CSS-TW1 May 2006

Tag based-coordination applied to Grid Computing

Isaac Chao (ichao@lsi.upc.es)
Oscar Ardaiz
Ramon Sanguesa

Work partially funded by FP6 IST CATNETS project
www.catnets.org

Distributed Systems group
UPC Barcelona

Outline

- **Grid Computing**
- Tag mechanisms
- Tag mechanisms applied to the Grid
- Conclusions

The Grid (definitions)

- **The Grid** consists in coordinated resource sharing and problem solving in dynamic, multi-institutional Virtual Organizations VOs (Ian Foster)

- **VO**: Virtual entity englobing many physical organizations sharig a common goal.
  - Long term (stable)
  - Short term (ad-hoc)

The Grid (motivation)

- Leverages computing power and resources (data, knowledge) from many heterogeneous sources

- Applications
  - Collaborative problem-solving and resource brokering emerging in industry, science, and engineering

Examples of VOs

- the application service providers, storage service providers, cycle providers, and consultants engaged by a car manufacturer to perform scenario evaluation during planning for a new factory [defined term]

- a crisis management team and the databases and simulation systems that they use to plan a response to an emergency situation [short term, ad-hoc]

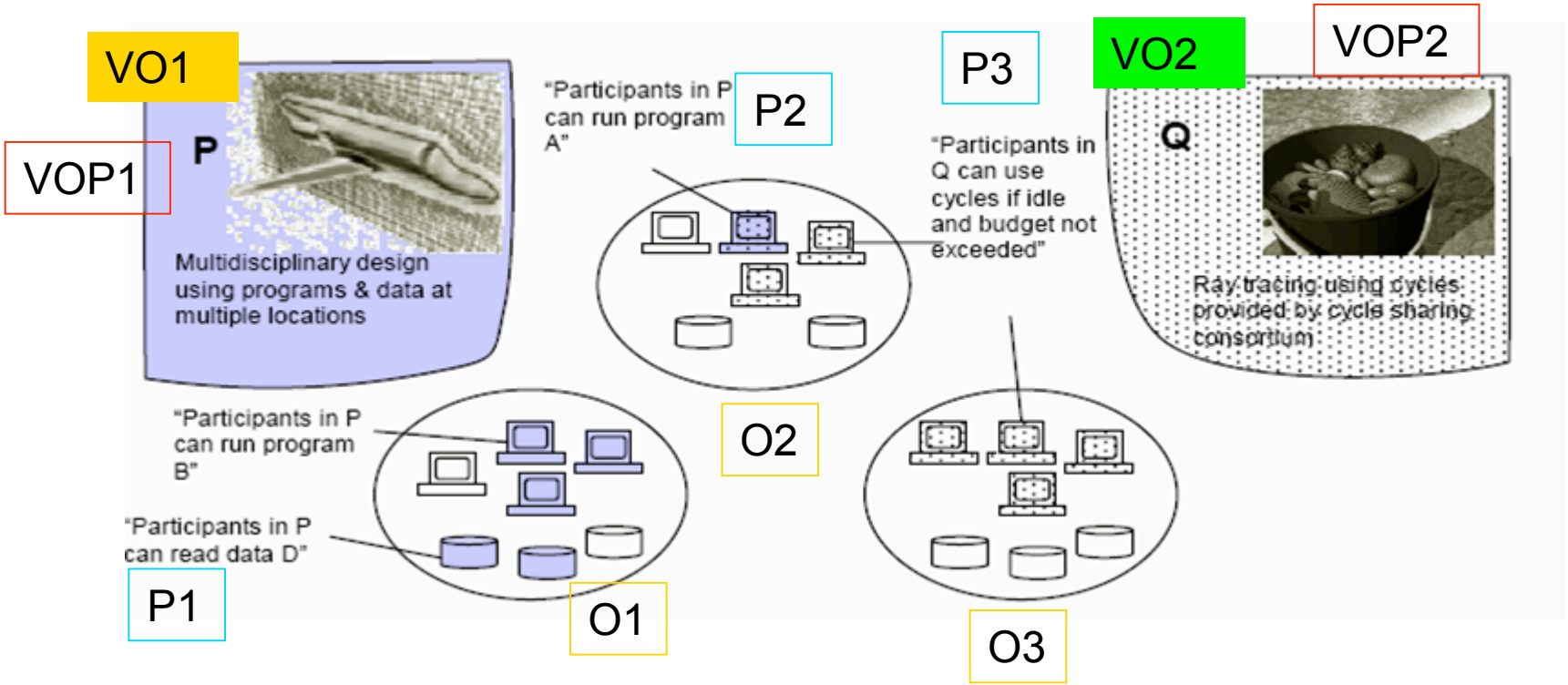
- members of a large, international, multiyear high energy physics collaboration [long term, stable]

Key concepts

- **Highly controlled**: Sharing in the grid is highly controlled, with resource providers and consumers defining clearly and carefully just what is shared, who is allowed to share, and the conditions under which sharing occurs → VO polices

- **Geographically distributed**: Multi-institutional VOs span across physical organizations boundaries at internet scale (World Wide Grid)

Example of Grid scenario



Grid Computing evolution

end 90s – now - future
scientific collaborations
Institutional Grids
-NSF TeraGrid
-e-Science UK
-EU DataGrid

Academy-based

2000 - now
commercial settings
scientific and technical computing applications

Trusted partners grids

Early adopters

***Now - 5 to 10 years on*.**
Next generation Grids.
Inter-Grids: large scale open systems

no pre-trusted, highest level of complexity, dynamicity, heterogeneity

Industrial takeover

Time Line

Next generation Grids

- Characteristics
  - **Highly dynamic**
  - Highly heterogeneous
  - On-demand utility
  - Large

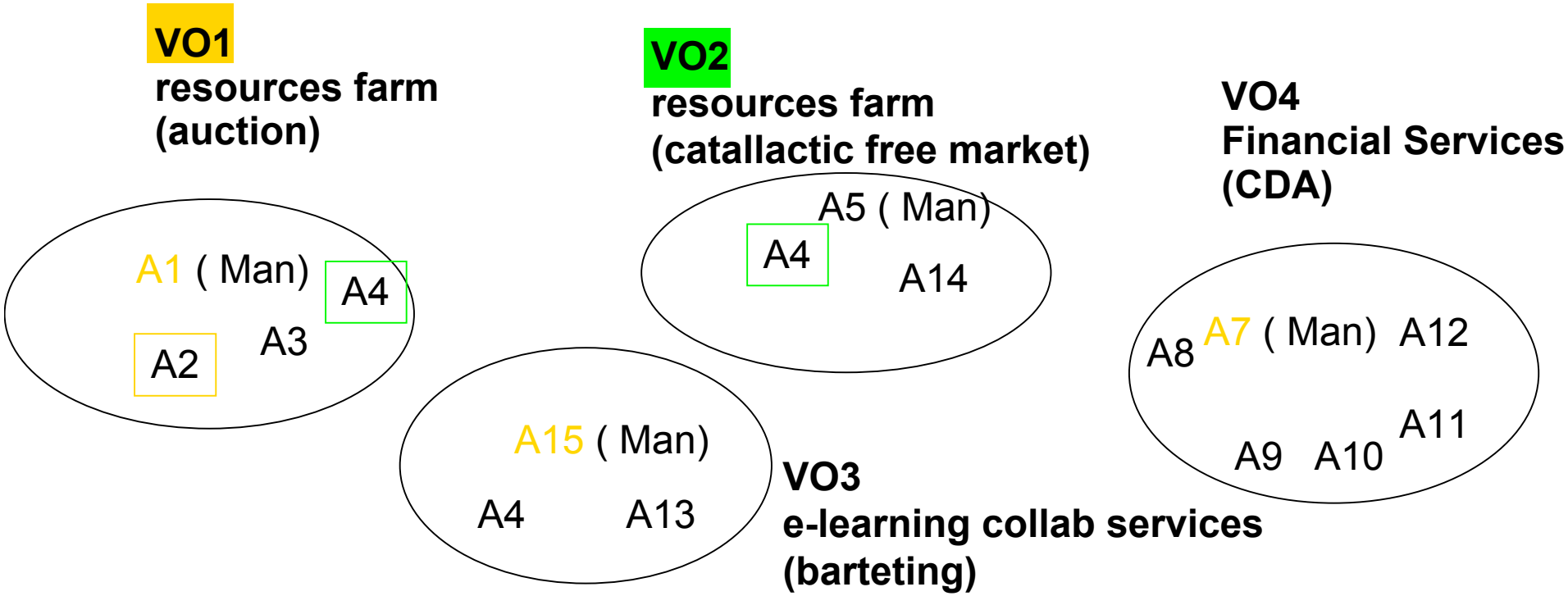
Increased **Complexity** to meet requriments

- Applications
  - Open, multi-disciplinary, collaborative and distributed
  - **dynamically evolving VOs**

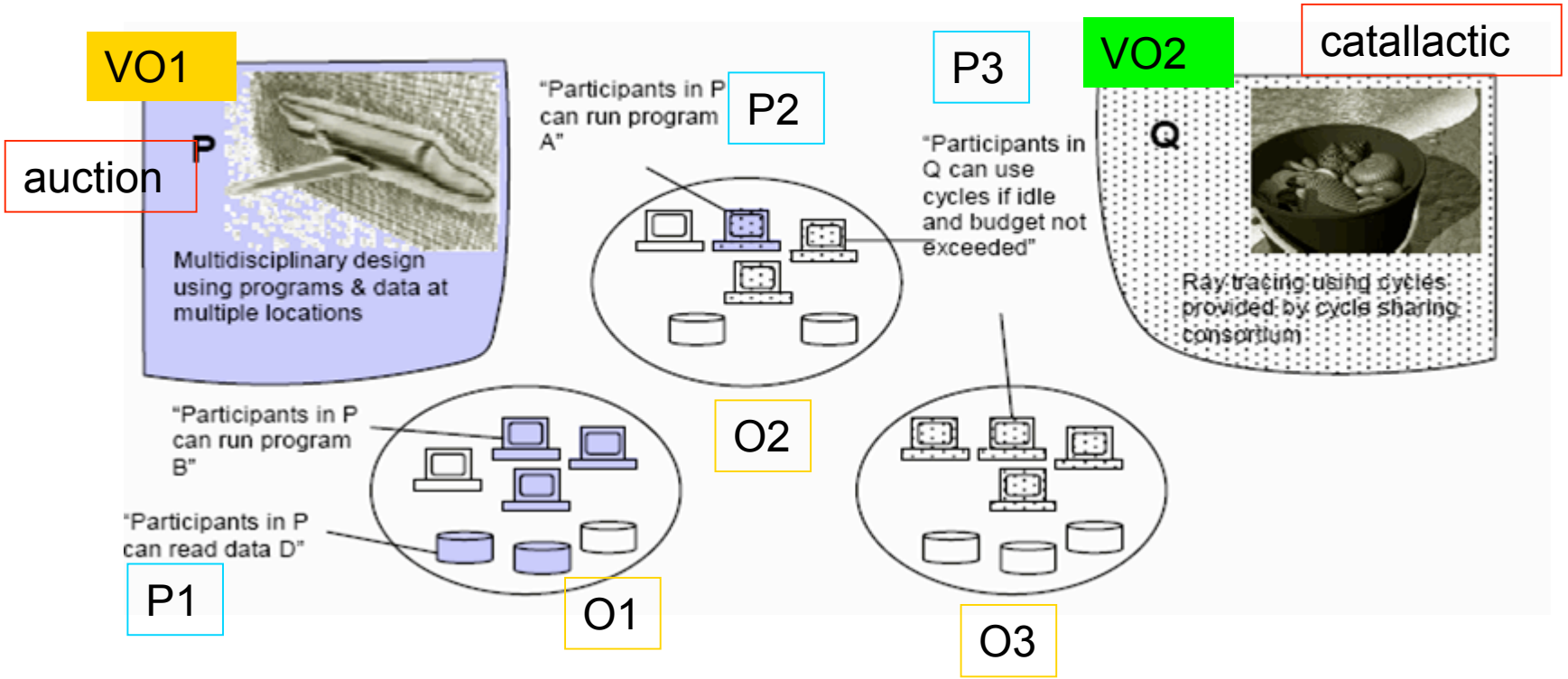
- Ref: Next Generation Grids Expert Group Report 3, Future for European Grids: GRIDs and Service Oriented Knowledge Utilities, 2006

Target Grid scenario

- Ecosystem of **competing** VOs (e.g. Grid services markets)



Mapping example Grid scenario



Outline

- Grid Computing
- **Tag mechanisms**
- Tag mechanisms applied to the Grid
- Conclusions

Tag mechanisms

- Tags: Social marks used as coordination mechanism to self-organize agents interactions in a system (Holland 1993) (Riolo2000) (**Hales 2000 - 2006**) ….

- Two steps mechanism:
  - **Tag biased Interaction**: agents interact and derive utilities, interaction preferred with agents of same Tag
  - **Tag Evolution**: Comparison of fitness, the “loser” copies the winner's strategy (cooperate or defeat) and Tag (i.e. Joins the “winner's” group)
    - eventually includes Mutation (variability)
- System evolve over time and **cooperative** groups (defined each by a tag) emerge as a result

Tag mechanisms open issues

- 1) Compare utilities might be hard in heterogeneous systems
  - How to compare utility of heterogeneous Grid Services?
- 2) Blind copy (evolutionary algorithm) of the fittest might not be always the most convenient action
  - How to enforce VO-wide specific policies provided the grid evolves following the evolutionary algorithm ?
- 3) How to handle non-adaptive agents which:
  - Report noise (false strategies and utilities)
  - Never adapt copying successful cooperative strategies

Outline

- Grid Computing
- Tag mechanisms
- **Tag mechanisms applied to the Grid**
- Conclusions

Tags in the Grid

- Groups in Tag models ←→VOs in a Grid
- Individual Agents ←→ Physical Organizations (single resources or pools)
- Emergence of cooperation ←→ Emergence of profit maximizing cooperation-based VOs in the Grid

What is different?

- Grid → highly controlled
  - VOs must retain **autonomy** to enforce VO specific policies.
  - Additional Intra-VO mechanisms can exist to assure VO operation respecting VO policies

- VO concept
  - The VO defines the **scope** of agents interactions
  - In order to perform transactions agents must register in VOs and adhere particular conditions

so… concrete differences with Hales TagWorld model

- Agents delegate some autonomy in the VOs they dynamically conform:
  - Once group (VO) goals are stated (those can also be evolved!), intra-VO mechanism controls agents operation inside the VO.
  - It can be argued this prevent mechanism to work, but this is not new: metaphor of how our societies work (e.g. urban tribes)
- Agent interactions strictly constrained to the group (VO) they inhabit.
- No need to use strategy mutation , but uses Tag mutations (acceptable)

Two-tier generic model

- **Inter-VO level: Emergent Tag Mechanism**
  - VOs lifecycle (*formation/disbanding* and *evolution*) is regulated following a Tag mechanism, the system self-organizes.

- **Intra-VO level: Control point**
  - Control agents *operation* inside the VO
  - Able to enforce VO specific internal policies and/ or support inter VO relationship (e.g. Grid Services utility comparison) → address open issues 1 and 2
  - Can incorporate complementary sanctioning → address 3
  - Each VO should be free to **autonomously** choose its intra-VO mechanism

1st Model instantiation: **Reputation Management in Grids**

- Intra-VO control mechanism:
  - Sanctioning mechanism: Applying sanctions to free-riders, provides incentives for agents to adapt to cooperative behaviours
  - Cheap pseudonyms issue can be solved by charging fees to newcomers (but not implemented)

Algorithm

- *(**Initial bootstrapping**)*
- *For a number of rounds*
- *begin main loop*
- *begin interaction phase*
- ***Interaction (VO operation phase):***
- *For each VO in the system:*
- *For each agent in the VO:*
- *Interact with another agent from the VO.*
- *Payoffs are generated from interaction*
- *Sanctioning mechanism is applied*
- *end interaction phase*
- *begin evolution phase*
- ***Evolution (VO evolution phase):***
- *For each agent in the system:*
- *Reproduce: contact an agent from another VO*
- *Compare agent's payoff from last interaction*
- *If (the other agent outperforms current agent)*
- *then*
- *Current agent moves to the other's VO*
- *Agent adapts strategy following its type*
- *else current agent stays on its current VO*
- *Mutate: Agent applies probabilistic Tag mutation*
- *end evolution phase*
- *end main loop*

Interaction constrained to current VO

Intra-VO Sanctioning mechanism

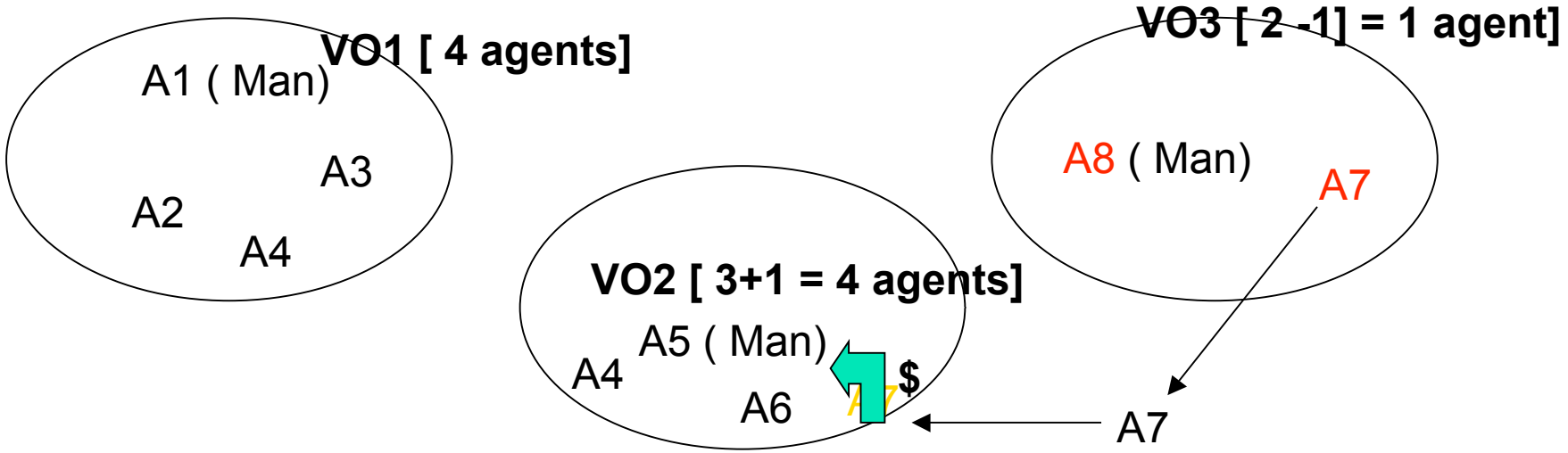
Learns from agents in other VOs

Interaction: PD game

	Cooperate	Defect
Cooperate	R, R	S, T
Defect	T, S	P, P

- T > R > P > S, and the constraint 2R > T + S makes a PD. We set T=1900, R =1000 and P=S=1 (same as Hales model)

System dynamics: VO selection



-**A7 in VO3 learns that fitness is better for agent A6 in VO2, and moves to cooperation-based VO2 (TAG MECHANISM : inter-VO co-evolution)**

- A7 it will perform cooperative actions. In contrary case A5 will collect feedback inside the VO and will punish A7 from misbehaving, eventually expulsing A7 from VO2 (intra-VO MECHANISM: Sanctioning within a VO)

- VO3 will remain with just A8 and will probably need to be disbanded (TAG MECHANISM : VO extinction

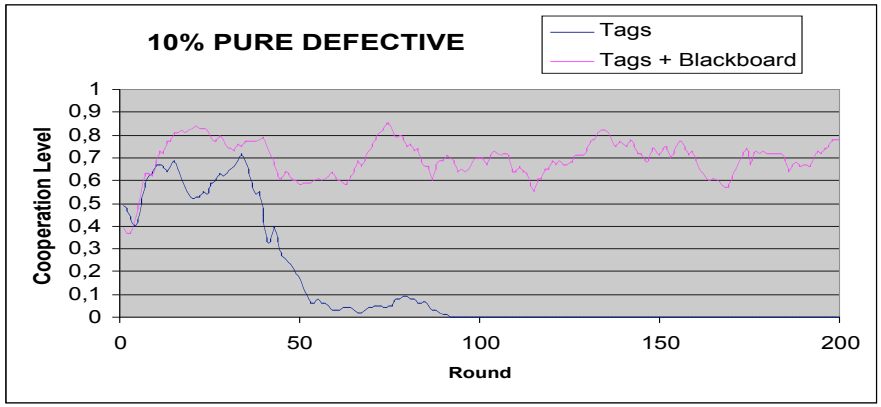
Sanctioning mechanism

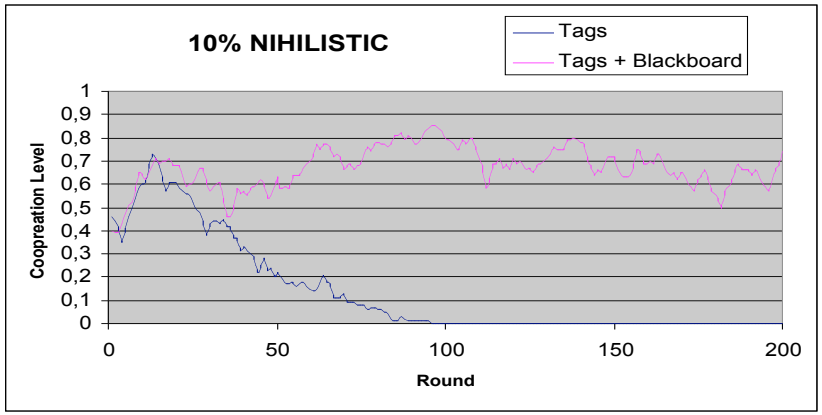
- Centralized **blackboard** keeps records of agent's misbehaviors within the VO
- helps adaptive agents to filter their partner agents for interaction within the VO
- two variables:
  - sanction period for the agent within the VO (the sanctioned agent will not be able to interact within that VO for that period)
  - maximum allowed number of total defeat operations for any agent in the VO, for the VO lifetime

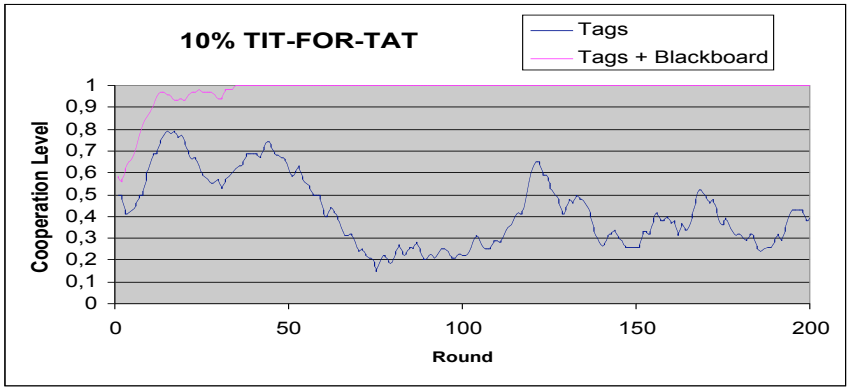
Type of non adaptive agents

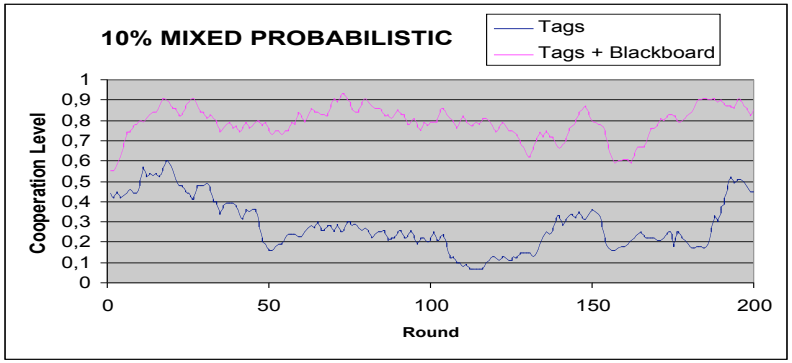
- -**Pure defective**: Always play defeat
- -**Nihilistic**: Always play defeat, and always report have played defeat, so other agents become cheaters too. The target of nihilistic agents is to destroy the mechanism itself by spreading defection
- -**Mixed-Probabilistic**: They play cooperate or defeat in a probabilistic basis. These can be considered a kind of outsiders who don't follow clear incentives.
- -**Tit-for-tat**: Apply tit-for-tat strategy; they play the same action as the last partner they encountered. Not to mistake with the tit-for-that in iterated PD. Here each partner is a different agent.
- -**Greedy**: Always play defeat, and always report having played cooperative (so other agents will keep cooperating and they can continue free-riding on them)

Results (cooperation facing non-adaptive agents)

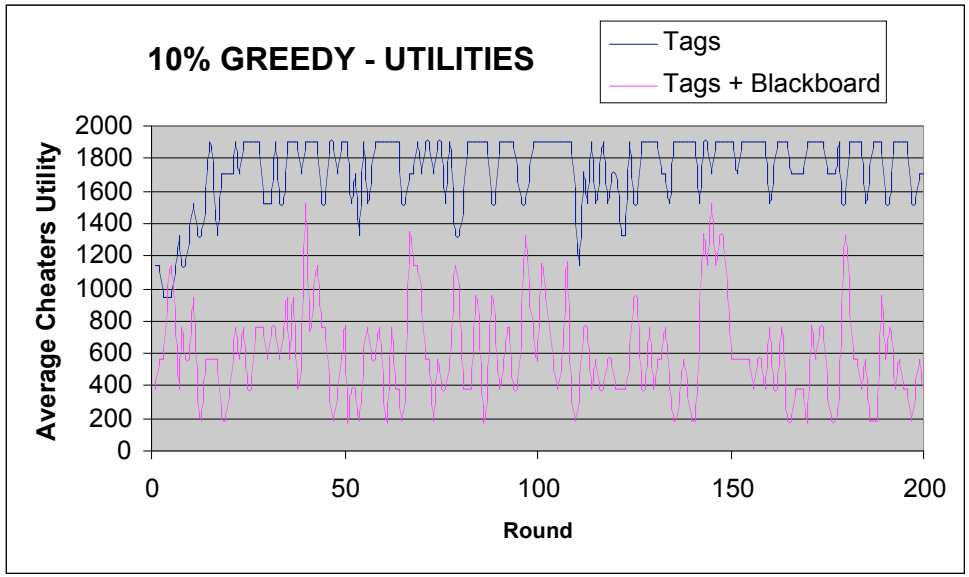








Results (agents utilities)



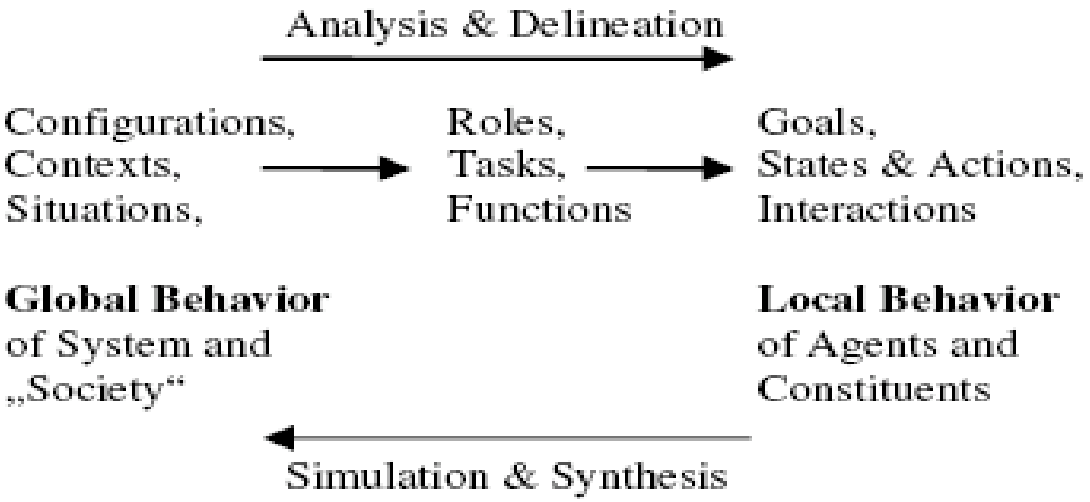
Intra-VO mechanism dramatically reduces the level of free-riding
non-adaptive agents are able to commit at expenses of adaptive agents

2nd Model instantiation (ongoing)
Macro properties engineering

- Use Tags to **coordinate** the VO evolution on the Grid, incorporating the emergence of the required macroscopic system properties from local agent's interactions

- Tags must provide the agents with the right incentives to promote coordination/cooperation, achieving global system objectives rather than individual self-interested local objectives

Micro-Macro engineering



MACRO PROPERTIES:

- Stability of the generated VOs :average lifetime VOs

-**Diversity** of VOs: total number of VOs in the Grid

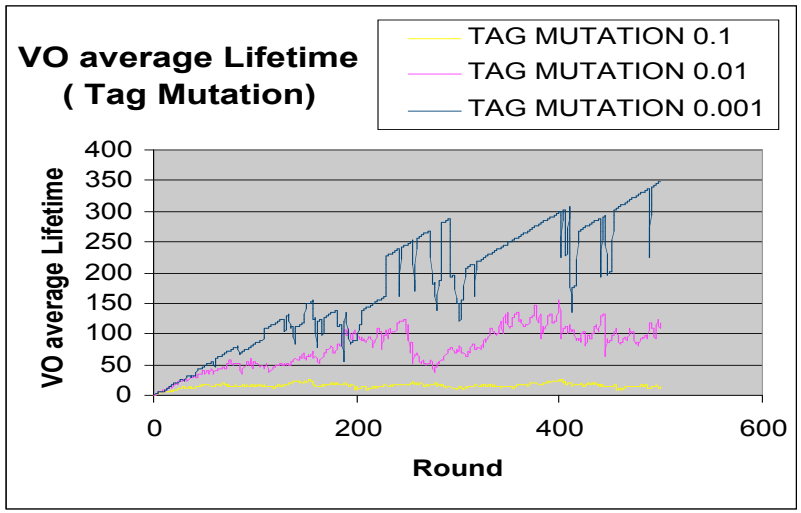
-**Robustness of the Grid:** …. to be defined

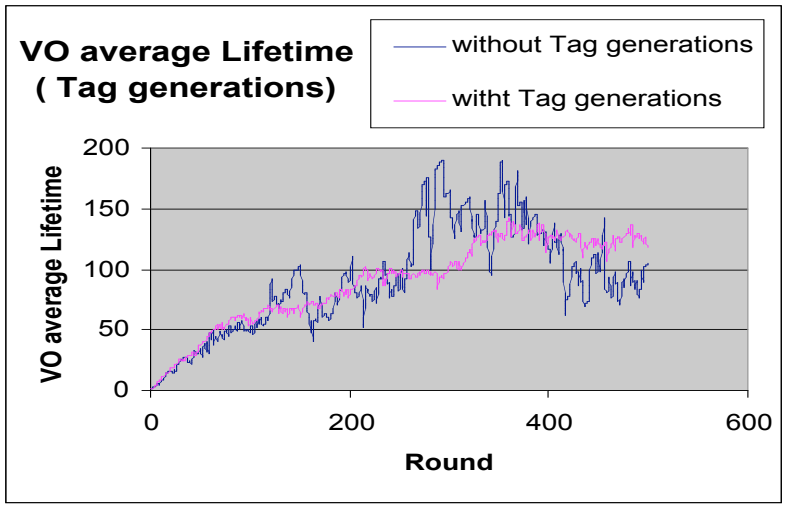
MICRO PROPERTIES (MECHANISM PARAMETERS):

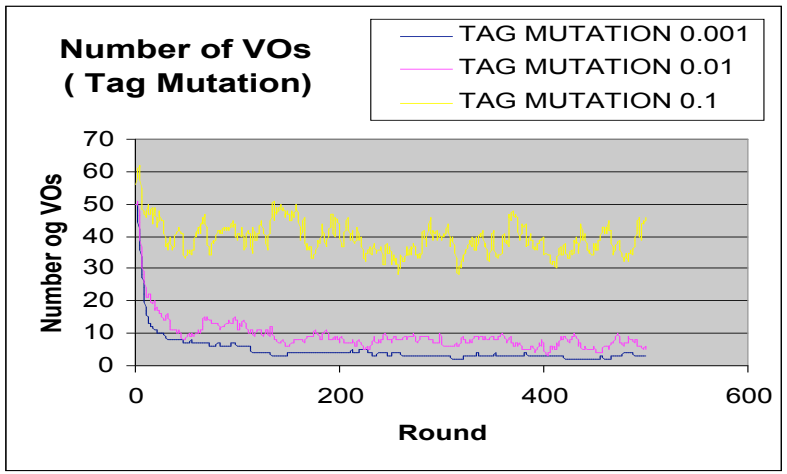
- Tag mutation

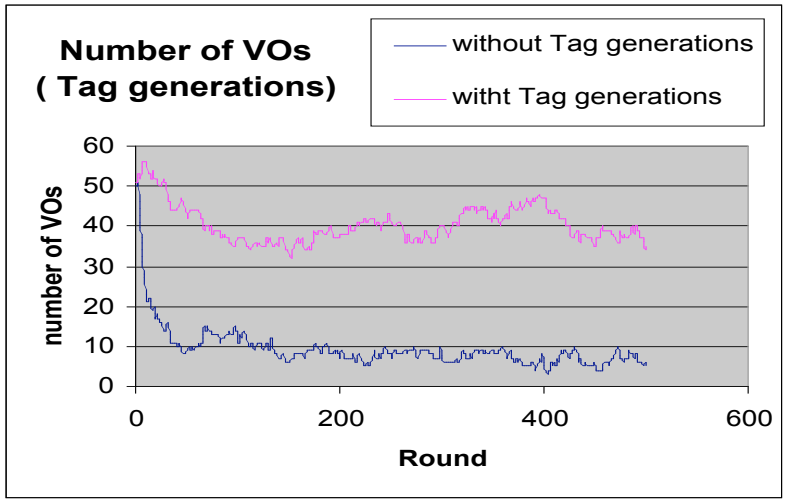
- Tag generations (intra-VO evolutionary pressure, up to 90%)

Results (macro properties)









Evaluation parametric study

- Tag generations is a “free parameter” respecting VO stability.
- Tag generations highly increases the number of VOs for a fixed value of Tag mutation (0.01) maintaining roughly the same VO lifetime
- We can assure high stability of the VOs, while we use Tag generations as the tuning parameter to provide the VO ecosystem with much higher diversity. E.g. application in Grid Markets

Outline

- Grid Computing
- Tag mechanisms
- Tag mechanisms applied to the Grid
- **Conclusions**

Conclusion

- Tag mechanism can be applied as a convenient MAS coordination mechanism for VO management in Next generation Grids

- Open questions:
  - Is the intra-VO mechanism freedom to organize its VO compatible with emergence of properties on the inter-VO Tag mechanism?
  - Is the model truly relevant to realistic Grids applications?
  - If yes, is it possible an implementation in realistic Grid settings ?

Future work (short term)

- Exploration of variations on the Tag mechanisms (allowing for agents to belong to various VOs simultaneously)
- Use of alternative, decentralized sanctioning mechanisms within the VO for reputation management
- Modeling an application scenario different from the PD and closer to a grid VO → incorporate VO polices coord (SkillWorld?)

Future work (medium-long term)

- Application to Grid Markets (CATNETS)
  - Each VO would represent a market, and migration of agents from one market to another would be ruled by the Tag mechanism, achieving a self-organization of the agents in a set of competing markets.
- Application to Social Networks Grids
  - Social networks between Grid participants would be formed between agents sharing Tags paths.The evolutionary pressure on the Tag algorithm would impact the social network organization.

Selected References

- Isaac Chao, Oscar Ardaiz, Ramon Sanguesa, Tag Mechanisms Applied to Open Grid Virtual Organizations Management, “Second International Workshop on Smart Grid Technologies”, coallocated with The 3rd IEEE International Conference on Autonomic Computing Dublin, Ireland June 2006, accepeted

- [NGG06] Next Generation Grids Expert Group Report 3, Future for European Grids: GRIDs and Service Oriented Knowledge Utilities.

- [Hale00] Hales, D. (2000) Cooperation without Space or Memory: Tags, Groups and the Prisoner's Dilemma. In Moss, S., Davidsson, P. (Eds.) Multi-Agent-Based Simulation. Lecture Notes in Artificial Intelligence Springer-Verlag ..... and much more

- [Catn05] CATNETS Project IST-FP6-003769 (2006), http://www.catnets.org


Questions?