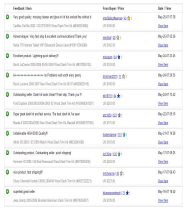
2.1) By simple retaliation. E.g. eBay





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2.2) By incentivization of other agents. E.g., Far West
2.3) By institutionalization of other agents. E.g., Law enforcement



## Implementation = Ensuring Compliance

| | | |
|---|---|---|
| regimentation | mental states | |
| | actions | |
| enforcement | artifacts | |
| | agents | retaliation |
| | | incentivization |
| | | norms |

## Implementation by Institutional agents (I)

- "Who controls the controllers?"
- Paradox: Norm implementation yields more norms.

PRIMARY NORM: "Citizens ought to pay taxes"

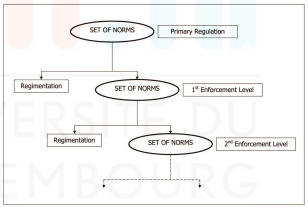
CHECK NORM: "The Tax Office ought to search for evidence of tax evasion practices"

REACTION NORM: "If the Tax Office collects evidence about tax evasion by one citizen it ought to pursue him according to the law"



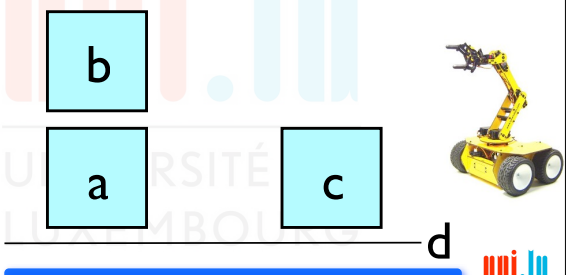
## Implementation by Institutional agents (II)

- "Who controls the controllers?"
- Paradox: Norm implementation yields more norms.

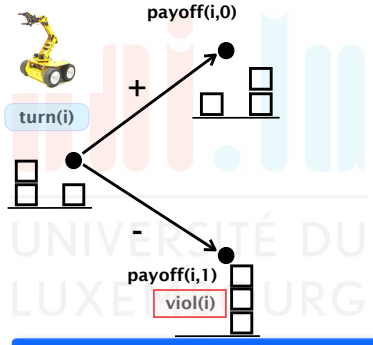





## *Simple Example:* Norm Implementation in BW



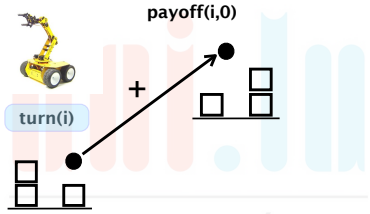




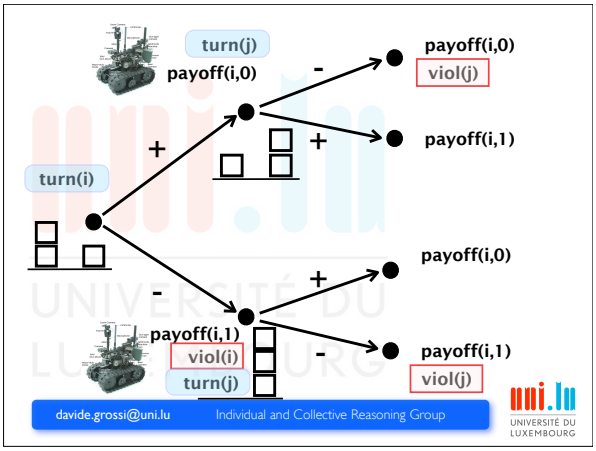

## Regimentation





# Enforcement Agents

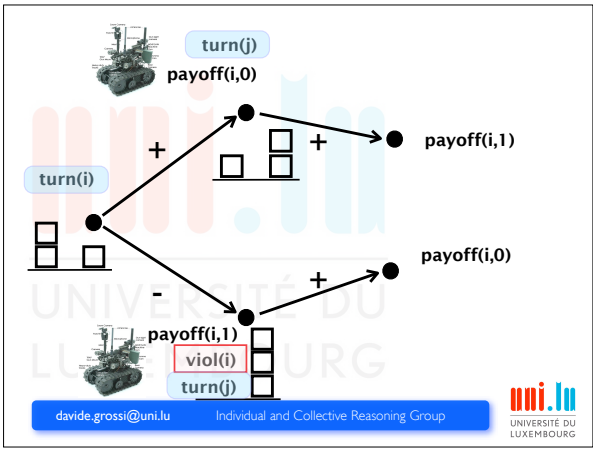







# Regimenting Enforcers

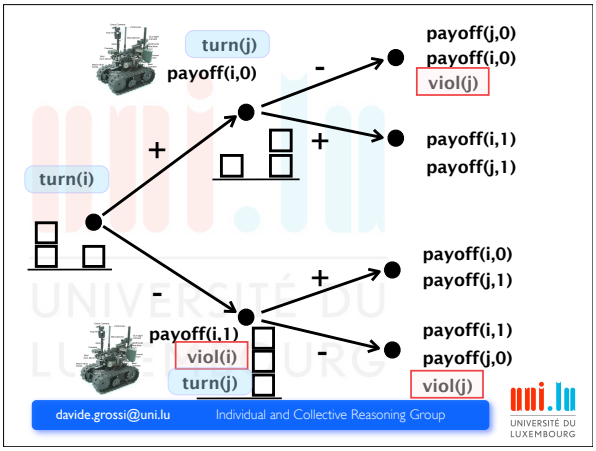







# Enforcing Enforcers





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# Conclusions

- The "*TÛ-TÛ Technique*" and its basic bricks: regulative and constitutive norms.
- What does it mean to follow a regulative and, respectively, a constitutive norm: i.e., the *COMPLIANCE* issue.
- How can we make agents follow regulative and constitutive norms: i.e., the *IMPLEMENTATION* issue.



# References = How To Know More


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# Roles in MultiAgent Systems

EASSS'08 Tutorial

## Role Metaphor

Laurence Olivier,
HAMLET, 1948

How can we effectively apply the role metaphor in multiagent systems?

## Role Metaphor

Laurence Olivier,
HAMLET, 1948

- Roles are defined by a script, in relation to other roles
- Actors are replaceable; the role remains stable.
- Actors must have certain qualifications to enact a role.

## Coordination

"A coordination problem arises when a group of people share an interest or goal and the success of each person's actions to achieve that goal depends on the actions of the others (Schelling 1960)."

- Kinds of dependencies (Malone 1987):
  - task; resource (including information); time
- Coordination devices (Clark 1996; Lewis 1969):
  - salience, convention, explicit protocol,
  - authority structure

## Example: Robocup

(e.g. Stone & Veloso 1999)

- Robot soccer team; no time to deliberate!

**Exercise:**

- What are the roles?
- What is the underlying coordination problem?
- What kind of dependencies apply?
- What coordination device is chosen?

## Example: Robocup

(e.g. Stone & Veloso 1999)

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**Exercise:**

- What are the roles?
- What is the underlying coordination problem?
- What kind of dependencies apply?
- What coordination device is chosen?

## Function of roles

- Roles help to solve coordination problems:
  - Prescriptive: an agent in a role must … obligation/permission, power
  - Descriptive: an agent in a role will … stereotype
- Agents can cooperate, given that they know each other's roles. (cf. assume - guarantee)

## Roles in Linguistics

- Eve bit an apple. (Sowa 1984)
- An apple was bitten by Eva.
  [Person: Eve] ←(Agnt)← [Bite] →(Ptnt)→ [Apple].

- Thematic role: the semantic relationship between predicate (V) and argument (NP) of a sentence.
  - Agent: performs the action,
  - Theme/Patient: undergoes the action
- Placeholder in a structure or pattern.

## Roles in Sociology

(Nadel 1957)

- The term "social structure" has become useless. We need a structural notion to describe societies irrespective of the individuals that populate them.
- Social structure = coherent system of roles
- Elements of a Role:
  - Rights and obligations with respect to other people or classes of people
  - Roles require a 'role compliment': parent – child, teacher – pupil, …consumer – producer, client – server

## Roles in Management Science

(Mintzberg 1979)

- Managerial roles (in a bureaucracy)
  - Allocator: assign people and resources to tasks; issue orders and authorise decisions by subordinates;
  - Disturbance Handler: resolution of conflicts, exceptions
  - Monitor: assess success of tasks and employees
  - Disseminator: of information,
  - Leader: select and motivate employees.

- Position: collection of roles conventionally enacted by a single agent (e.g. manager)

## Separation of Concerns

- Roles in a position must not interfere.
- E.g.
  - Professor is not allowed to review a paper by a colleague (reviewer ⊥ colleague)
  - Manager must authorize all travel expenses paid by the department, except for her own. (authorizer ⊥ applicant)

## Working Definition

- A role is a conventional invariant of related expertise, responsibilities and powers, defined by one or more social activities in a complex and changing environment.

- A role relation (dependency) is a conventional invariant of related interaction patterns.
  - Doctor - patient
  - Doctor - nurse

# Role of Roles?

- Roles are used
  - as placeholders in relational structures
  - as stereotypes, to predict
  - in task allocation, to assign responsibilities
  - in norms, to assign obligations or permissions
  - to control access to resources
  - ….
- No single notion of roles can do all of these!

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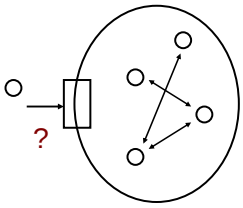
# (semi) Open Institutions



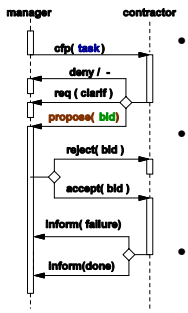

- Agents can enter and exit.
- Before: agents must meet requirements, have expertise, capabilities: qualifications.
- After: agents must fulfill responsibilities and stick to the protocol

  but can rely on permission, entitlement to resources, authority, …: powers.

# Mapping Agents to Roles

| Agent | Role |
|---|---|
| knowledge | expertise |
| goals | responsibilities |
| capabilities | institutional powers |
| communicative acts | protocol |

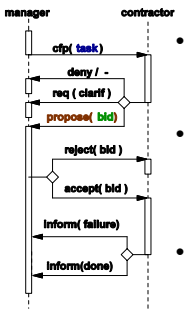
# Example: Contract Net




**Exercise:**

- Which entrance qualifications?
- What are the responsibilities?
- What powers are provided?

# Example: Contract Net




**Exercise:**

- Which entrance qualifications?
- What are the responsibilities?
- What powers are provided?

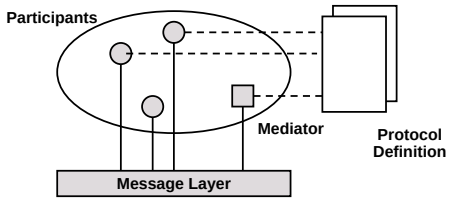
## Enforcing a protocol

- by central administrator
  - ISLANDER (Esteva et al 2002)
  - efficient; effective, but rigid
- by participants themselves
  - flexible (Yolum and Singh 2000; Dastani et al)
  - But high reasoning capabilities needed
- by mediator on agent platform
  - balance between flexibility and feasibility (Dastani et al 2004)

## Mediator

Mediator: no special capabilities; only powers

Mediator detects violations of the protocol and informs other participants; may also sanction

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## Role & Organization (Goffman)

- Ambassadors do not know beliefs & goals nation
  - mislead another nation by obliging them to propose some deal or manage a negotiation.
- Because:
  - Agent can play his role in a more spontaneous way,
  - It avoids the risk of a security violation,
  - Its beliefs are too complex for the actor,
  - It is violating the law and actor should not know.
- Also in agent theories of fraud and deception?

## Role and Agent

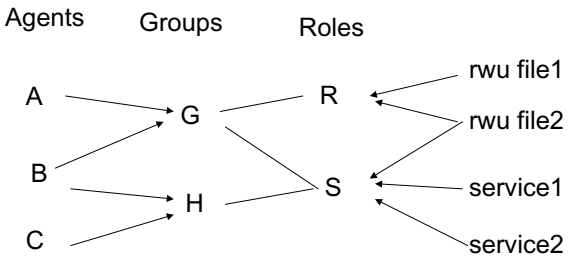
- Role is different from goals organization
  - e.g., a role can be attributed the responsibility of proposing some deal to another agent just because his organization wants to mislead this agent about its true intentions (Goffman).
- Role is different from goals agent
  - e.g., an employee can fulfill his role for his salary, not for the sake of the organization;

## Why do we need Roles in NMAS?

- Role based access control (RBAC):
  - Group collects agents
  - Role collects access rights
- Policies (& organizations) without agents
- Normative multiagent systems (NMAS):
  - Agents: obligations and permissions
  - Roles: responsibilities and rights

## Roles in RBAC

Ferraiolo and D.R. Kuhn,1992




## Example Parking Regulations

- Access to parking lot
- Guard admits cars

## Delegation of Access Control

- Bottom up
  - ACL: File with read and write access
  - ACL2: Read and write ACL
  - ACL3: Read and write ACL2
  - …
- Top down (Firozabadi et al)
  - Boss has power to create rights
  - Delegates it to other

## Role Hierarchies in RBAC

- Role hierarchy
  - Role Specialist contains roles of Doctor and Intern. Members of the role Specialist are implicitly associated with the operations associated with the roles Doctor and Intern without the administrator having to explicitly list the Doctor and Intern operations. Moreover, the roles Cardiologist and Rheumatologist could each contain the Specialist role.
- Role hierarchies are a natural way of organizing roles to reflect authority, responsibility, and competency:

## Separation of Concerns

- Accounting:
  - Principle: only fraud in case of coalitions
  - Create conflicting goals (e.g., sign delivered quantity)
- Separation of concerns
  - Authority to let other people access files, without being able to do so oneself

## Exercise: Library Regulations

- How can we describe library regulations using RBAC and a role hierarchy?

## Questions Organizations

- Organizational design
  - Which roles for organizational goals?
- Role assignment
  - Which agents to assign to role?
- Organizational governance
  - How to monitor and control organization?

## Normative Multiagent Systems

- Regulative norms
  - Obligations, prohibitions, permissions
- Constitutive norms
  - Counts as conditionals (e.g., dynamics)

- Foundations by Searle and others
- Used for organizations, contracts, …

## What is a Role?

- Normative descriptions (Pacheco & Carmo)
- Expectations (Lindemann & Munch)
- Standardized patterns of behavior (Esteva et al)
- Commitments (Cavedon & Sonenberg, Fasli)
- Goals and planning rules (Dastani et al)
- Goals, plans, actions (Sichman & Conte)
- Our proposal: role as socially constructed agent

## Obligations and Roles

- Motivate actor to fulfill responsibilities role
  - To act as if he possessed the role's beliefs
- Obligations addressed to actors (not roles)
  - E.g., agent playing buyer role has to pay when goods are shipped.

## Creation of Obligation

- Obligations created when an agent starts playing a role;
  - e.g., when he becomes enrolled in an organization by signing an employment contract.
- Starting from the responsibilities of role
  - If role is responsible to pay when good shipped, then when actor enters role, obligation pay when good is shipped is created.
- Sanctions or rewards associated to new obligations are chosen according to policies of organization
  - E.g., an employee can be fired for not fulfilling an obligation or paid for having done his work or rewarded with some additional benefit.

## Behavior

- Actor knows that
  - trade organization considers him obliged to pay the fee in case the bill of lading has been issued, since this means that the good has been shipped.
- When the actor decides what to do, he assumes that his actions are evaluated according to expectations role
  - he is obliged to pay: the good has been shipped since the bill of lading has been issued
  - he could believe that the good has not been shipped, despite the bill of lading, so, from his point of view, he is not obliged to pay.
- The actor has to act as if he had the role's beliefs,
  - or else he violates his duties; when he takes a decision, he figures out which beliefs the organization attributes to his role.

## Obligation of Buyer

- Directed towards the actor's actions
  - not towards his beliefs, even if there is a deontic component in the assertion that the bill of lading should be considered as evidence of the shipment.
- Because an autonomous agent cannot be compelled to change his mental attitudes:
  - he can be persuaded or motivated, but not coerced.
  - Moreover, his mental states are not accessible.
- What can be punished is only his behavior:
  - if he does not act in the same way as the role would have done, he is punished.
- Therefore, the organization considers the actor behavior from the point of view of the role.

## Summary

- Role based access control (RBAC):
  - Group collects agents
  - Role collects access rights
- Organizations & policies without agents
- Normative multiagent systems (NMAS):
  - Agents: obligations and permissions
  - Roles: responsibilities and rights

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