Engineering Socially Intelligent ICT
&
Self-Organization
Some Contributions

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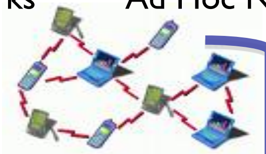
Outline

- Multi-Agents Systems @ GAMA Laboratory
- Context & Research Topics
- Socially Intelligent ICT & Self-Organization
- Contributions
- References

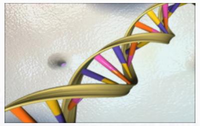
Context

Complex Networks

Ad Hoc Networks



Social Network



Biology & Health

Logistics

LA PLASTURGIE
FÉDÉRATION

Manufacturing

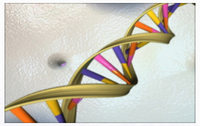
Data → Knowledge

Context

Complex Networks

Ad Hoc Networks

Social Network



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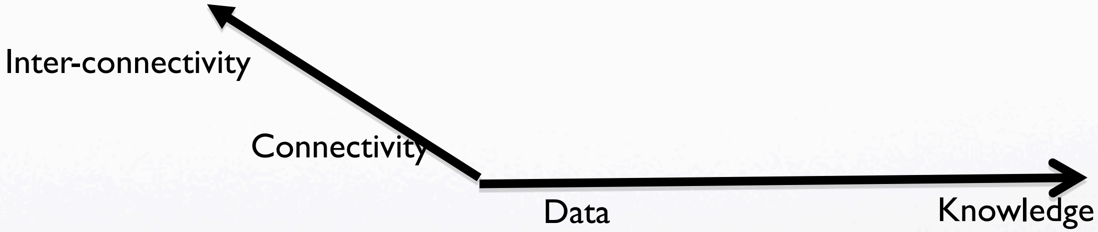

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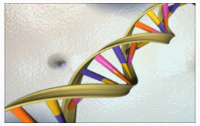

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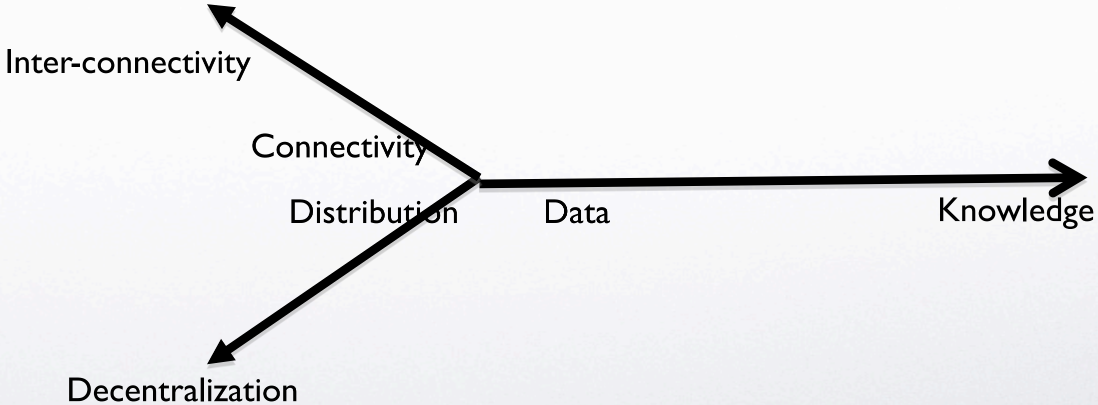

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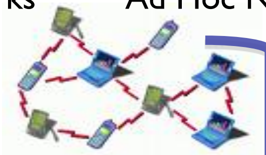

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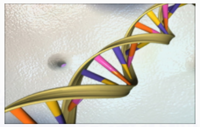

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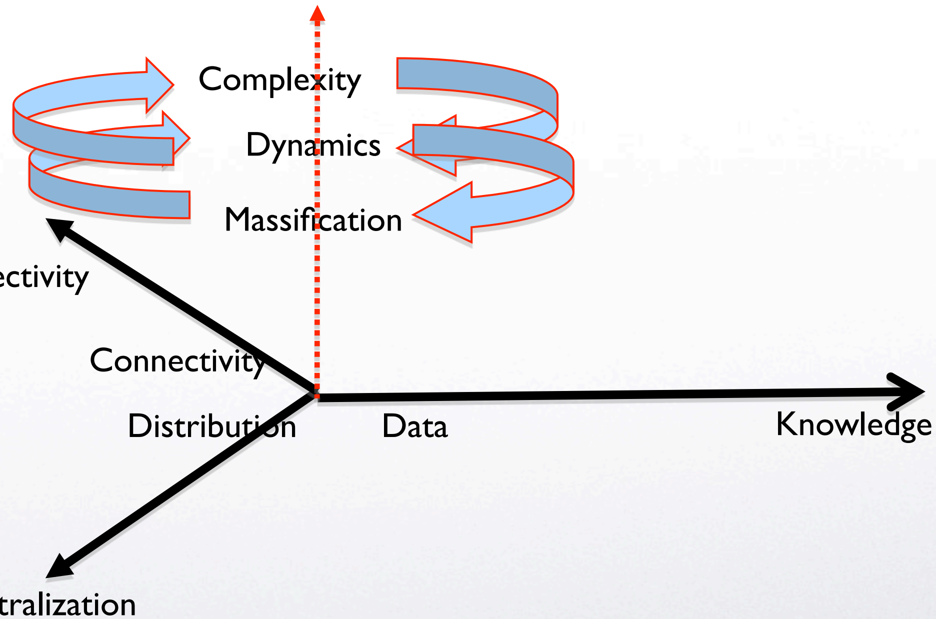

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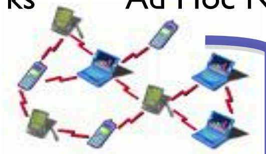

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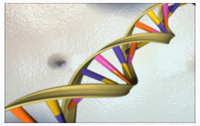

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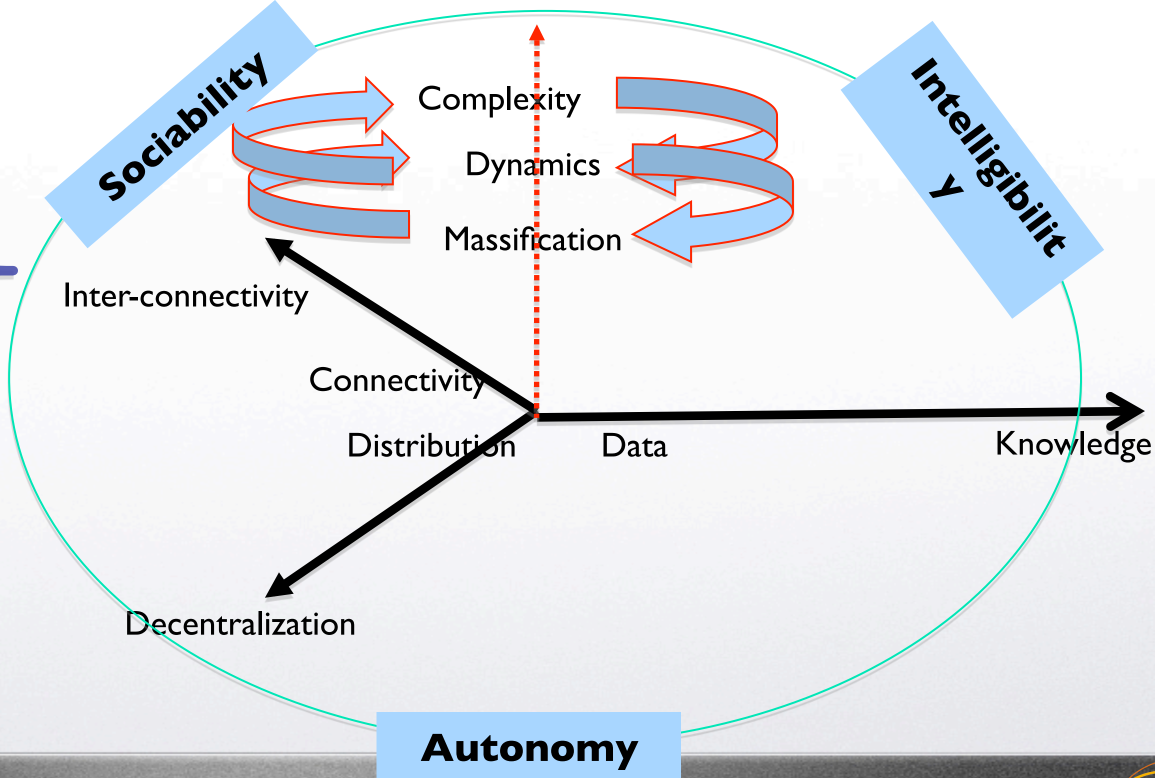


Research Topics

Research

Models and Algorithms for Complex Decision Making

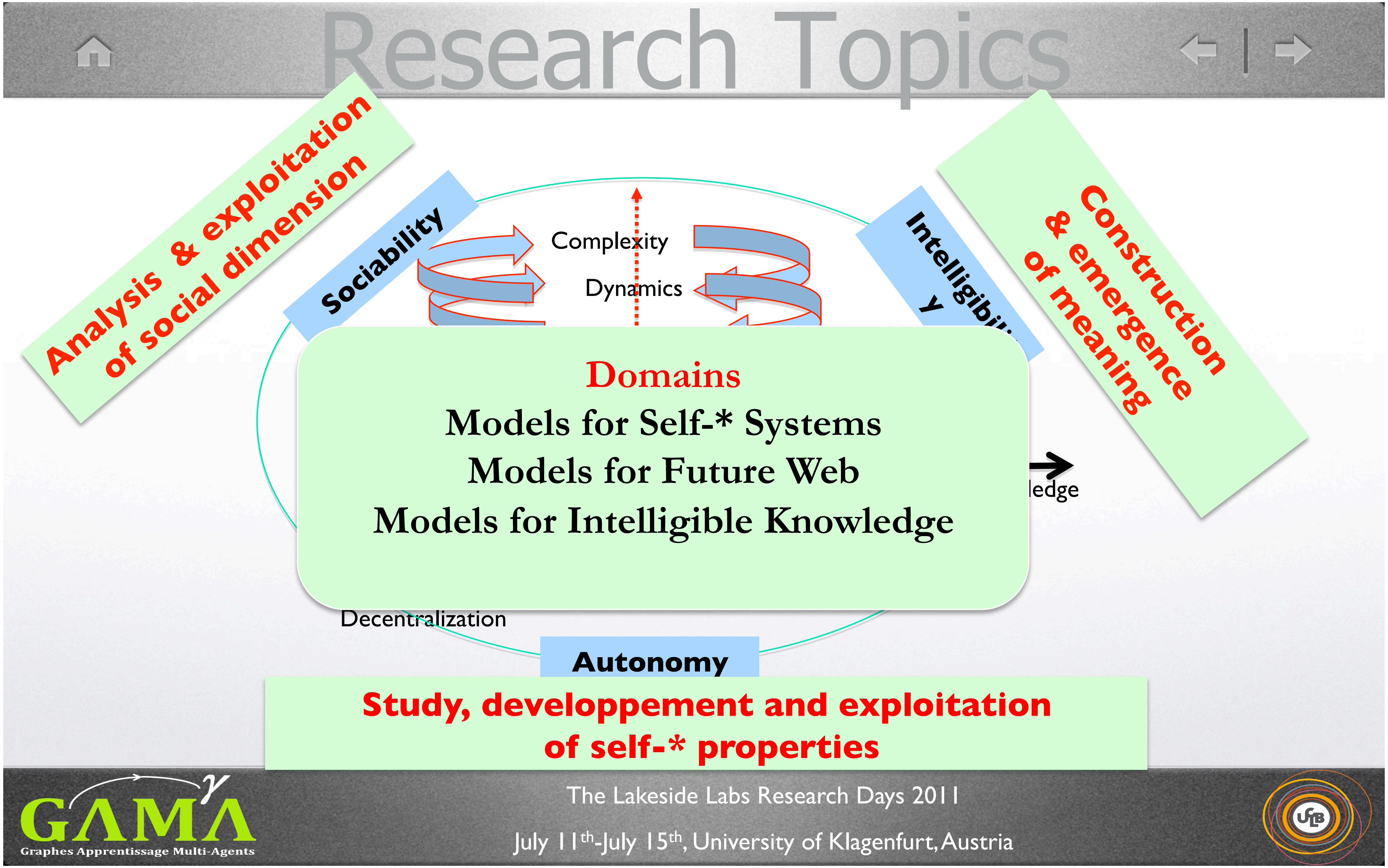
Domains

Models for Self-* Systems

Models for Future Web

Models for Intelligible Knowledge

Autonomy


Research Topics
Analysis & exploitation of social dimension
Sociability
Complexity
Dynamics
Construction & emergence of meaning
Domains
Models for Self-* Systems
Models for Future Web
Models for Intelligible Knowledge
Decentralization
Autonomy
Study, developpement and exploitation of self-* properties
GAMA
Graphes Apprentissage Multi-Agents
The Lakeside Labs Research Days 2011
July 11th-July 15th, University of Klagenfurt, Austria

Research Topics

- Socially Intelligent ICT: Implementation of Artificial Complex Systems

$\Longrightarrow$ Agents able to work collectively, in a smart way, sharing an open environment and that are able to have a collective intelligent reaction when faced with complex problems

$\Longrightarrow$ Distribution, decentralization, dynamics, openness, ..

Some Projects

Models for Self- Systems*

Objectives

Governance of Complex Systems

➔ Decentralized Control of Autonomous Interacting Entities

Mean ➔ Structure and Dynamics Coupling : Enactive Vision

Benefits :

- ✓ Coherence and robustness of functioning (resilience)
- ✓ Adaptation to dynamic and complex environments

Models for Self- Systems*

Projects

- Endogenous Control through Self-Organization in Complex Problem Solving

- Adaptive coordination and interactions → Stigmergic Negotiation
  ➔ CESNA, MANA, ALF Project

• Coherence and robustness in closed Multi-agents Systems containing defective agents

•Self-organization in (P2P) networks
➔ Combination of semantics and (emergent) network topology in search process

Some Projects

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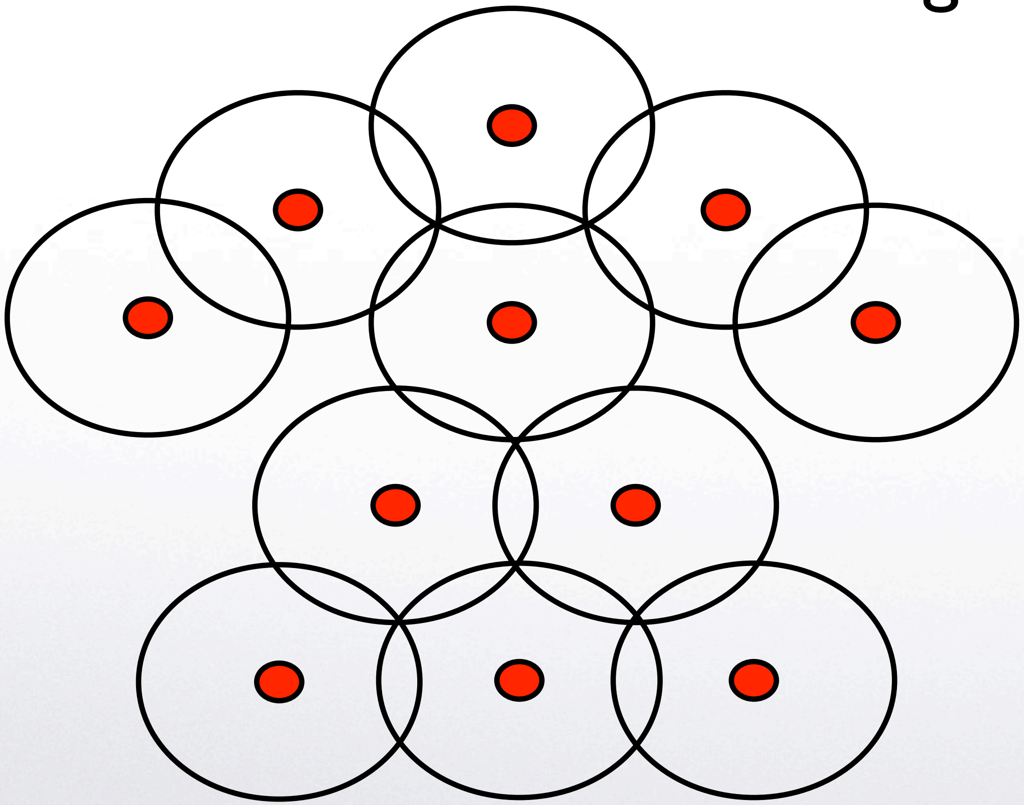
Self-adaptive tuning of dynamic changing problem solving : a first step to endogenous control in multi-agents based problem solvers

- Gaël CLAIR, Frédéric ARMETTA and Salima HASSAS

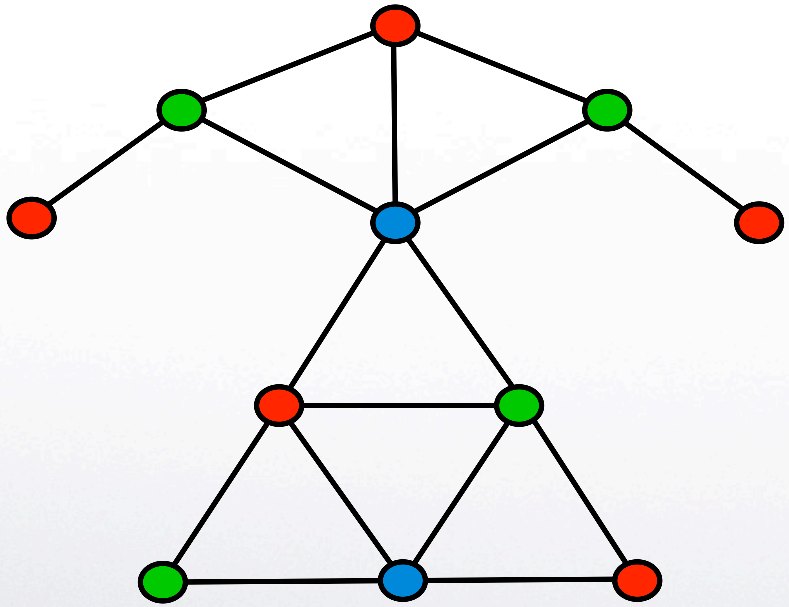
- GAMA Laboratory, University Claude Bernard Lyon 1, France

Control in Self-Organized Systems



- Illustrative example
➔ Frequency allocation problem

Control in Self-Organized Systems

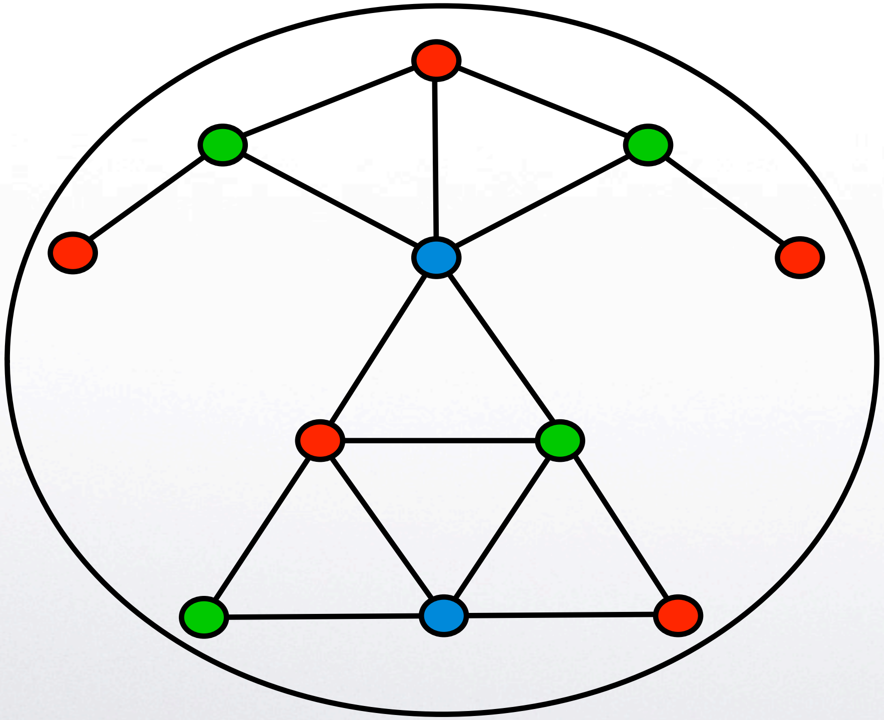


- Frequency allocation problem

=

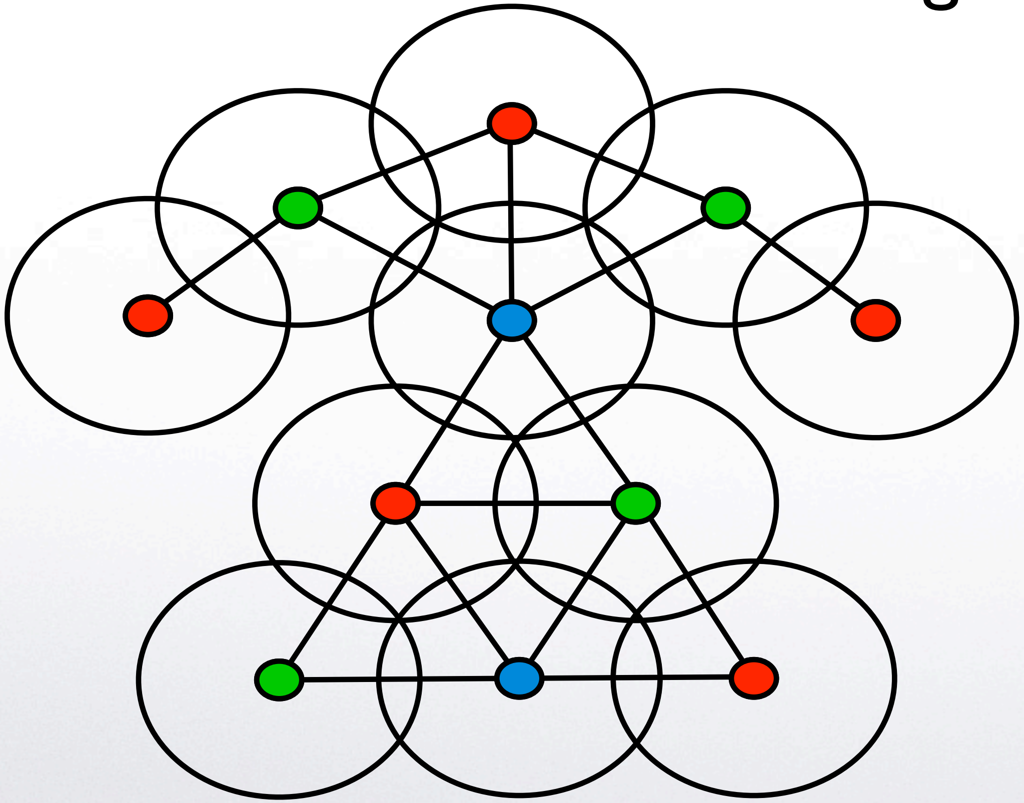
- Graph coloring problem

Control in Self-Organized Systems



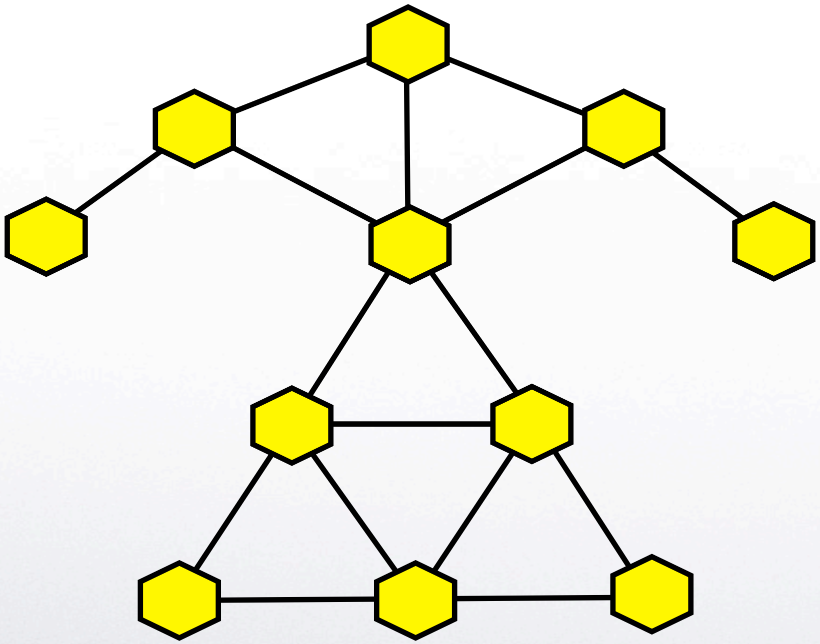
- Centralized methods (greedy, MinConflict ...)

Control in Self-Organized Systems

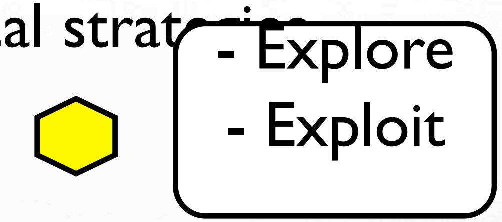


- Decentralized methods
- Divide the global problem
- Solve only local problems

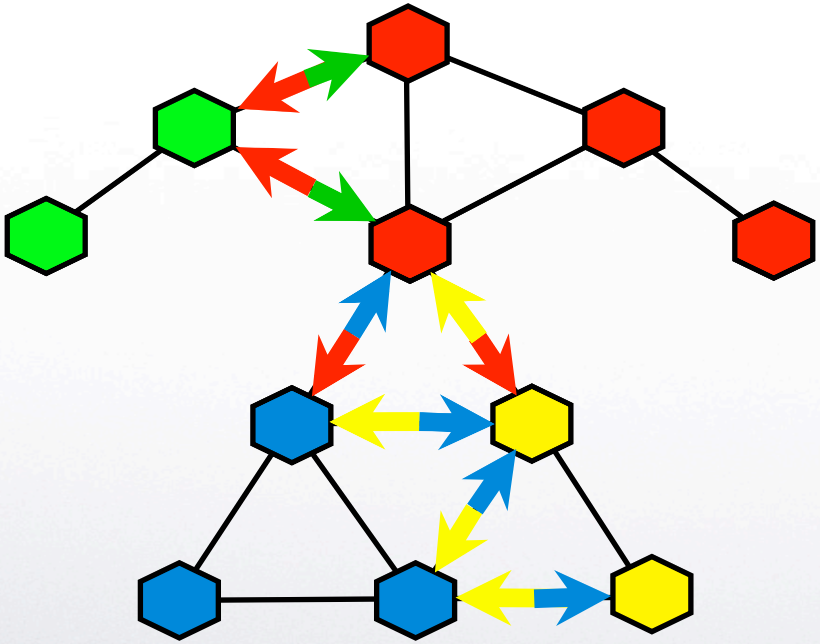
Control in Self-Organized Systems



- Decentralized methods
- Local strategies

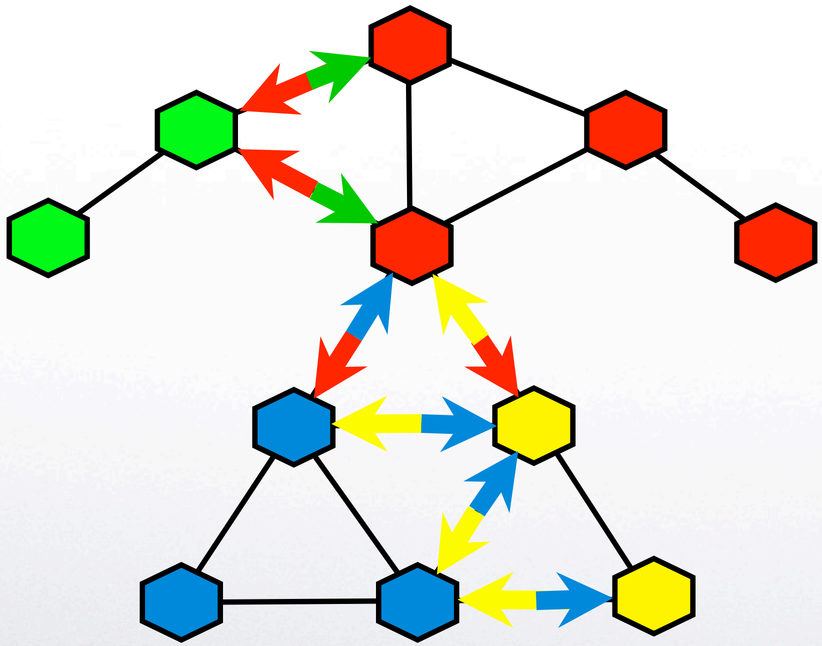


Control in Self-Organized Systems



- Decentralized methods
- Local strategies
  - Explore
  - Exploit
- Influences between local solving processes

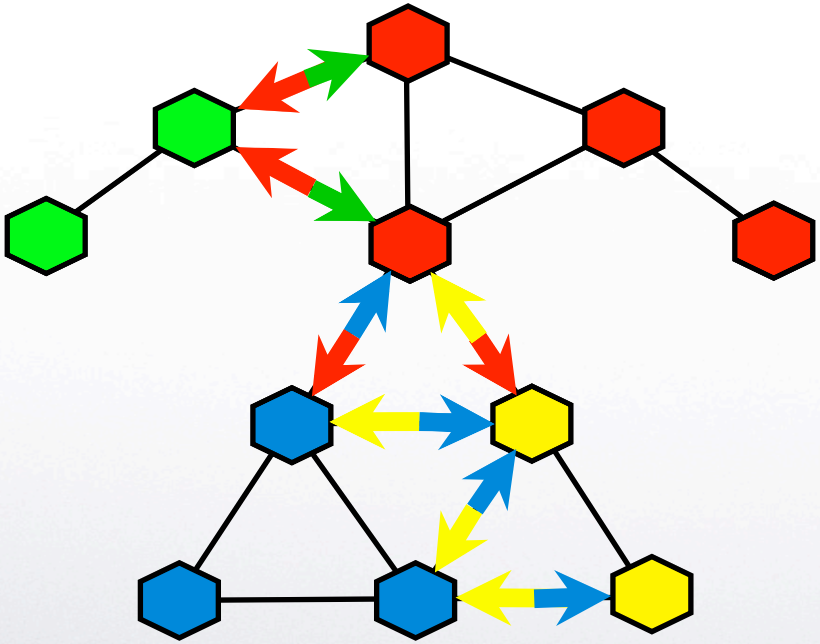
Control in Self-Organized Systems



- Decentralized methods
- Local strategies
  - Explore
  - Exploit
- Influences between local solving processes

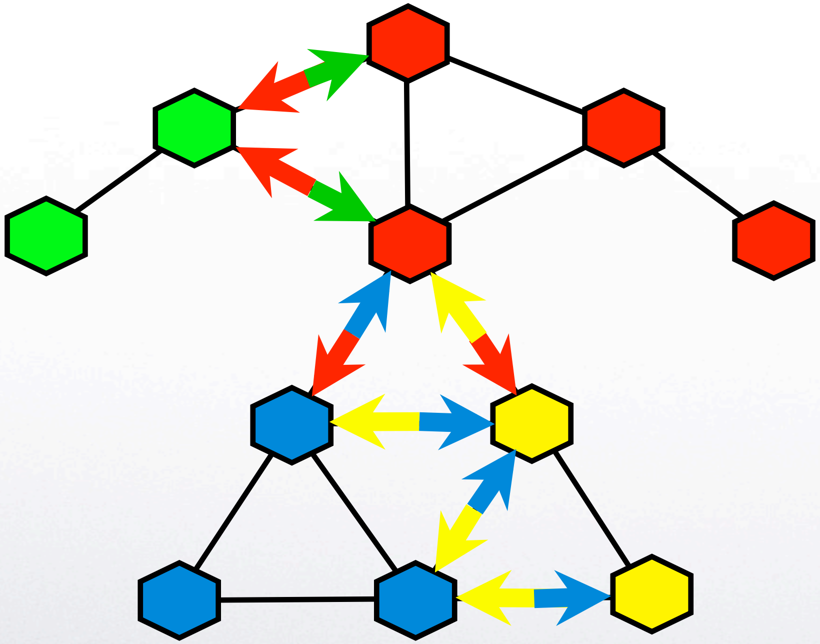
➡ Coordinate the several parallel resolutions

Exogenous control



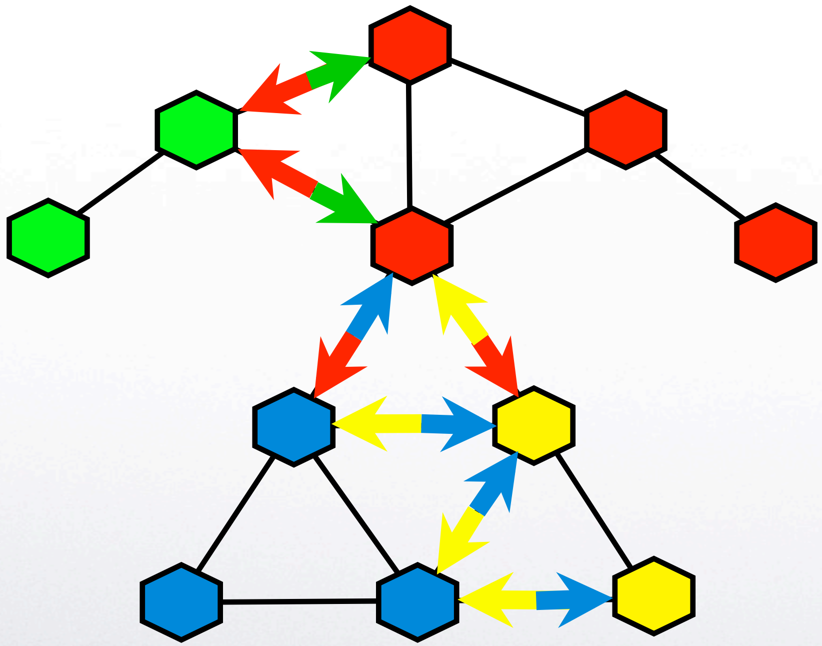
- Decentralized methods
- Design approaches
- Strategies and influences :
  - Conceptor knowledge, heuristics ...
- Design models : ADELFE[1], AALAADIN [2]

Exogenous control



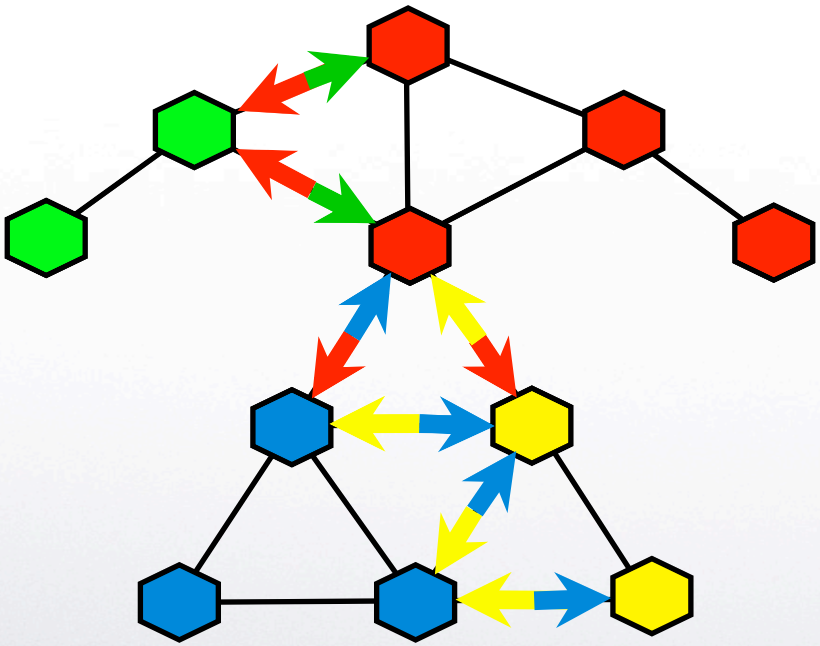
- Decentralized methods
- Calibration approaches
- Strategies and influences :
  - Conceptor knowledge, heuristics ...
  - Simulations [3][4]

Exogenous control



- Decentralized methods
- Dynamic *A priori* approach
- Strategies :
  - Predefined rules
- Influences :
  - Simulations to learn Markov Decision Processes (MDP), modeling local behaviors [5]

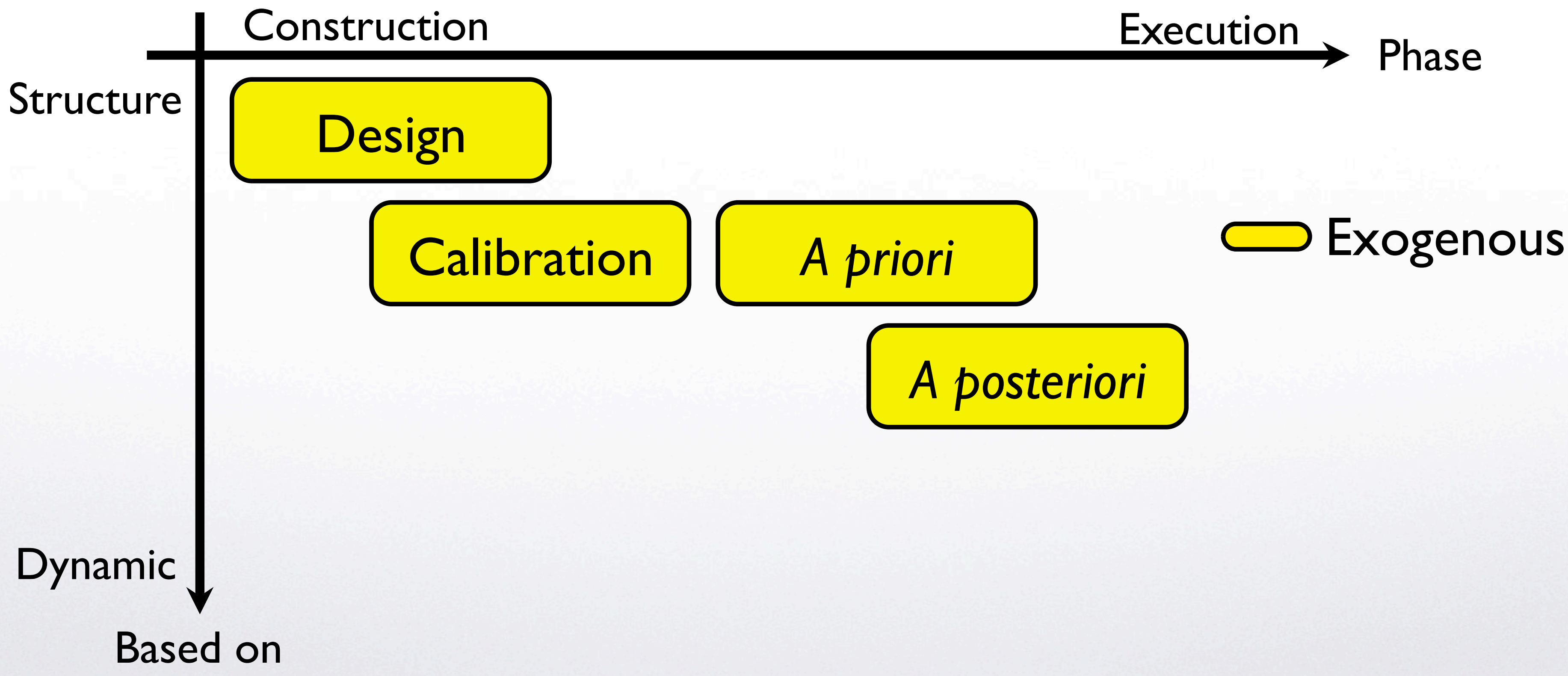
Exogenous control



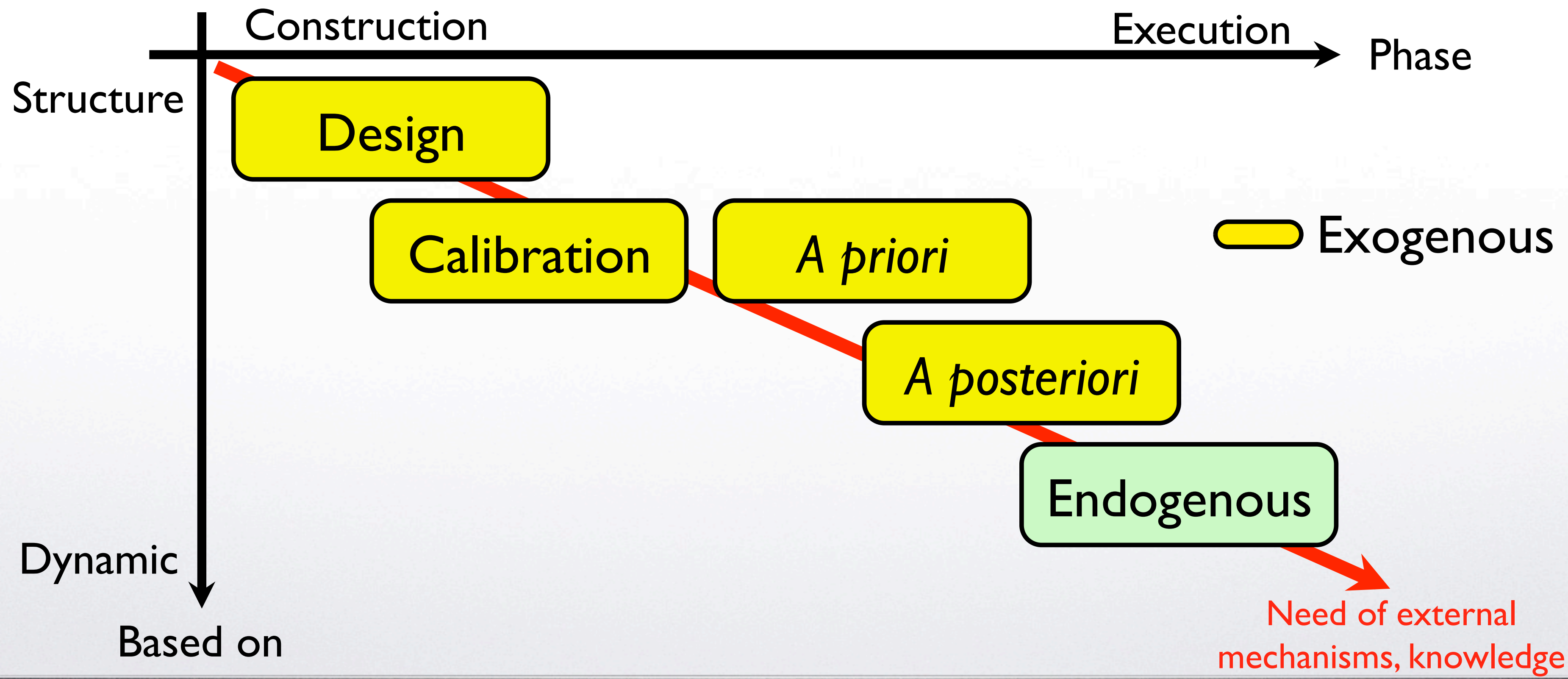
- Decentralized methods
- Dynamic *A posteriori* approach
- Strategies :
  - Conceptor knowledge
- Influences :
  - User
  - Global observation
  - Direct influence
- Morphocontrol [6]

Construction

Control in Self-Organized Systems



Control in Self-Organized Systems



Endogenous Control

Problem

Endogenous Control

Problem

Structure
- Variables
- Domain
- Constraints ...

Direct informations

Endogenous Control

Problem

Structure
- Variables
- Domain
- Constraints ...

Behavior
- Influences
- Indirect dependances
- Search space structure ...

Direct informations

Indirect informations

Endogenous Control

Problem

Structure
- Variables
- Domain
- Constraints ...

Dynamic

Behavior
- Influences
- Indirect dependancies
- Search space structure ...

Direct informations

Indirect informations

Endogenous Control

Observation :

- Local but globally representative
- Agents' State and system dynamic

Endogenous control

Endogenous Control

Learning :
- Problem structure
- System Dynamic

Observation :
- Local but globally representative
- Agents' State and system dynamic

Endogenous control

Endogenous Control

Learning :
- Problem structure
- System Dynamic

Dynamic of the control :
- Influences of the environment on the global system

Observation :
- Local but globally representative
- Agents' State and system dynamic

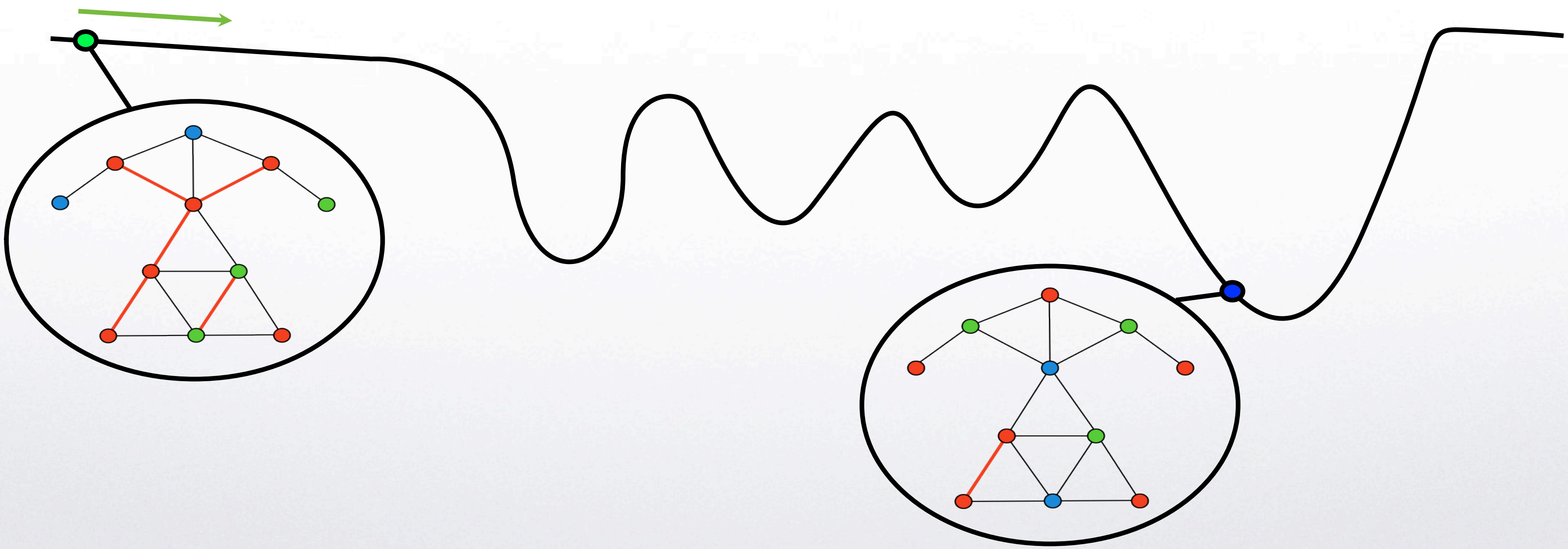
Endogenous control

The Exploitation / Exploration Dilemma

- Exploration
  - The process that aims to gather informations on the solution space
- Exploitation
  - The process that intensifies the search around selected areas, based on the informations collected through exploration

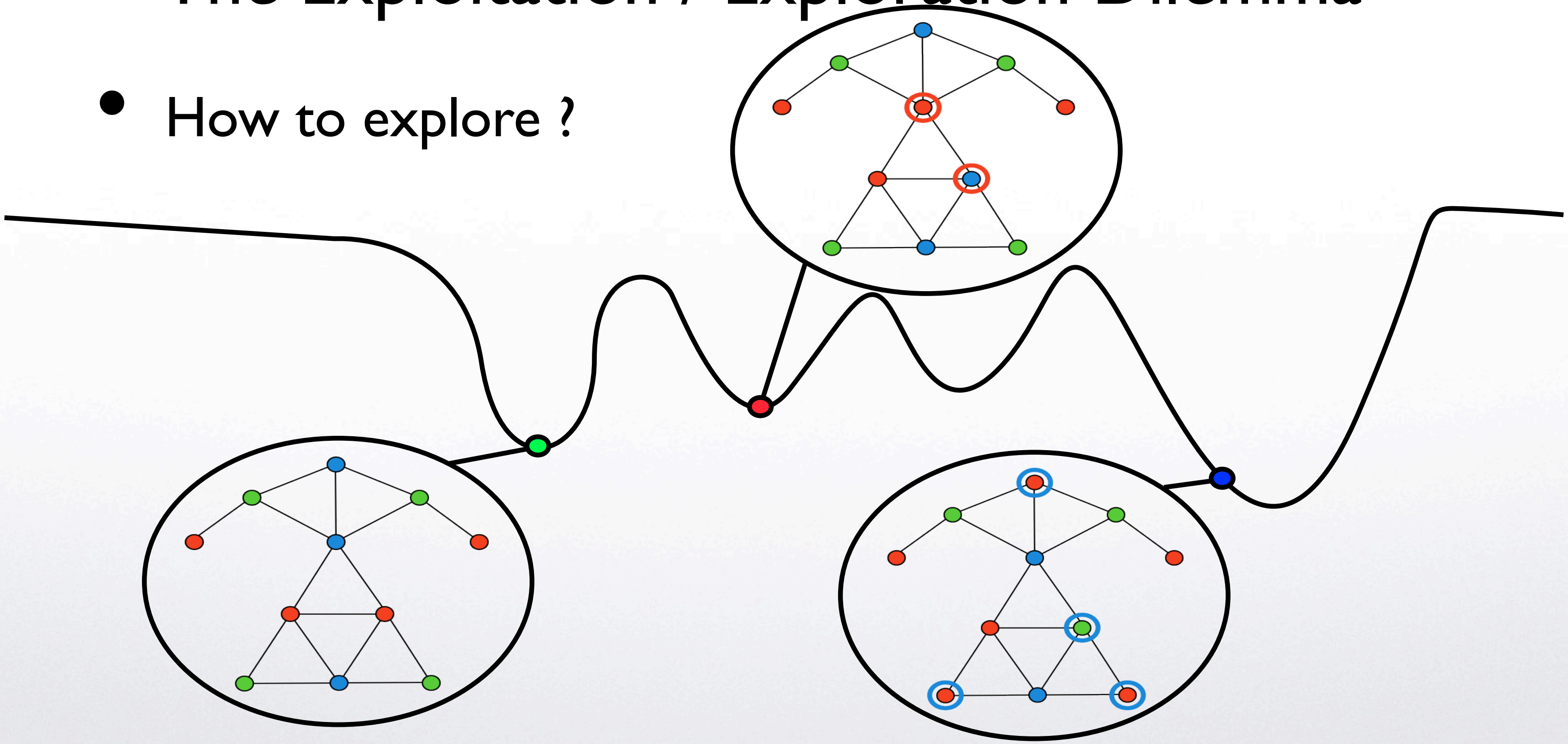
The Exploitation / Exploration Dilemma

- When to explore ?



The Exploitation / Exploration Dilemma

- How to explore ?



The Exploitation / Exploration Dilemma

- In complex self-organized systems
  - Agents can't memorize too much informations
  - We have to consider local action, local evaluation and the system dynamic

➡ Endogenous control could be used to solve the exploitation / exploration dilemma

Endogenous Control For Multi-Agent System Model

Problem

Structure
- Variables
- Domain
- Constraints ...

Dynamic ⟷

Behavior
- Influences
- Indirect dependances
- Search space structure ...

Direct informations

Indirect informations

Endogenous Control For Multi-Agent System Model

Resolution

Endogenous Control For Multi-Agent System Model

Resolution

Structure

Modeling the situation

Endogenous Control For Multi-Agent System Model

Resolution

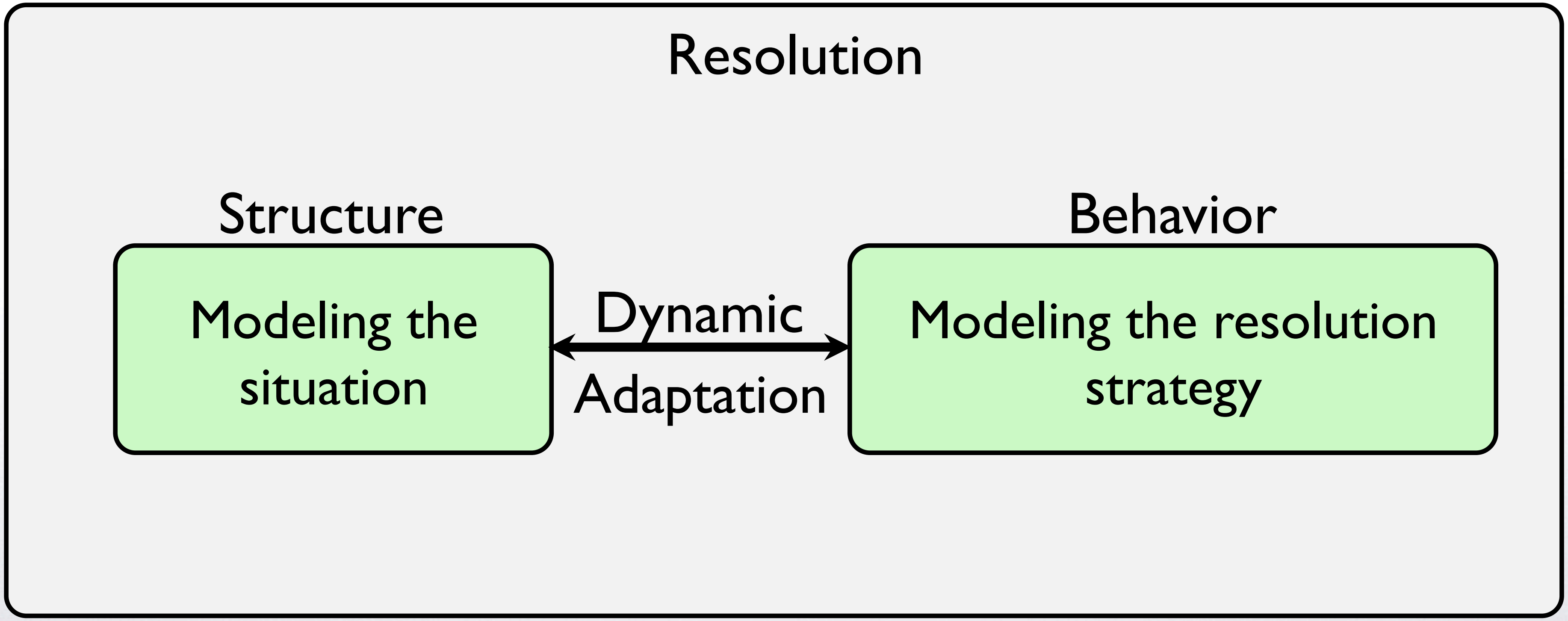
Structure

Modeling the situation

Behavior

Modeling the resolution strategy

Endogenous Control For Multi-Agent System Model



Endogenous Control For Multi-Agent System Model

- Construct a representation of the current situation
- Construct a representation of the current strategy
- Evaluate and adapt the current association of the situation and the strategy

Endogenous Control For Multi-Agent System Model

Structure

Modeling the situation

- Spatial organization
  - Spatial roles to highlight structural characteristics
  - A set of agents and relations of roles to model a particular configuration

Endogenous Control For Multi-Agent System Model

Behavior

Modeling the resolution strategy

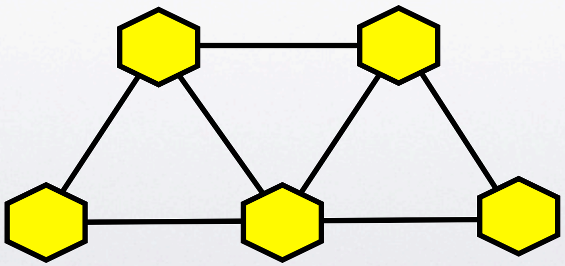
- Social organization
  - Social roles to model agents' actions
  - A set of agents and relations of roles to model a particular strategy

Endogenous Control For Multi-Agent System Model

Structure | Behavior
Modeling the situation ⟷ Dynamic ⟷ Modeling the resolution strategy

- Coupling
  - A fitness function to evaluate the evolution of the resolution
  - A function to update the value of the association between spatial and social configurations

Endogenous Control For Multi-Agent System Model



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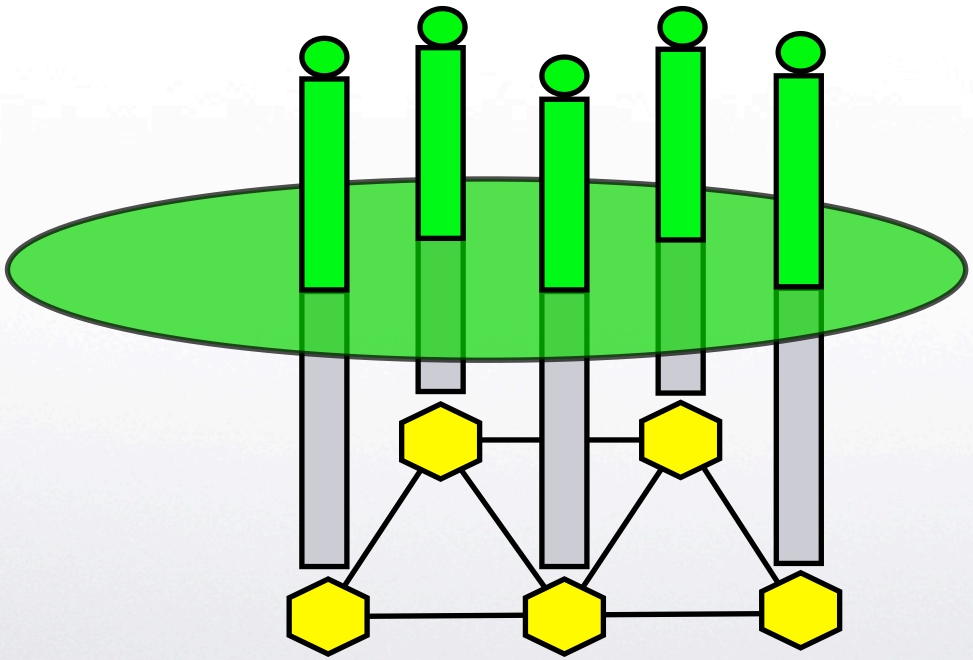
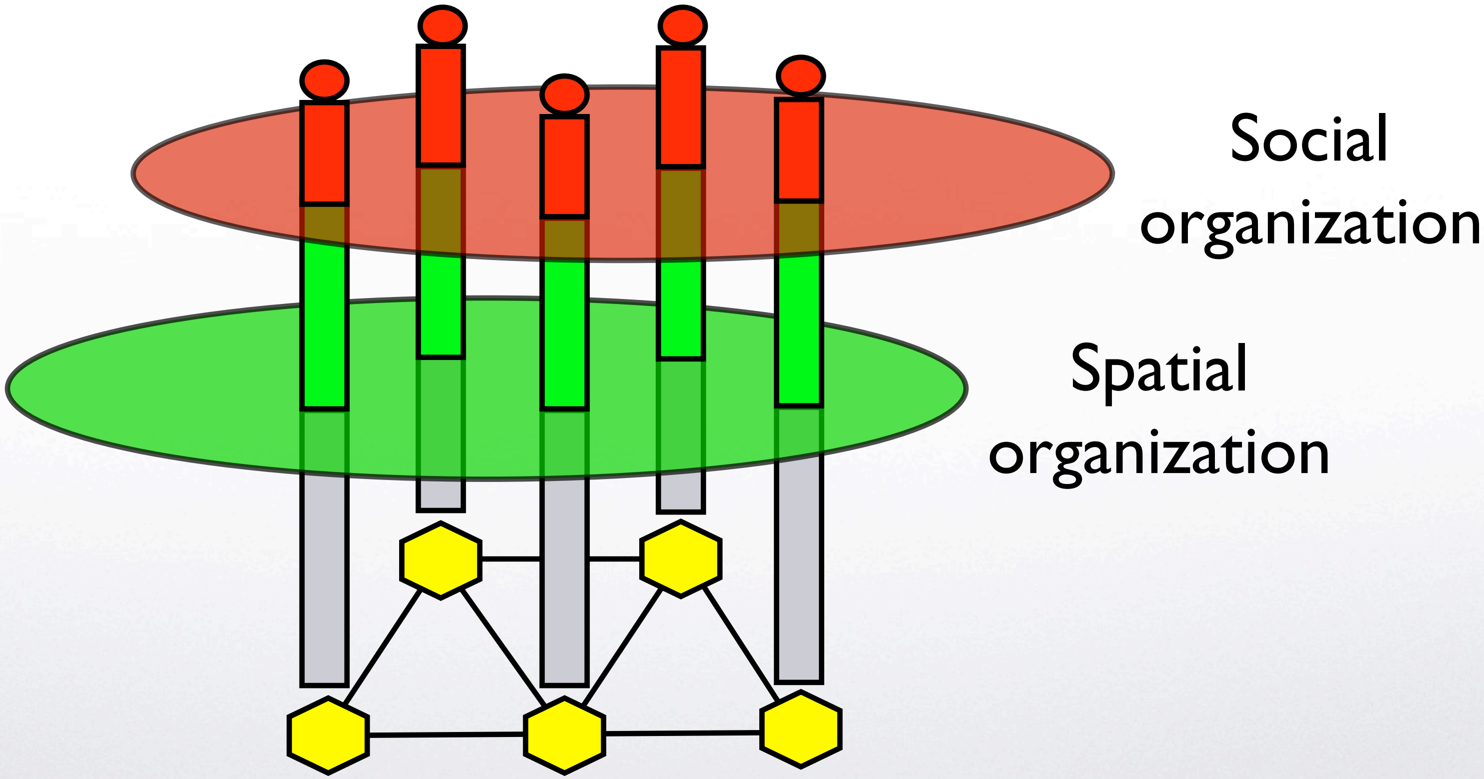


Spatial organization

Endogenous Control For Multi-Agent System Model



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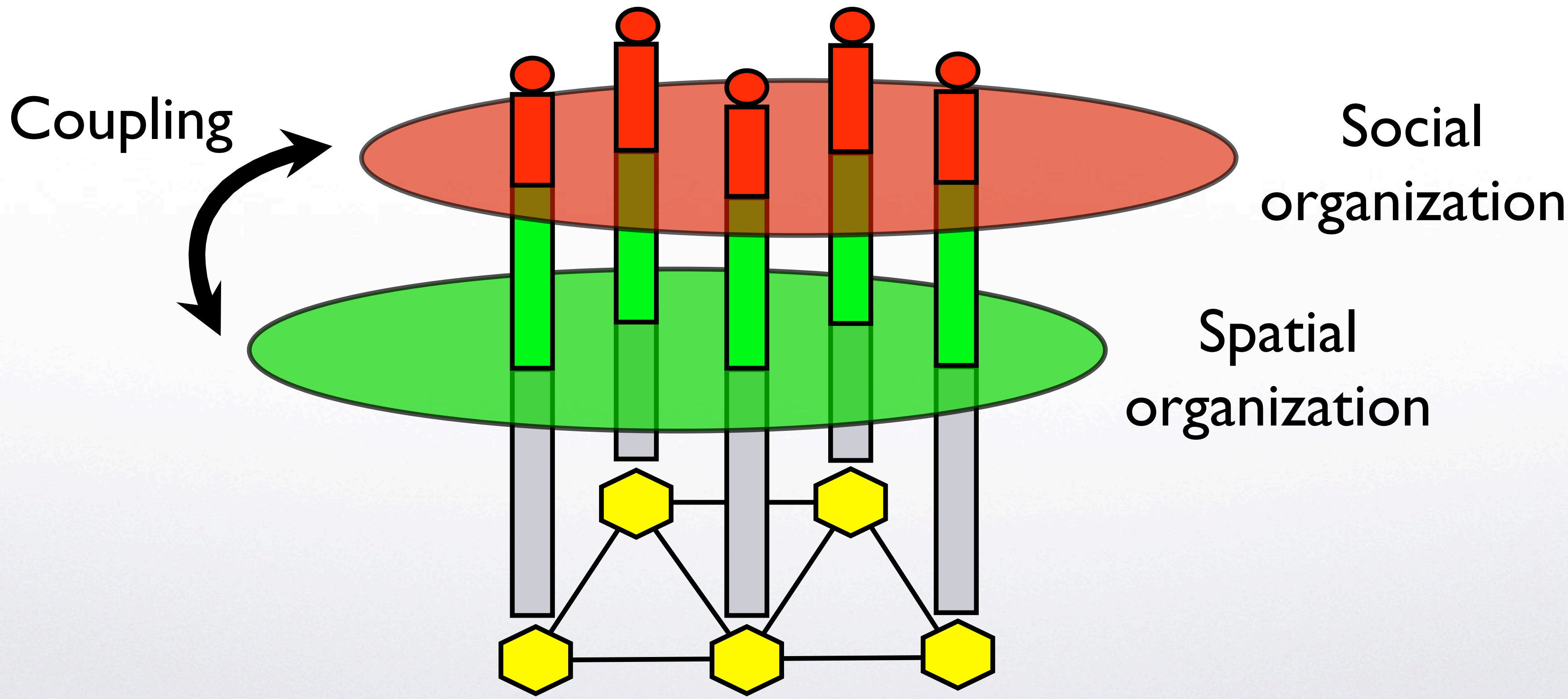


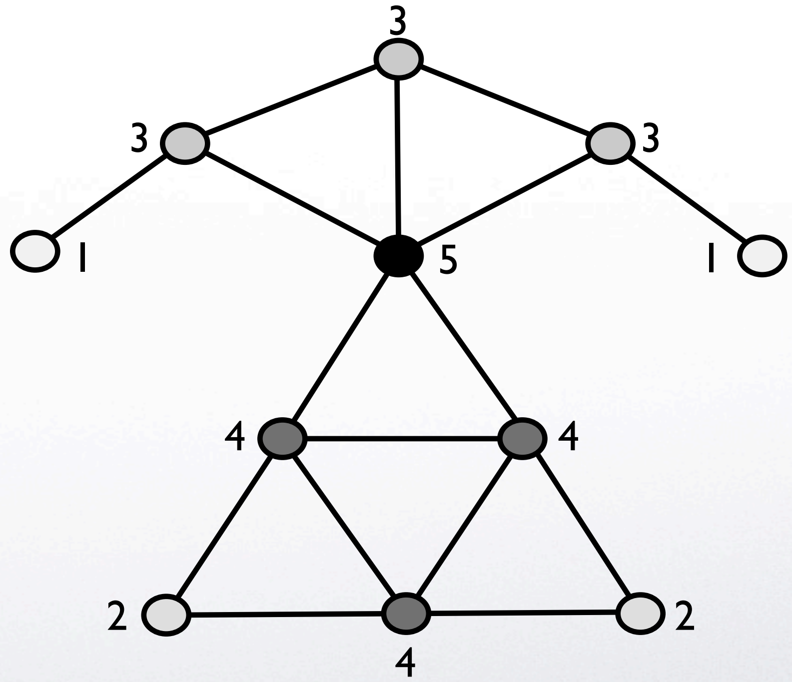
Experimental settings

- 100 different graphs, 300 nodes, 0.0233 edge connectivity
- 4 colors
- 1000 executions for each problem
- 1000 cycles max

- Reference problem
  - Min-Conflict with exploration : 234 cycles
  - Optimal exploration rate : 17 %

EC4MAS implementation

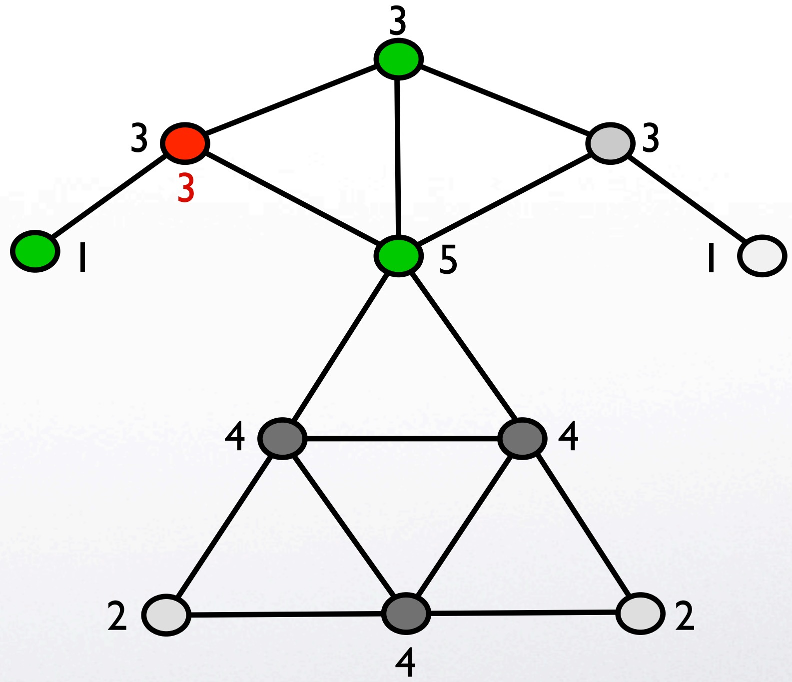
- Agent = graph node
- Spatial organization
  - Roles : node's degree



EC4MAS implementation

- Agent = graph node
- Spatial organization
  - Roles : node's degree
  - Relations : average node's

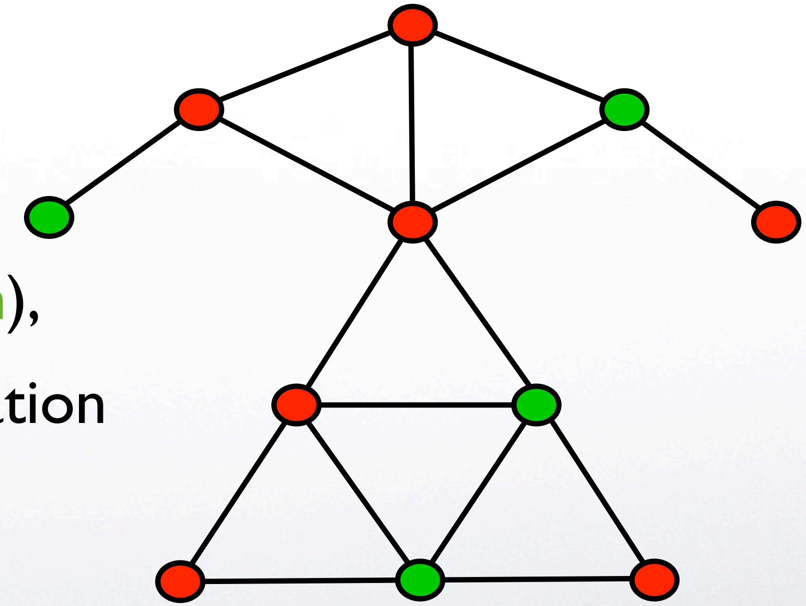
degree in the neighborhood



EC4MAS implementation

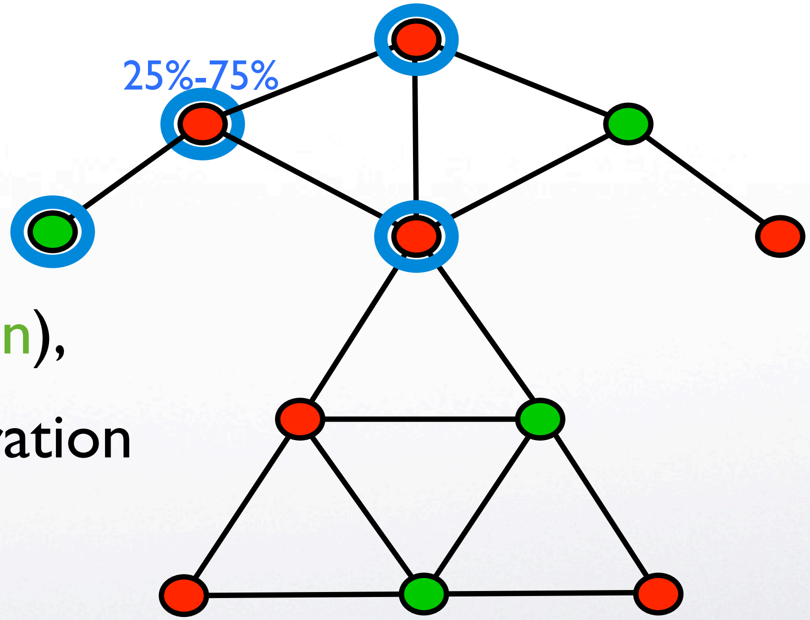
- Agent = graph node
- Social organization
  - 2 Roles
    - Min-Conflict (exploitation),
    - Min-Conflict with exploration

(exploration)



EC4MAS implementation

- Agent = graph node
- Social organization
  - 2 Roles
    - Min-Conflict (exploitation),
    - Min-Conflict with exploration (exploration)
  - Relations : social roles repartition in the neighborhood

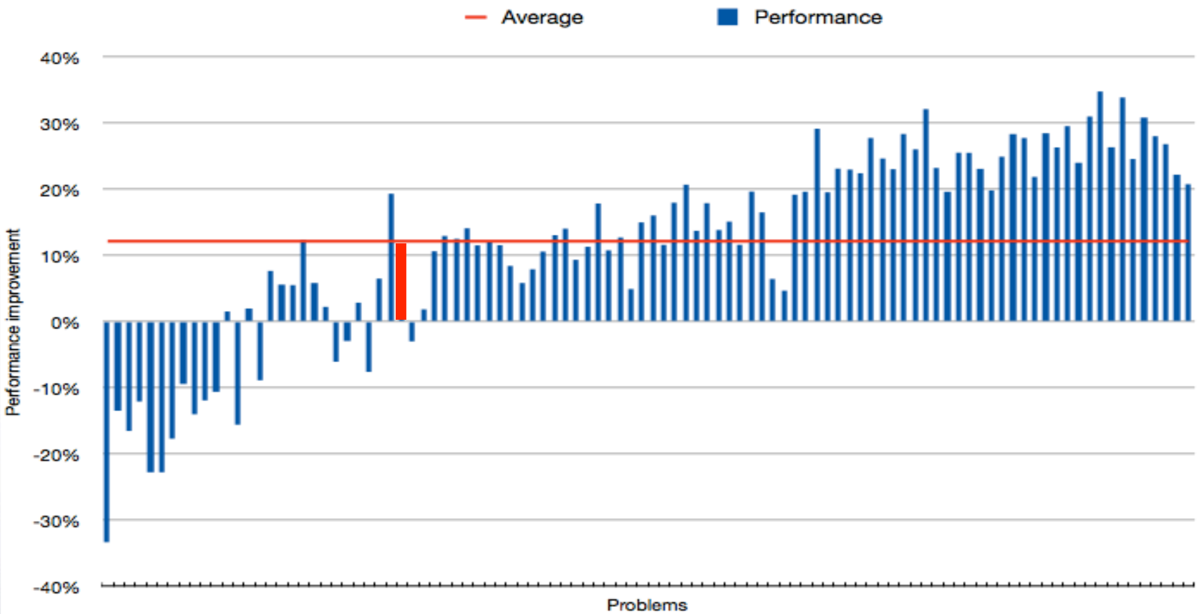


EC4MAS implementation

- Coupling
  - Genetic algorithm
    - Coupling values

	Social situation	
Spatial situation	0,2	0,8
	0,6	0,4
	0,7	0,3

Results



Performance improvement over Min-Conflict on100 problems

Average improvement : 12,4 %

- EC4MAS uses characteristics of the problem

Results

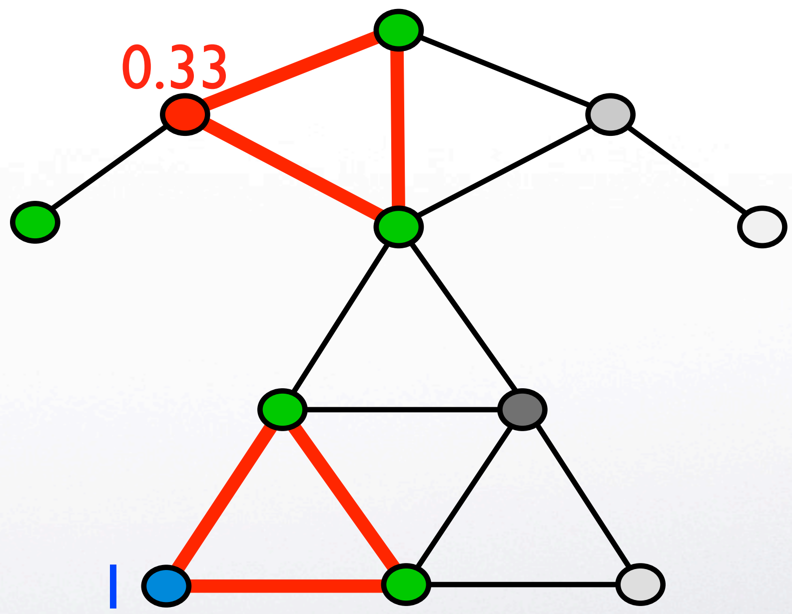
Resolution	Perf.	Tuning time	Efficiency
Min Conflict (17,7%)	100%	4	-
Optimal Min Conflict	124,71%	333	1,50%
EC4MAS (17,7%)	112,14%	22	20,39%

Performance tuning time (min) and efficiency (performance gain / tuning time gain)

- Min Conflict (reference)
  - Tuning time : exploring rate
- Optimal Min Conflict
  - Tuning time : exploring rate for each problem
- EC4MAS
  - Tuning time : exploring rate for reference problem + coupling values
    - EC4MAS makes the tuning of the system robust

Results

- Clustering coefficient [7]
- Measure of degree to which nodes in a graph tend to cluster together
- Good indicator of hardness for graph coloring problem



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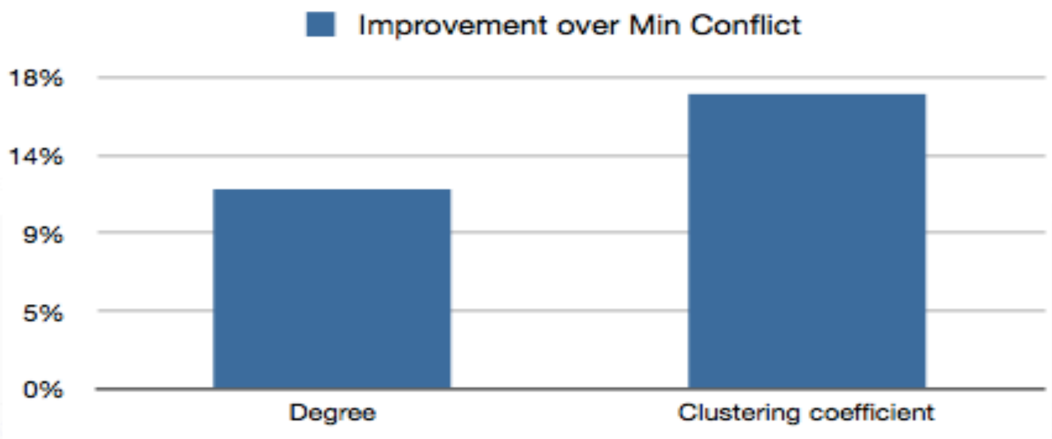

Performance improvement over Min-Conflict with two different spatial roles

- EC4MAS is generic but can be specialized to better adapt to a specific problem

Summary

- EC4MAS couples (coupling) the structural / topological characteristics of the problem (spatial organization) to the appropriate solving behavior (social organization)

- EC4MAS could be used to make the system tuning robust in front of dynamic changes of the problem

- EC4MAS is generic and could be used with or without problem specific informations

Future Work

- Dynamic adaptation of the coupling
  - Real-time evaluation of the resolution
  - Real-time update of the coupling values
- Social organization more specific
  - Finer granularity for social organization
  - Precise situation modeling

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