Dynamic Coalition Formation in Iterative Request For Proposal Environments

Carlos Merida-Campos

Knowledge Engineering and Machine Learning Group
UNIVERSITAT POLITÈCNICA DE CATALUNYA

Advisor: Steven Willmott
Tutor: Ulises Cortés

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2. Theoretical Framework
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   - Environments with Multiple Simultaneous Tasks
4. Conclusions

Limitations on Automated Negotiation

- Negotiations of commodities
- Auction design
- Bundle negotiations

Negotiation Between Providers

- Reverse Auction (RFQ)
- Contract Net (CNET)
- Request For Proposal (RFP)

Limitations on RFP Research Environments

- Limited to simple task allocation scenarios
- Dynamic aspects of negotiation are usually ignored
- Usually focuses on communicational aspects
- Consider individual bids instead of joint proposals

Coalition Formation

- Coalition Formation organizational paradigm
  - Solving optimization problem of each coalition
  - Dividing the value of the generated solution
  - Coalition structure generation
- Dynamic Coalition formation
  - Assuming a series of negotiation between agents

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Chapter 4

Theoretical Framework

- Aspects to consider in the model
  - Dynamism
  - Amount of information
  - Heterogeneity
  - Topology
  - Simultaneity

The General Model

- Tasks $T = \langle T^1, T^2, \ldots, T^k \rangle$
- Agents $\sigma_{il} = \langle \sigma_{il}^1, \sigma_{il}^2, \ldots, \sigma_{il}^k \rangle$
  - Coalitions $\sigma = \{\sigma_1, \sigma_2, \ldots, \sigma_w\}$
    - Aggregated skills $\widehat{\sigma}_i = \langle \sigma_i^1, \sigma_i^2, \ldots, \sigma_i^k \rangle \quad \sigma_i^l = \max(\sigma_{ij}^l) : 1 \leq j \leq m$
    - Quantitative value $\mathrm{scr}(\sigma_x, T) = \sum_{j=0}^{k} (\sigma_x^j * T^j)$
    - Rank $\mathrm{rank}(\sigma_x, \sigma) \rightarrow \mathbb{R}$
    - Payment $\mathrm{pay}(\sigma_x, \sigma) = \begin{cases} \mathrm{Mx}/2^{\mathrm{rank}^*(\sigma_x,\sigma)-1}, & \text{if } \exists \sigma_y : \mathrm{scr}(\sigma_x, T) \geq \mathrm{scr}(\sigma_y, T) \\ \mathrm{Mx}/2^{\mathrm{rank}^*(\sigma_x,\sigma)-2}, & \text{if } (\forall y : y \neq x) : \mathrm{scr}(\sigma_y, T) > \mathrm{src}(\sigma_x, T) \end{cases}$

Agents actions

- Stay
- Leave
- Leave - Join - [replace]

$$\psi_i = <(\sigma_x, \phi_{xy}), \ldots, (\sigma_w, \phi_{wz})>$$

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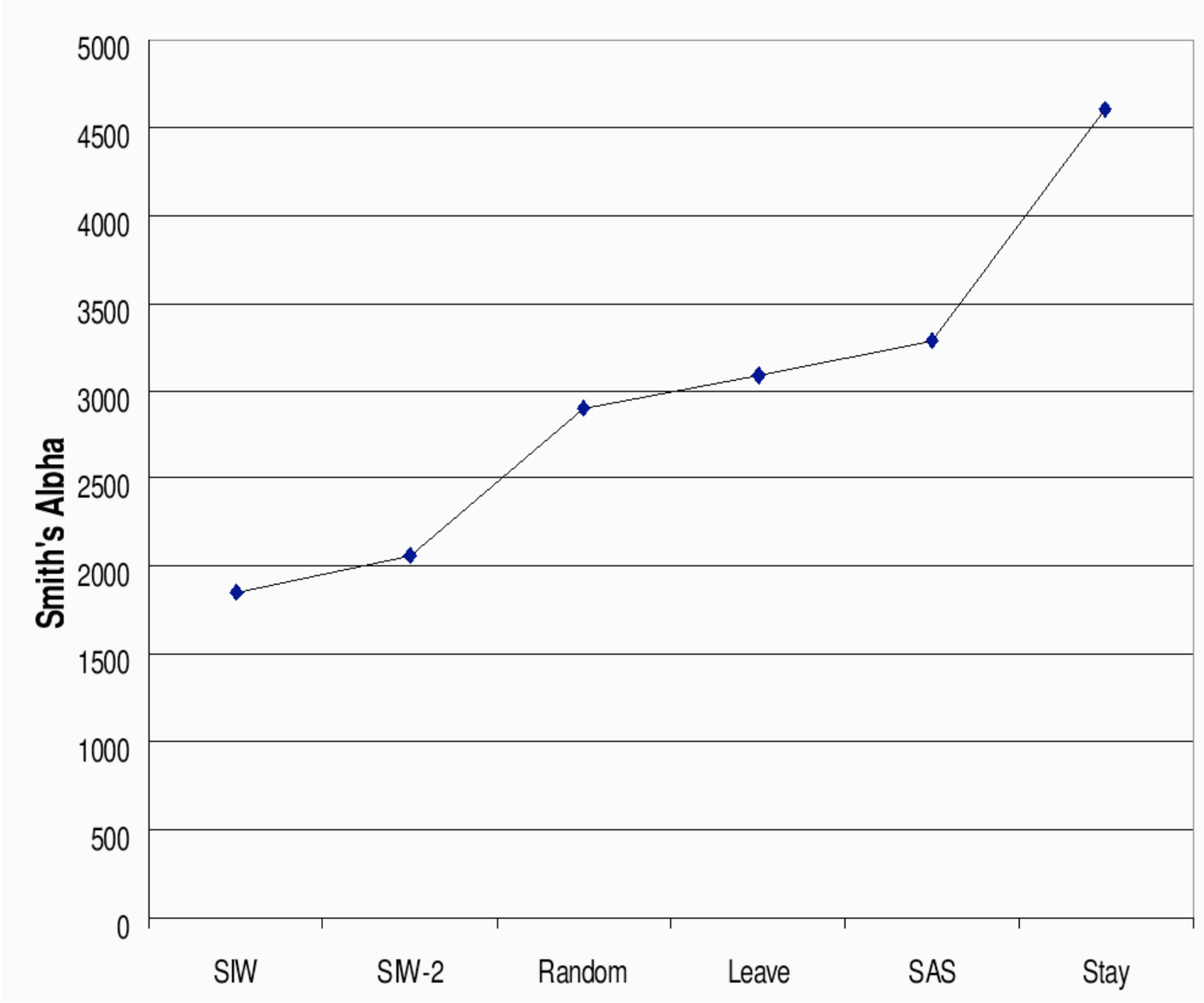
Part II

Simple Environments

- Reduced Strategic Set
  - Stay
  - Stay if all Stay
  - Stay if Win
  - Stay if Win-2
  - Leave
  - Random

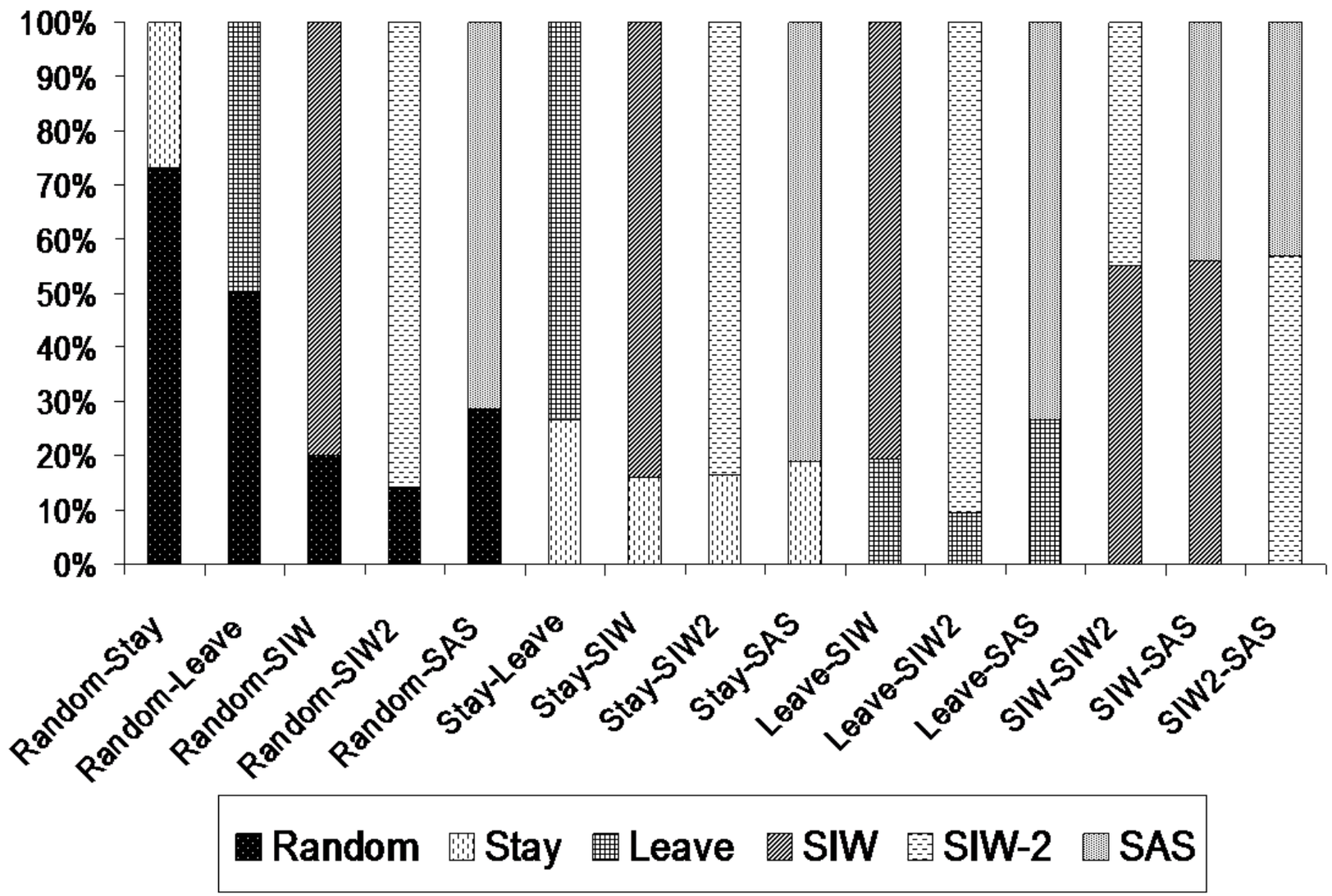
Simple Environments

- System Performance in isolation



Simple Environments

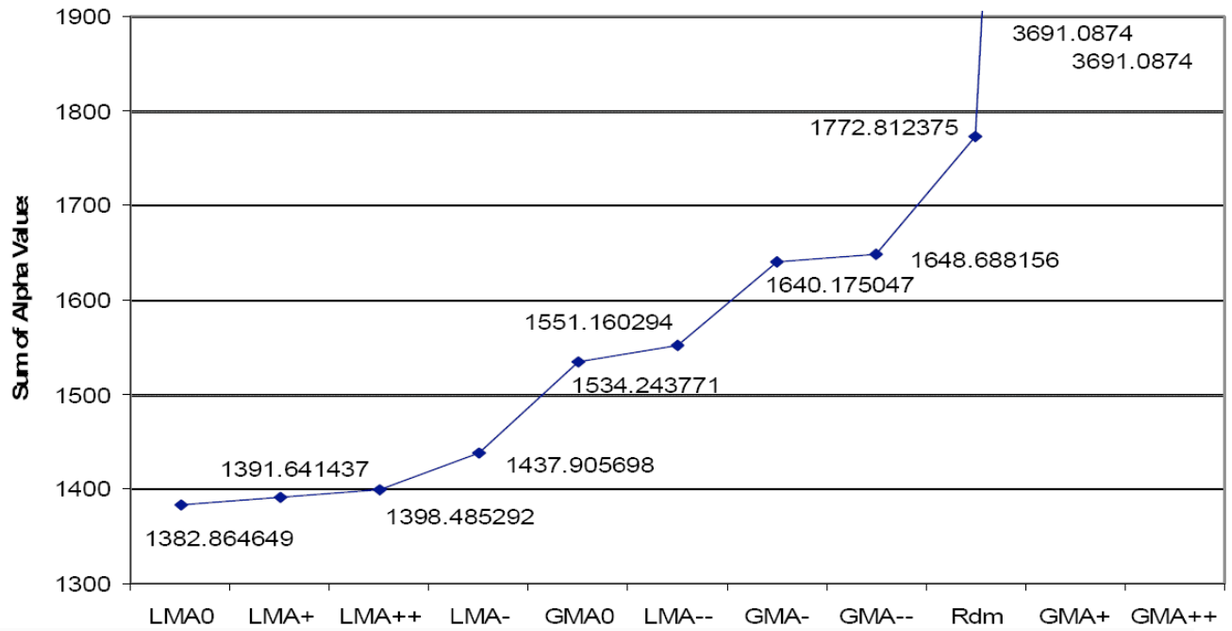
- Individual Performance in Mixed Populations

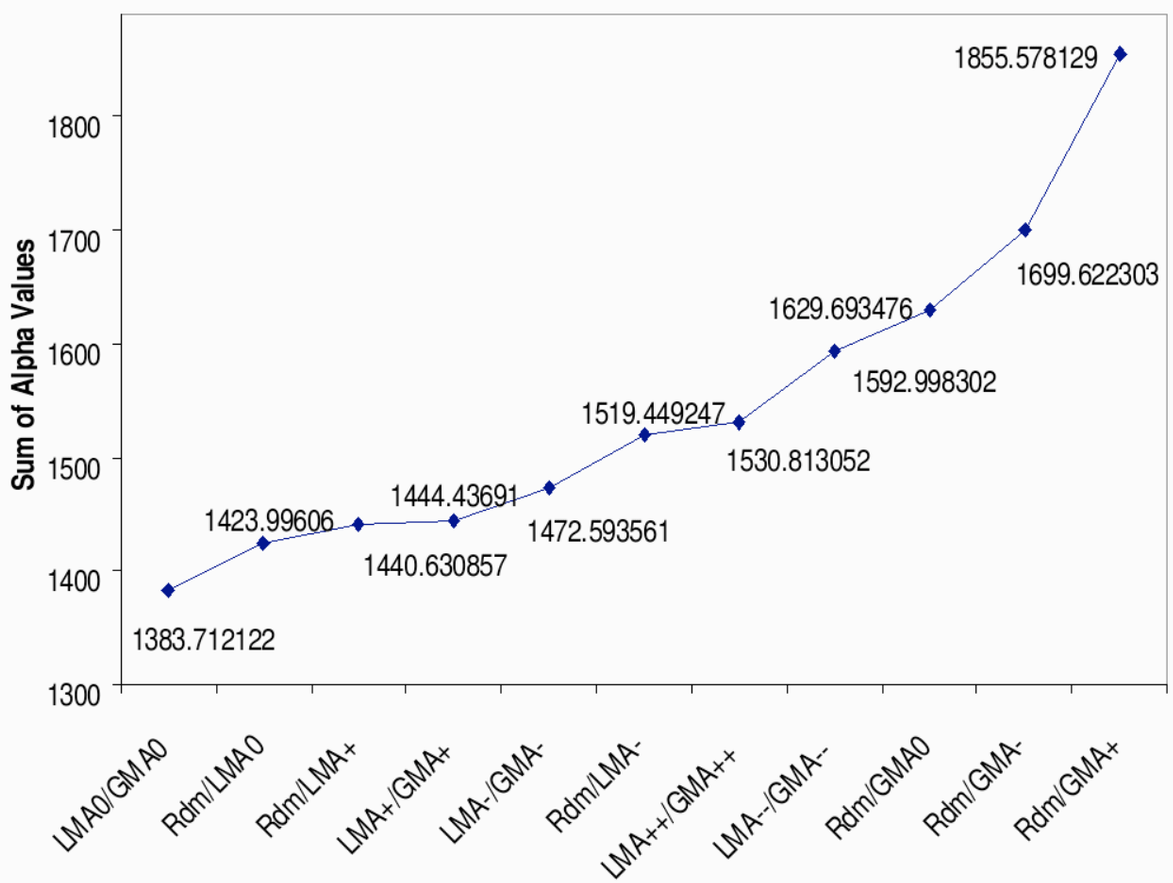


Simple Environments

- Adapting using indicators
- $$Leave(X, Y, \Delta) = (Y - X) > \Delta$$
- $$V_x^{t+1}(y) = \begin{cases} V_x^t(y) + R^+, & \text{if } V_x(y) + R^+ < \text{MaxValue} \\ V_x^t(y), & \text{if } V_x(y) + R^+ \geq \text{MaxValue} \end{cases}$$
  $$V_x^{t+1}(z \neq y) = \begin{cases} V_x^t(z) - (R^+/(n-1)), & \text{if } V_x(y) + R^+ < \text{MaxValue} \\ V_x^t(z), & \forall z \text{ if } V_x(y) + R^+ \geq \text{MaxValue} \end{cases}$$
- LMA: Local Memory Agents
- GMA: Global Memory Agents

Simple Environments





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Part III

Environments With Farsighted Agents

- Tasks $T = \langle T^1, T^2, \ldots, T^k \rangle$
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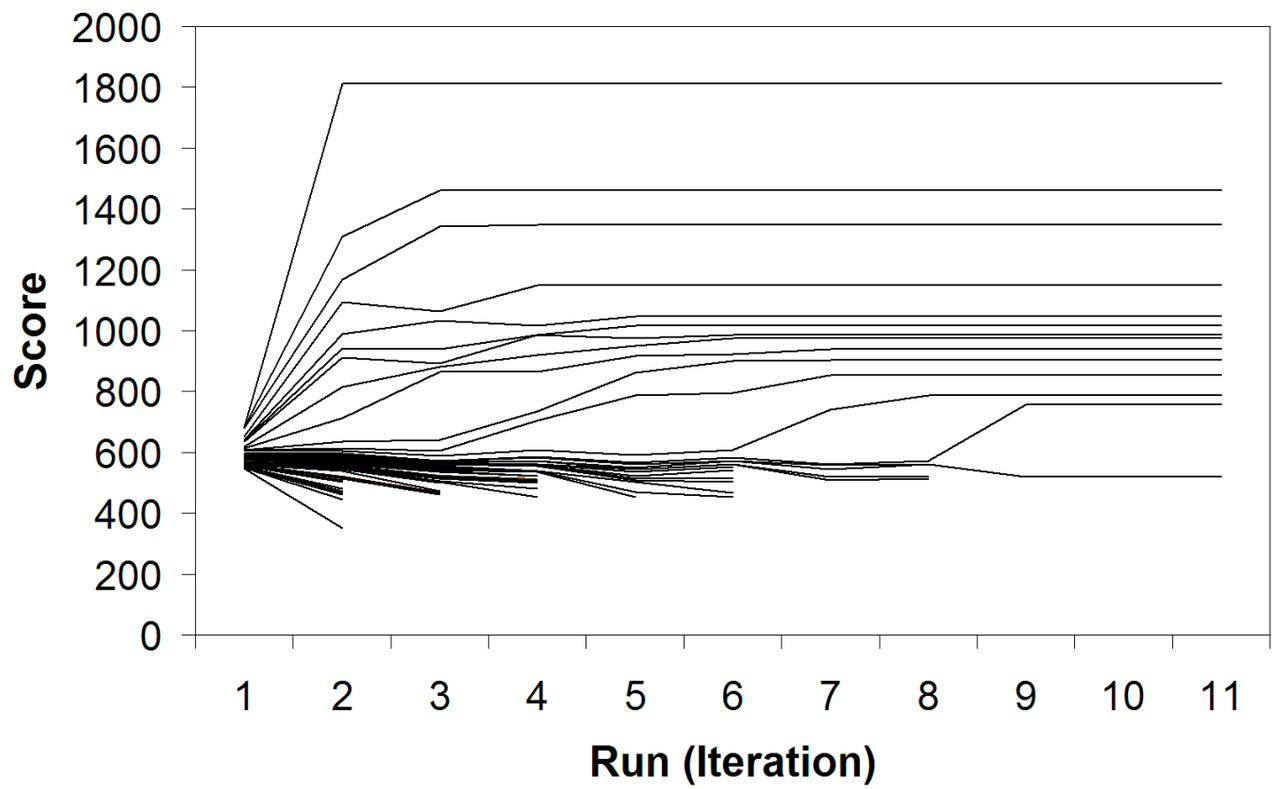
Payoff Maximizing

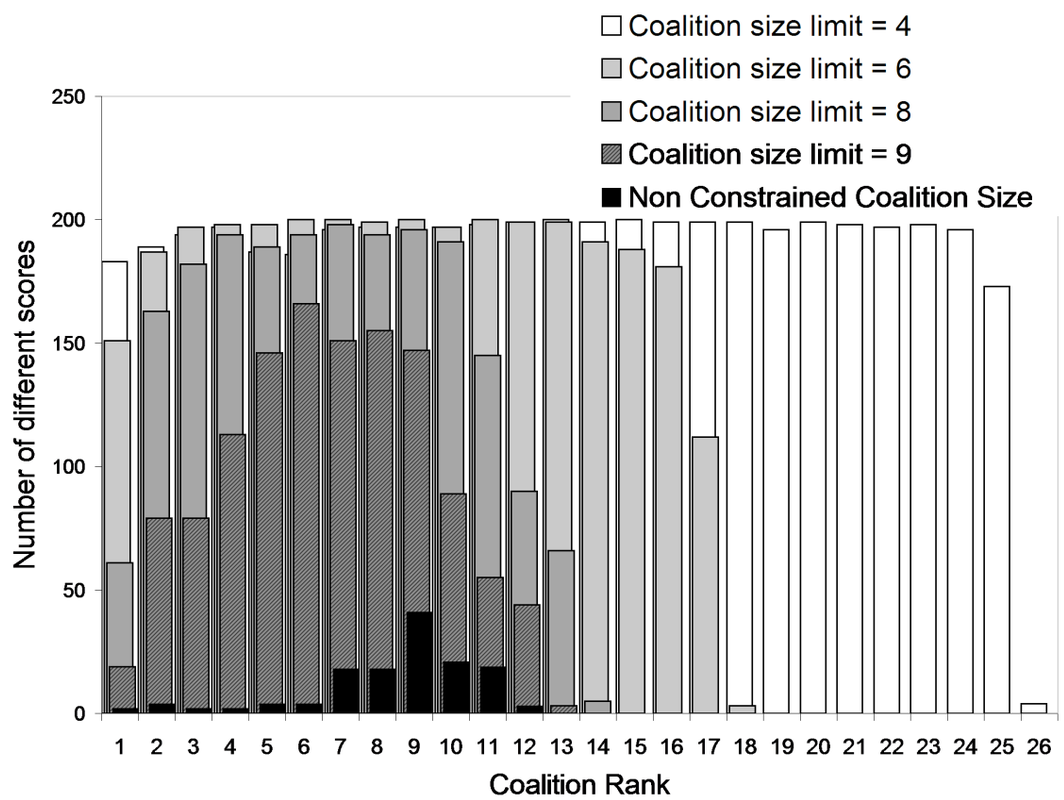
Environments With Farsighted Agents

- Stability Analysis
  - Leading Coalition never reduces its value



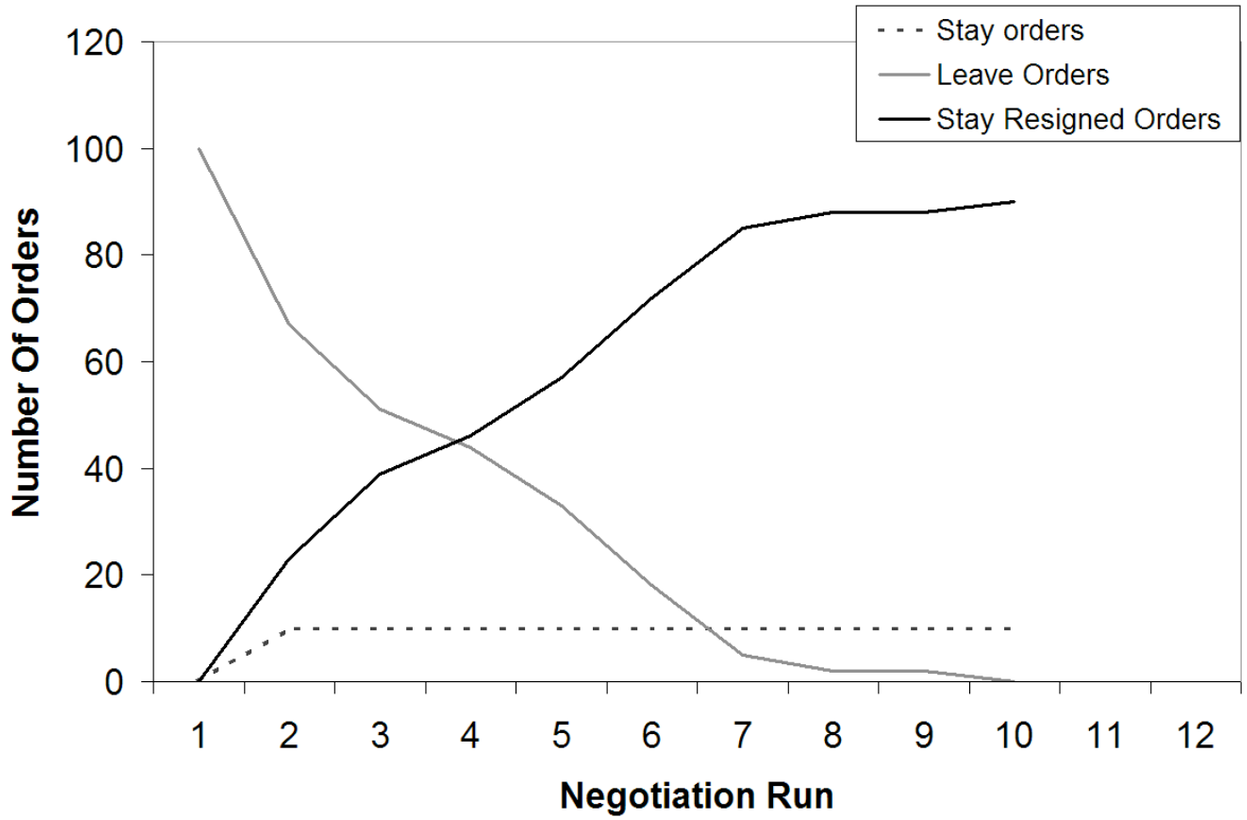
Environments With Farsighted Agents

- Equilibrium Analysis
  - Optimal Leading coalition (if coalition size is not limited)



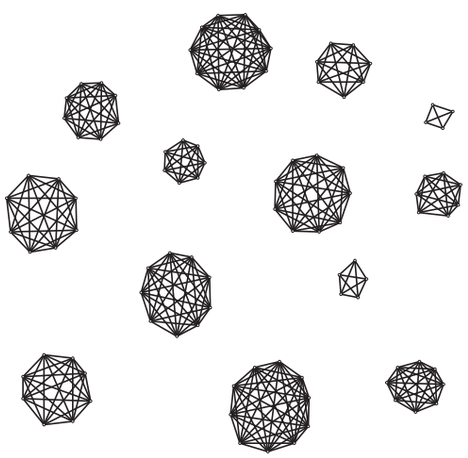
Environments With Farsighted Agents

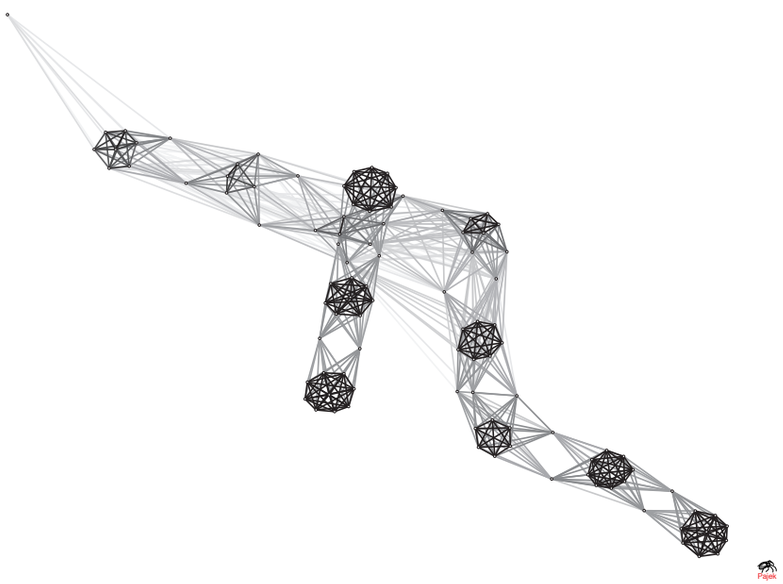
- Equilibrium Analysis
  - Score Maximizing population converges to an equilibrium

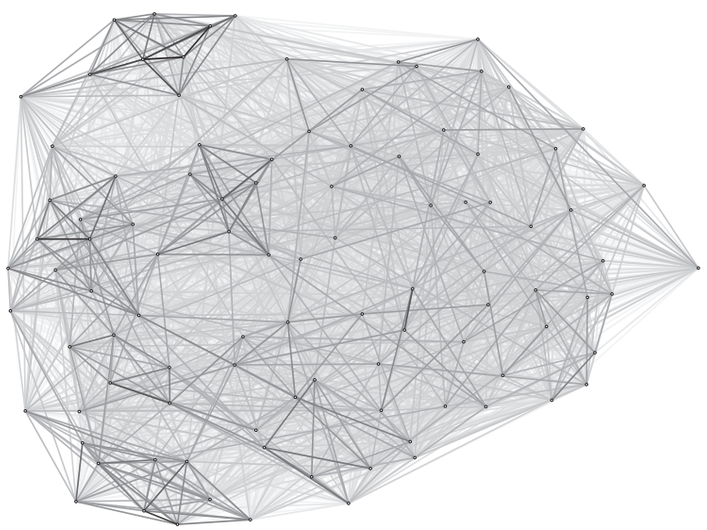


Environments With Farsighted Agents

- Equilibrium Analysis
  - Stability is lost when requirements change

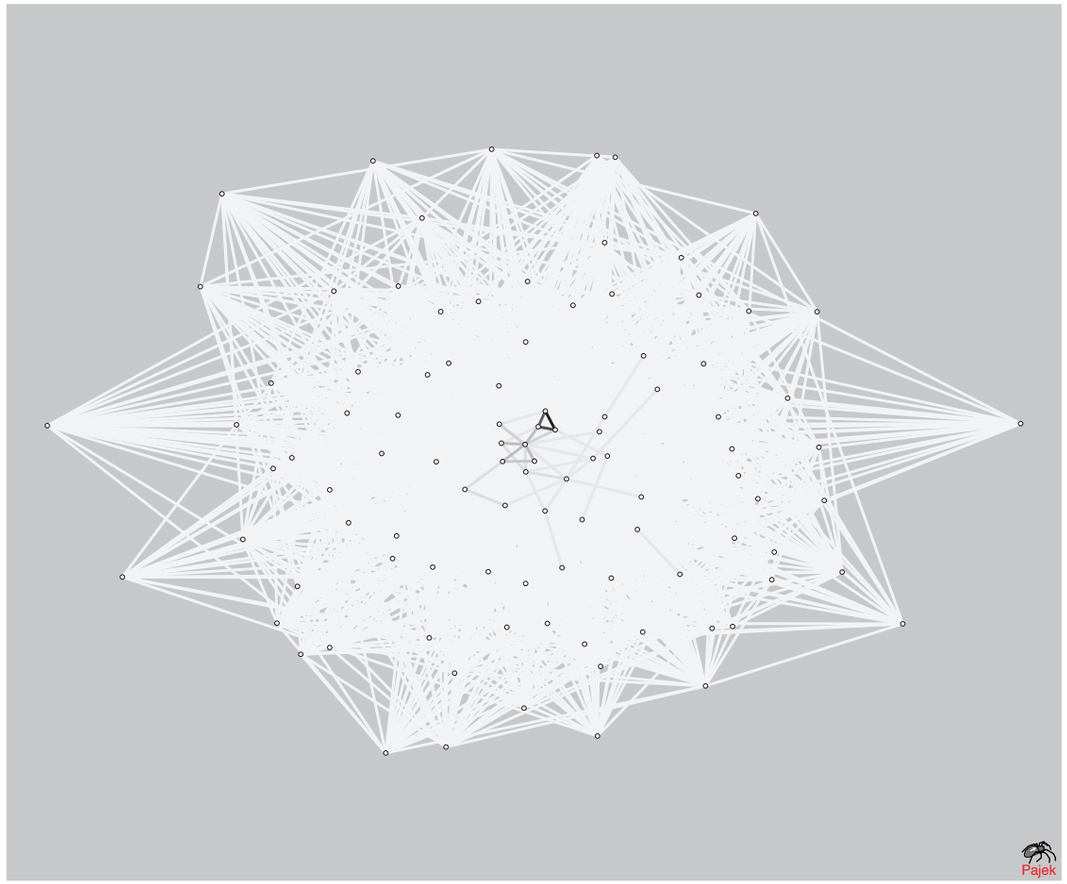






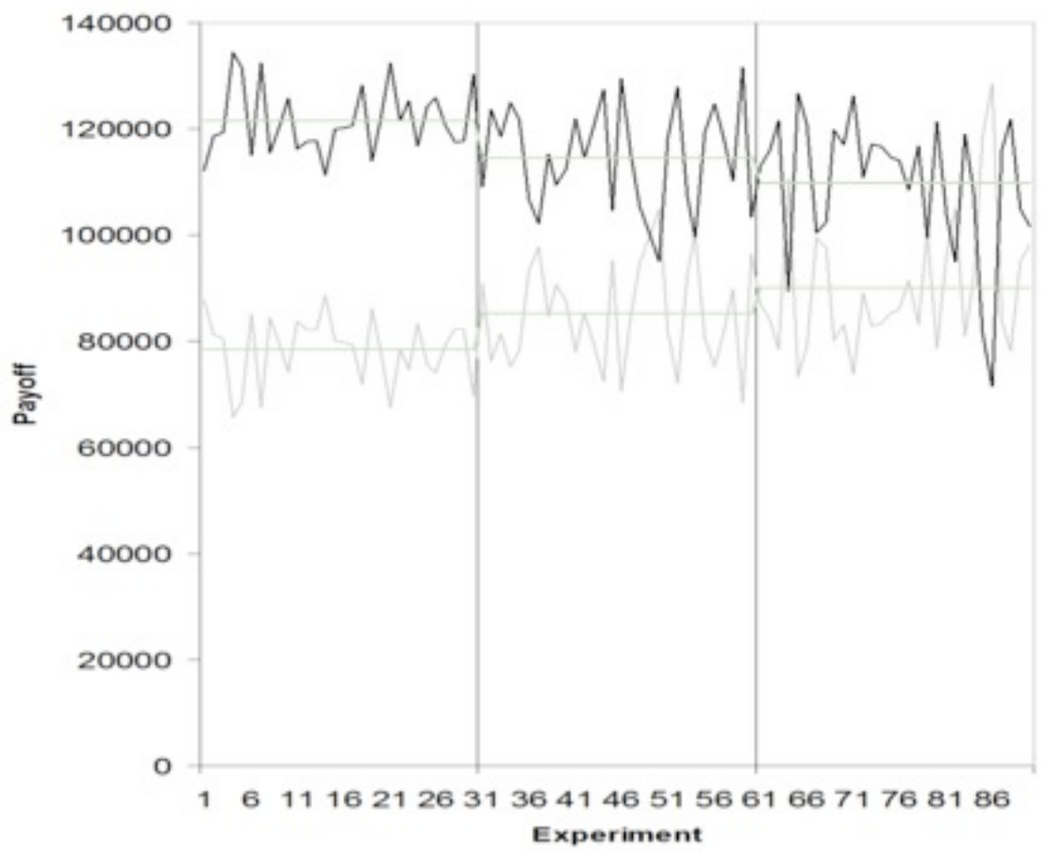
Environments With Farsighted Agents

- Equilibrium Analysis
  - Payoff maximizing systems are suboptimal and unstable



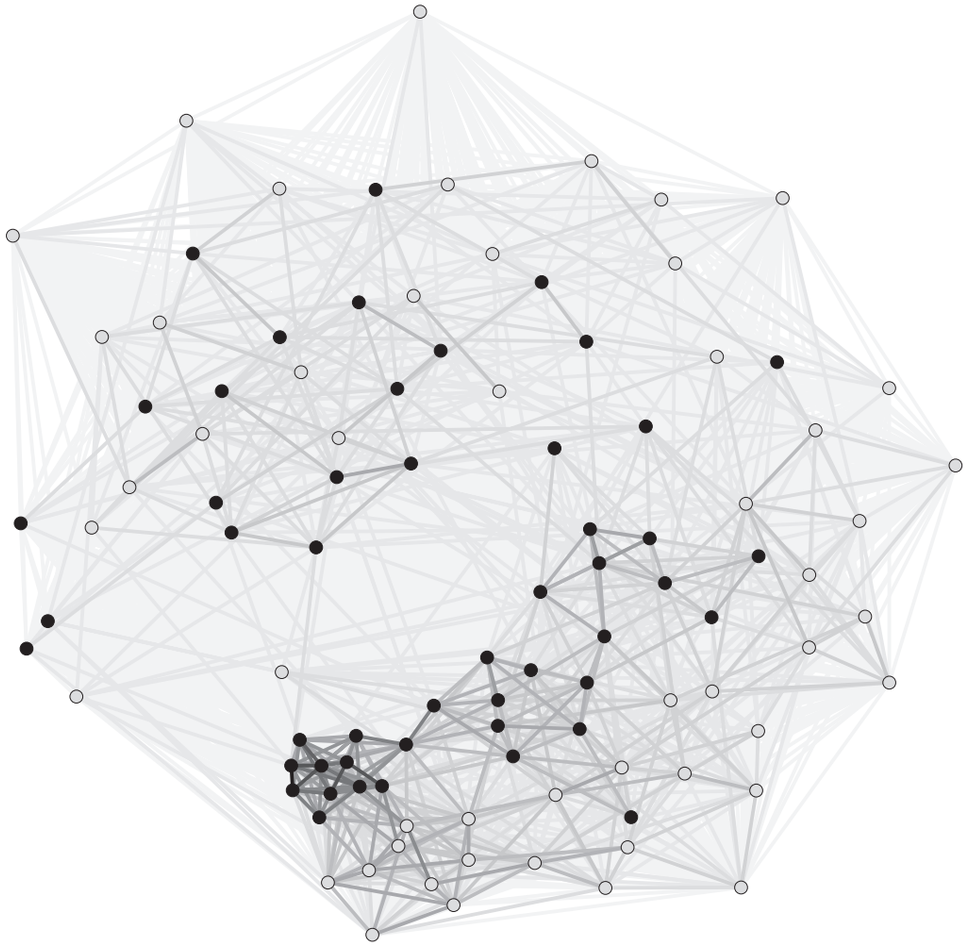
Environments With Farsighted Agents

- Strategies Comparison
  - Payoff maximizing systems are suboptimal and unstable
  - Correlation between performance difference and task competitiveness requirements



Environments With Farsighted Agents

- Strategies Comparison
  - Endogamic Collaboration Structures



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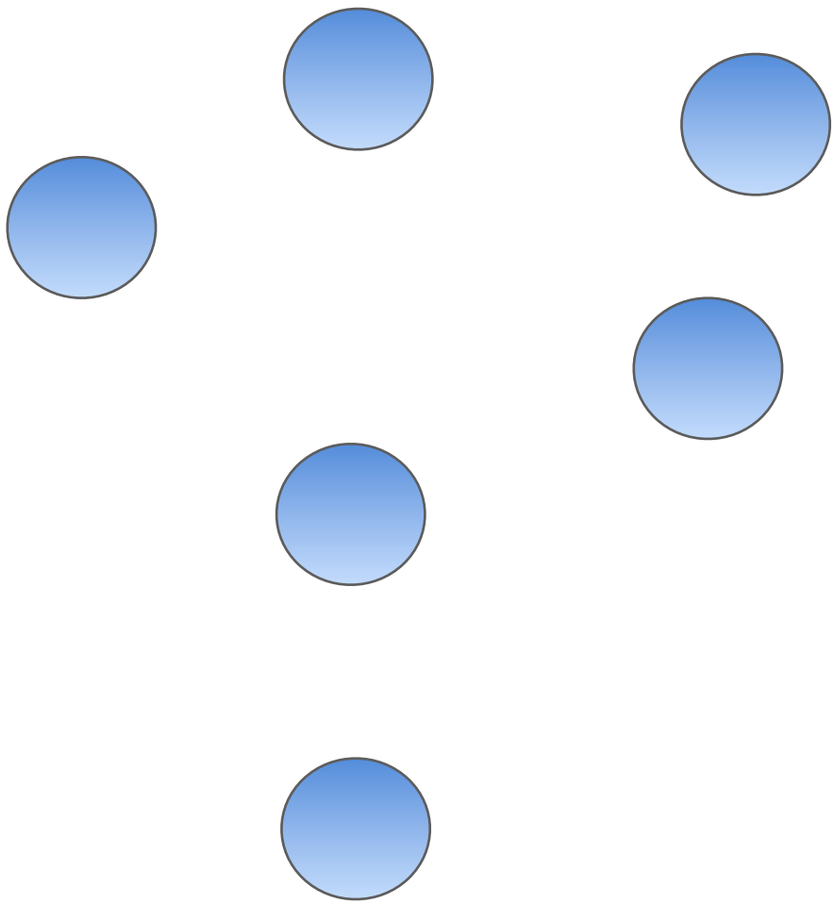
Part IV

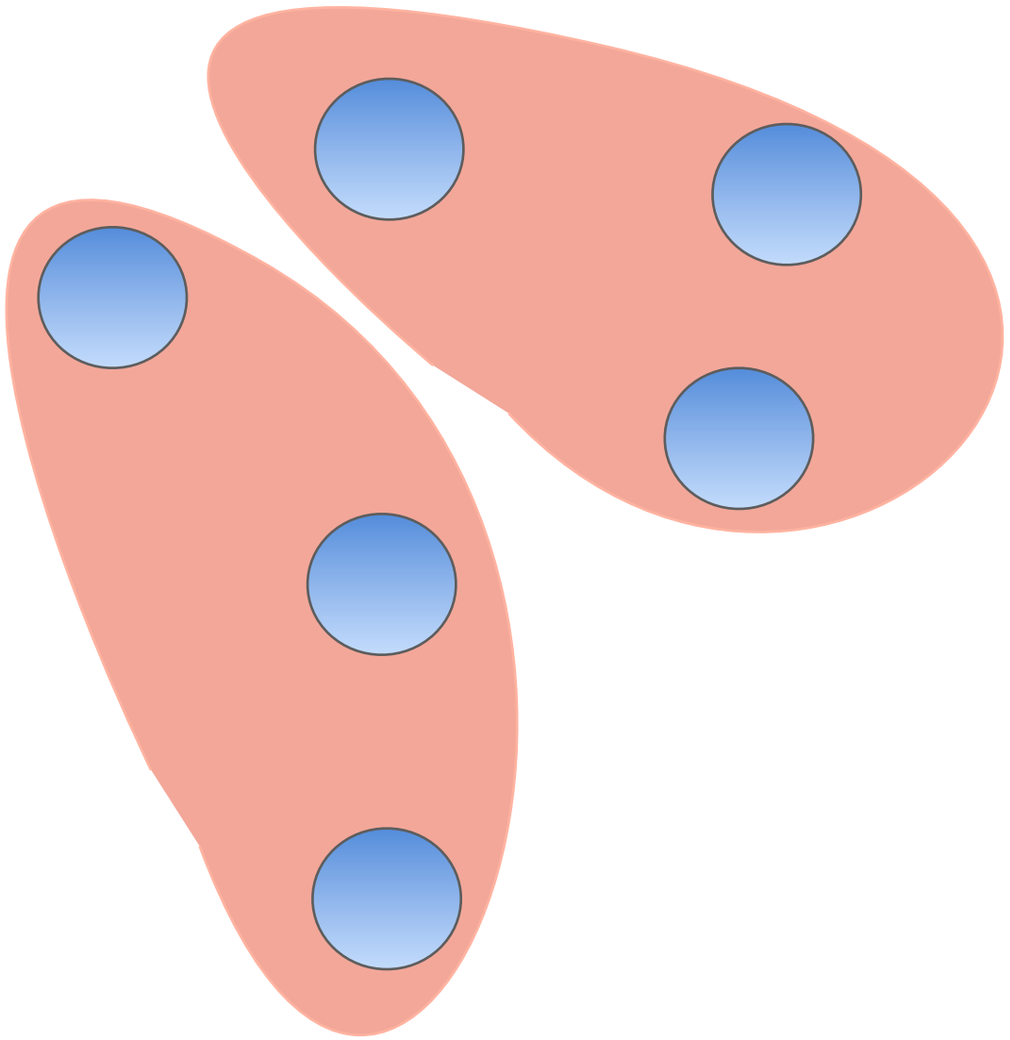
Environments With Myopic Agents

- Different Levels



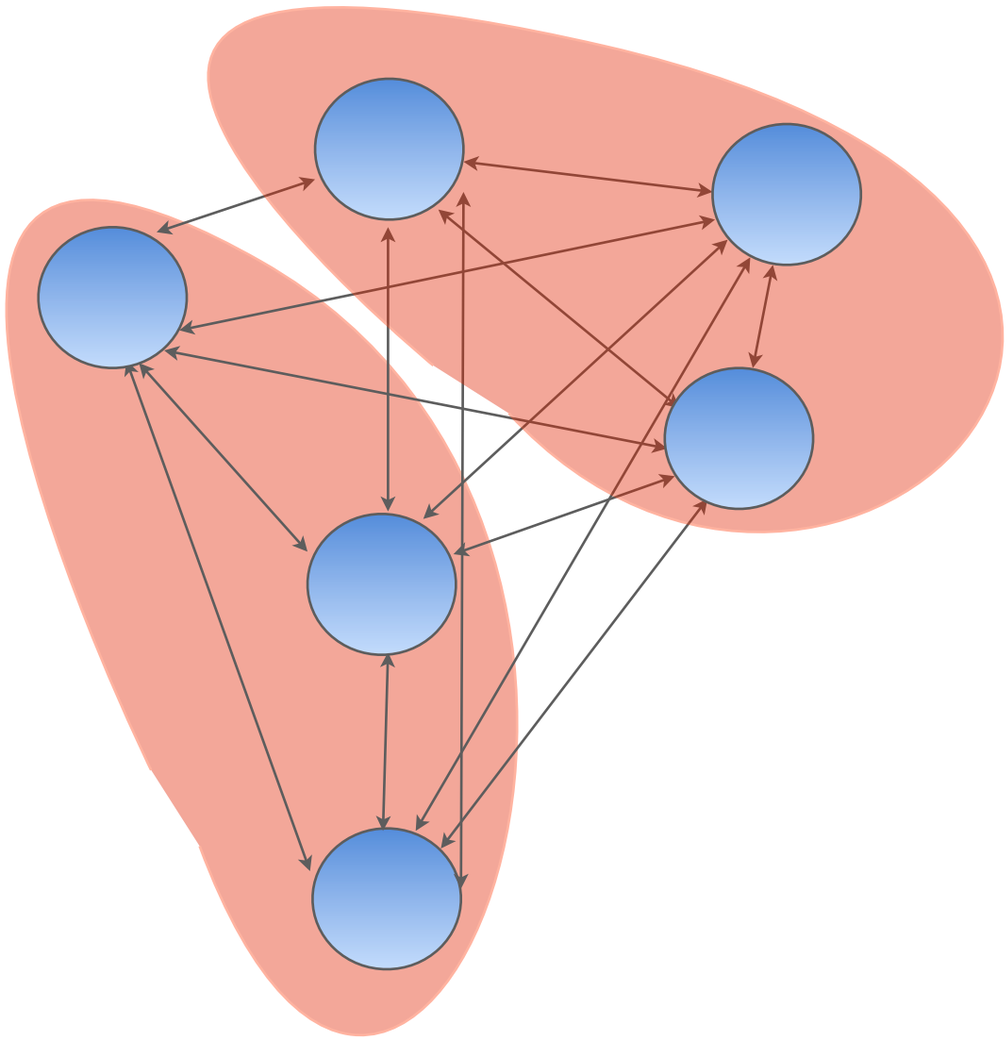
Environments With Myopic Agents

- Different Levels



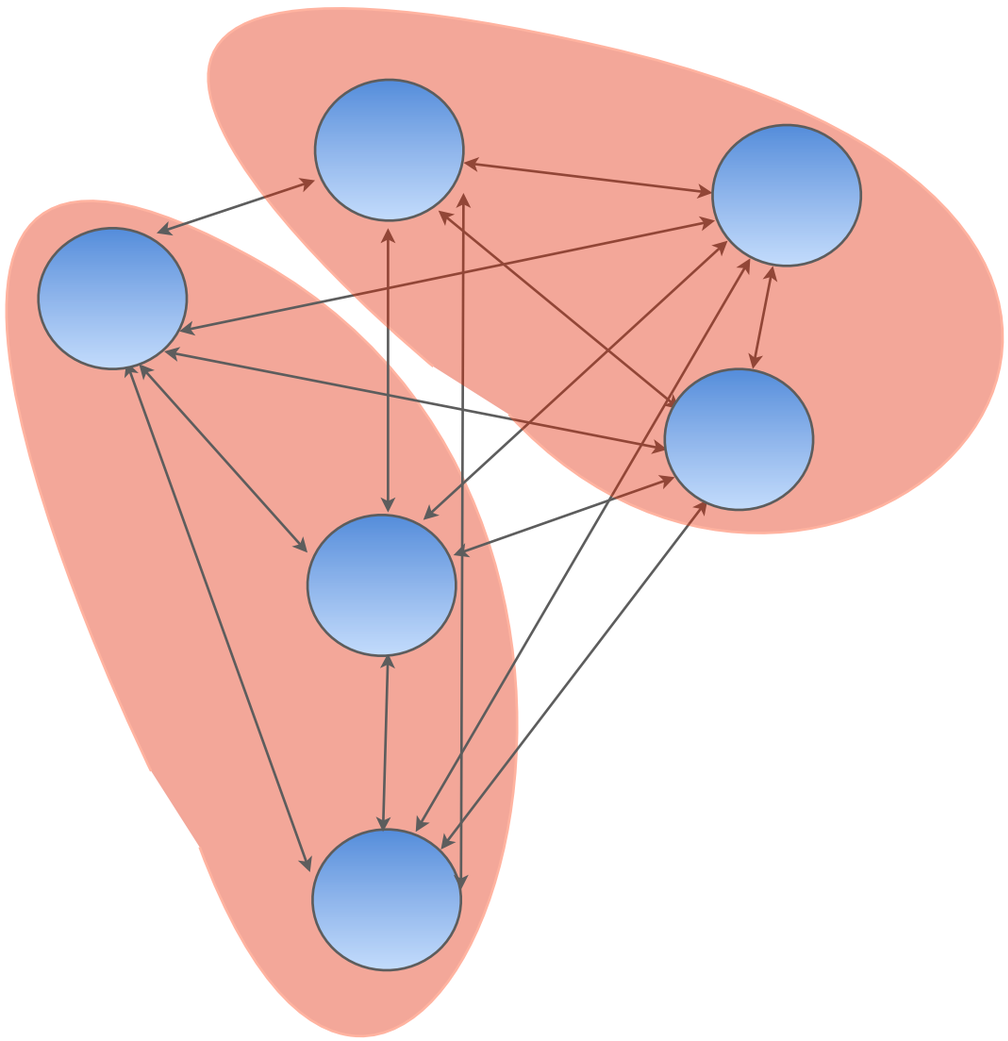
Environments With Myopic Agents

- Different Levels

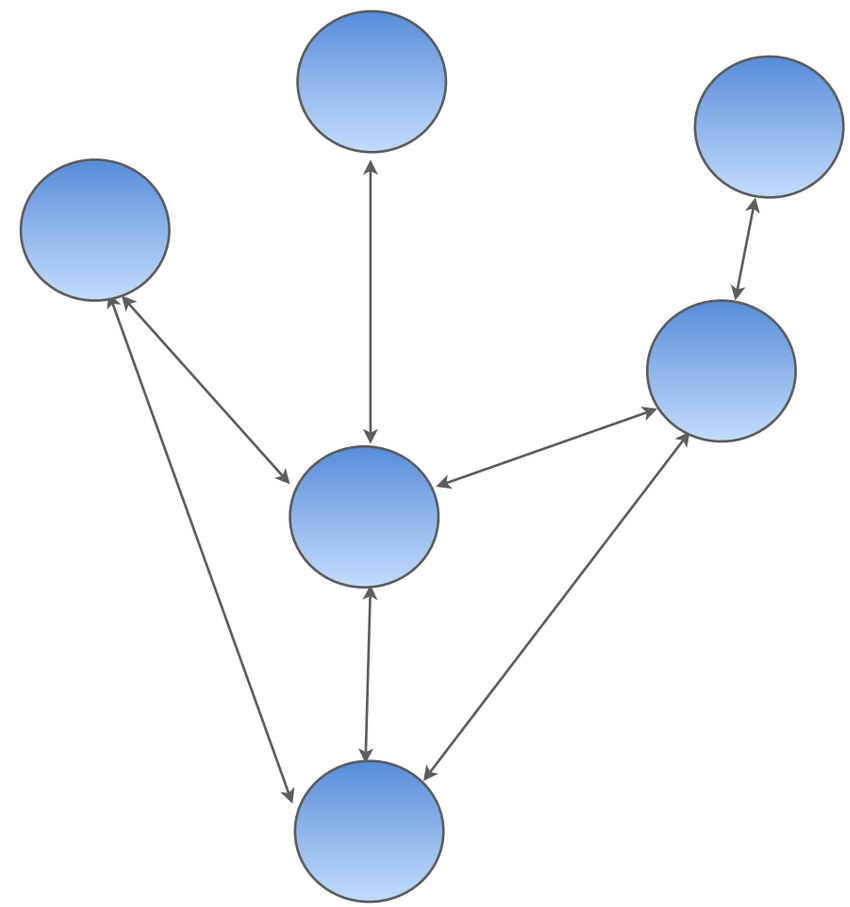


Environments With Myopic Agents

- Different Levels



Socially Farsighted

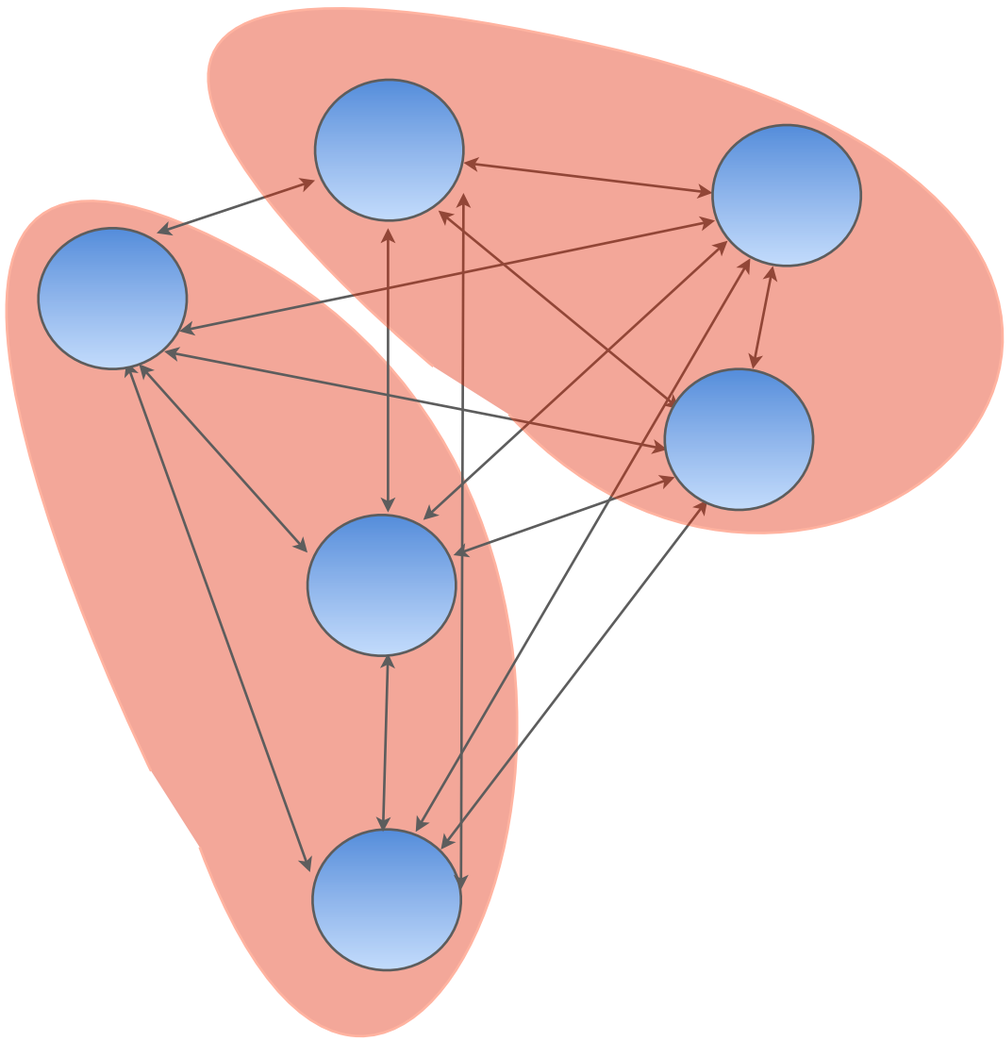


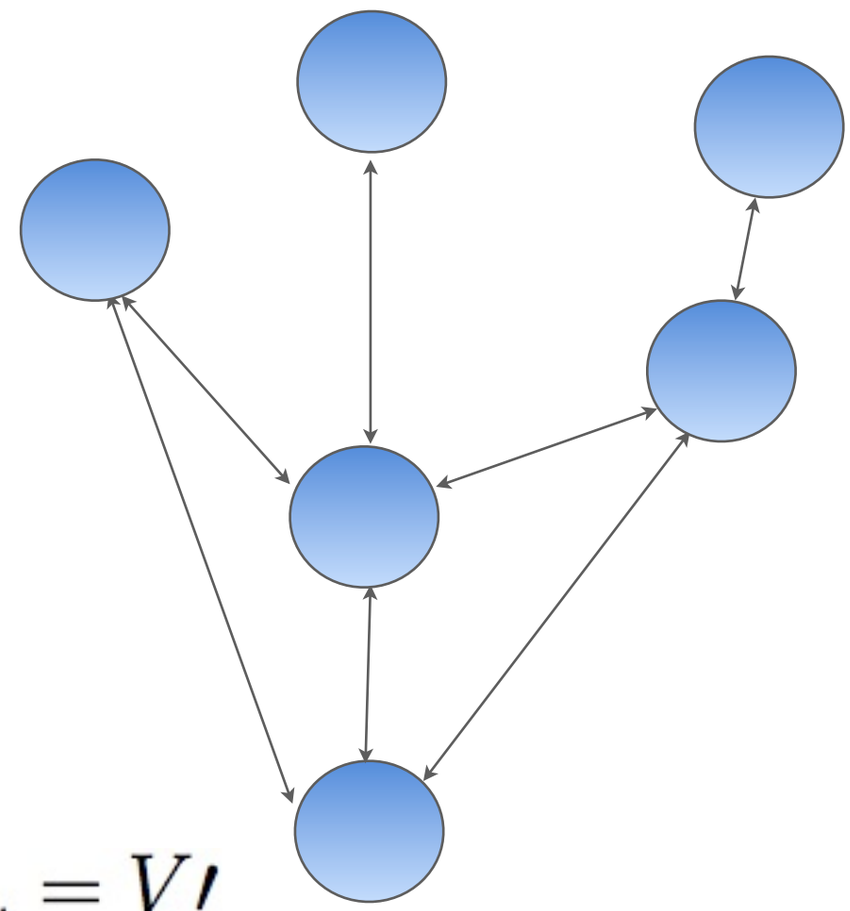
Socially Myopic

Environments With Myopic Agents

- Different Levels

$$\mathrm{SN}_I = (V, E)$$





$$\mathrm{SN}_{\sigma_{ij}} = V\prime$$

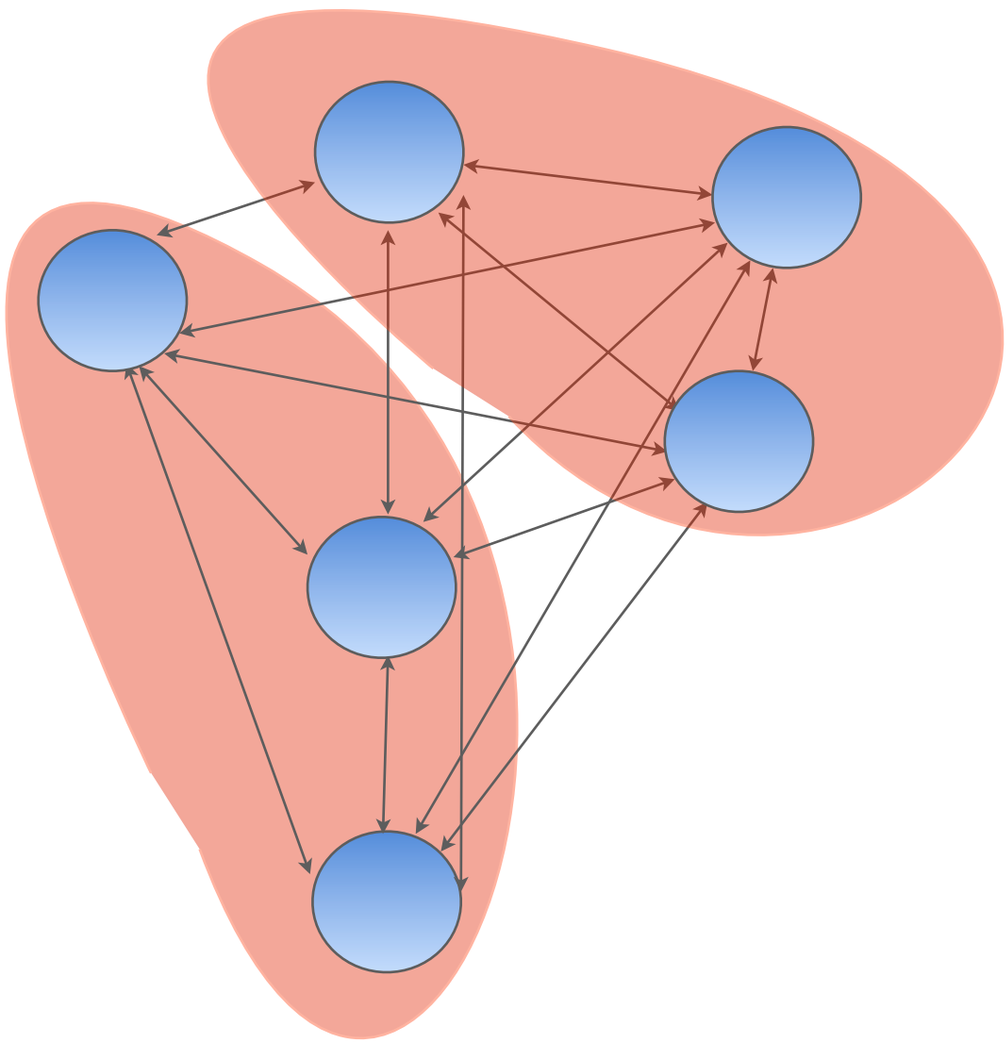
Socially Farsighted

Socially Myopic

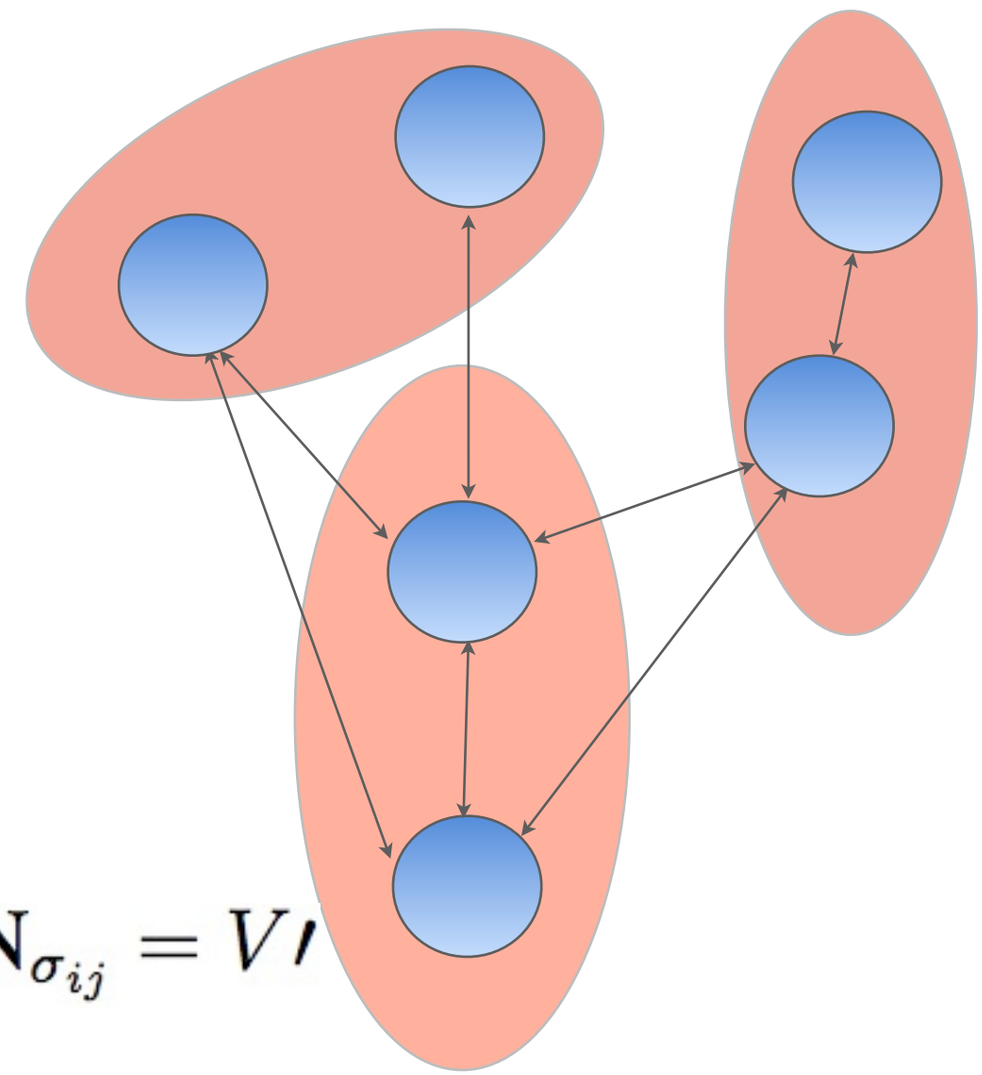
Environments With Myopic Agents

- Different Levels

$$\mathrm{SN}_I = (V, E)$$



Socially Farsighted



$$\mathrm{SN}_{\sigma_{ij}} = V'$$

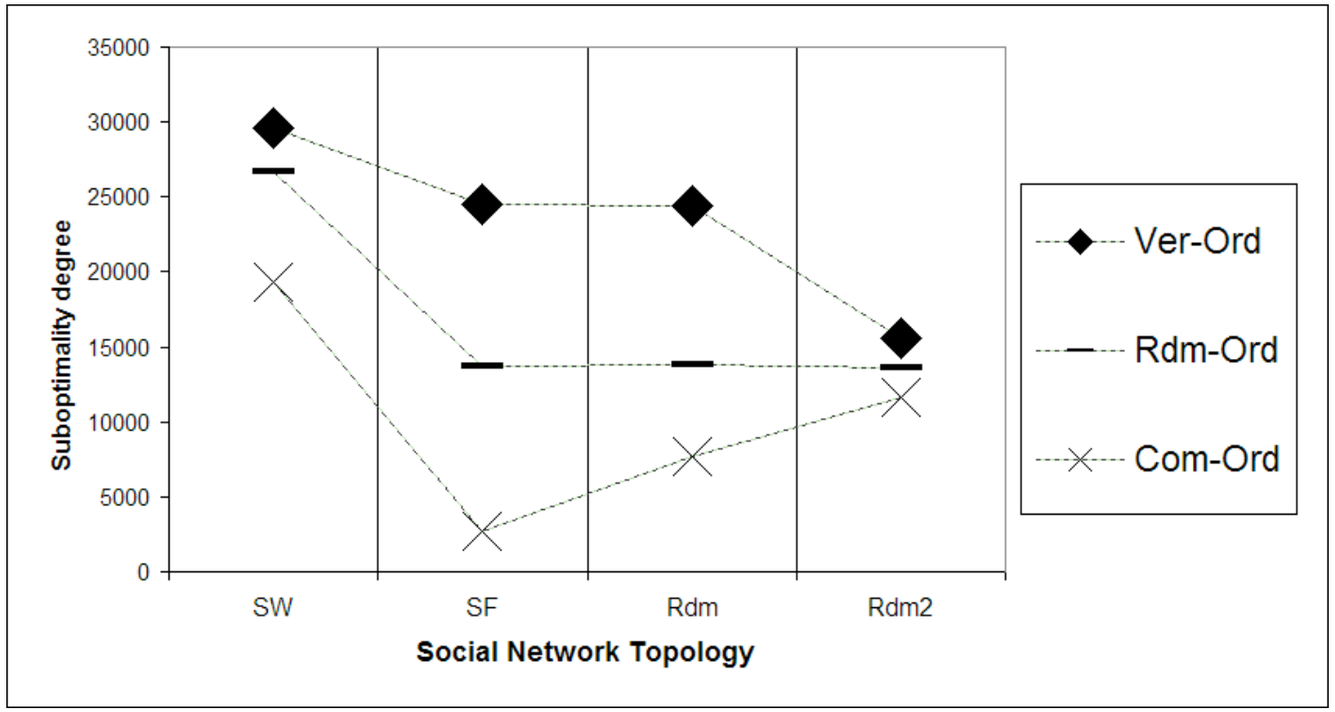
Socially Myopic

Environments With Myopic Agents

- Effect of social network topologies in performance and individuals in key regions
  - Agent Competitiveness
    - Competitive
    - Versatile
  - Social Networks placement
    - Degree Centrality
    - Betweenness Centrality

Experiments With Myopic Agents

- Effect of social network topologies in performance and individuals in key regions



$$Sc(\sigma) = \sum_{\text{rank}=0}^{p} (\text{scr}(\sigma_{\text{rank}}, T) * 1/2^{\text{rank}})$$

$$\text{Sub} = \text{Sc}(\sigma^{+}) - \text{Sc}(\sigma)$$

Environments With Myopic Agents

- Effect of social network topologies in performance and individuals in key regions
  - HAD Metric

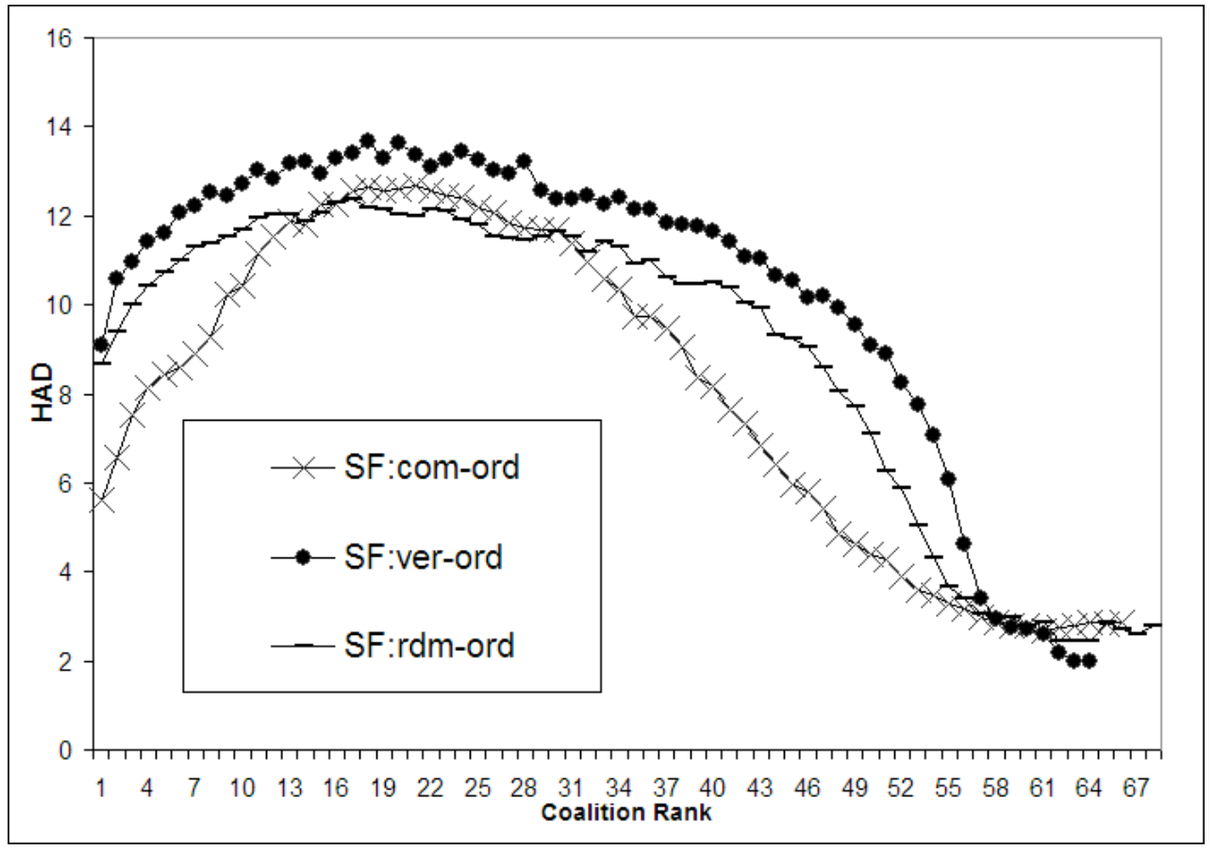
$$\mathrm{HAD}(\sigma_{xy}, \sigma_{xj}) \rightarrow N$$

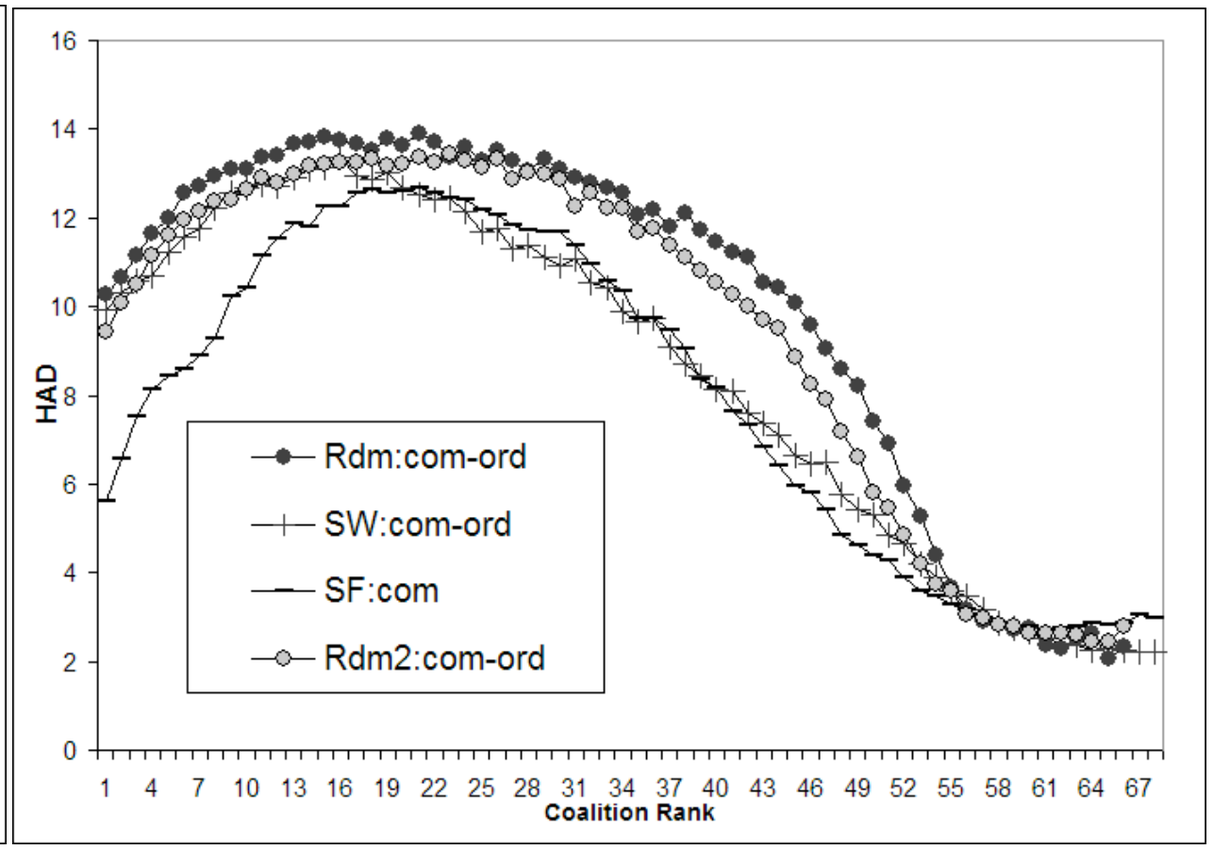
$$(\mathrm{HAD}(\sigma_{xy}, \sigma_{xj}) = 1) \Leftrightarrow ((\sigma_{xj}, \sigma_{xj}) \in E)$$

$$\mathrm{HAD}(\sigma_{xy}, \sigma_{xk}) = 1 + d_{\mathrm{HAD}}(\sigma_{xj}, \sigma_{xk})$$

Environments With Myopic Agents

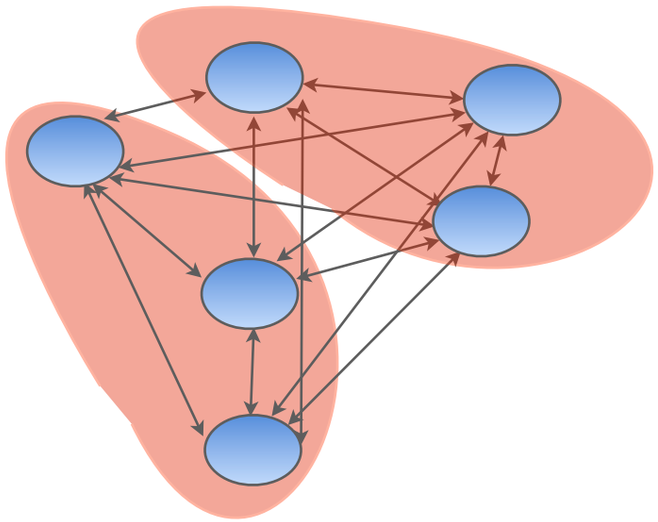
- Effect of social network topologies in performance and individuals in key regions
  - Degree centrality



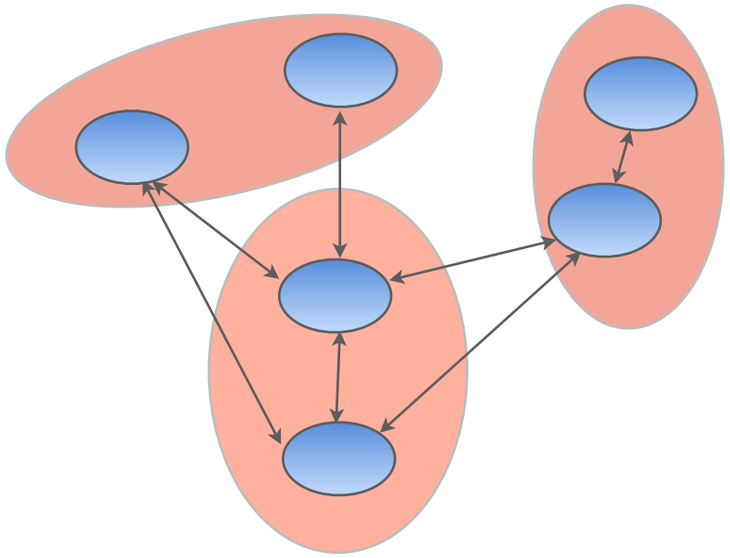


Environments With Myopic Agents

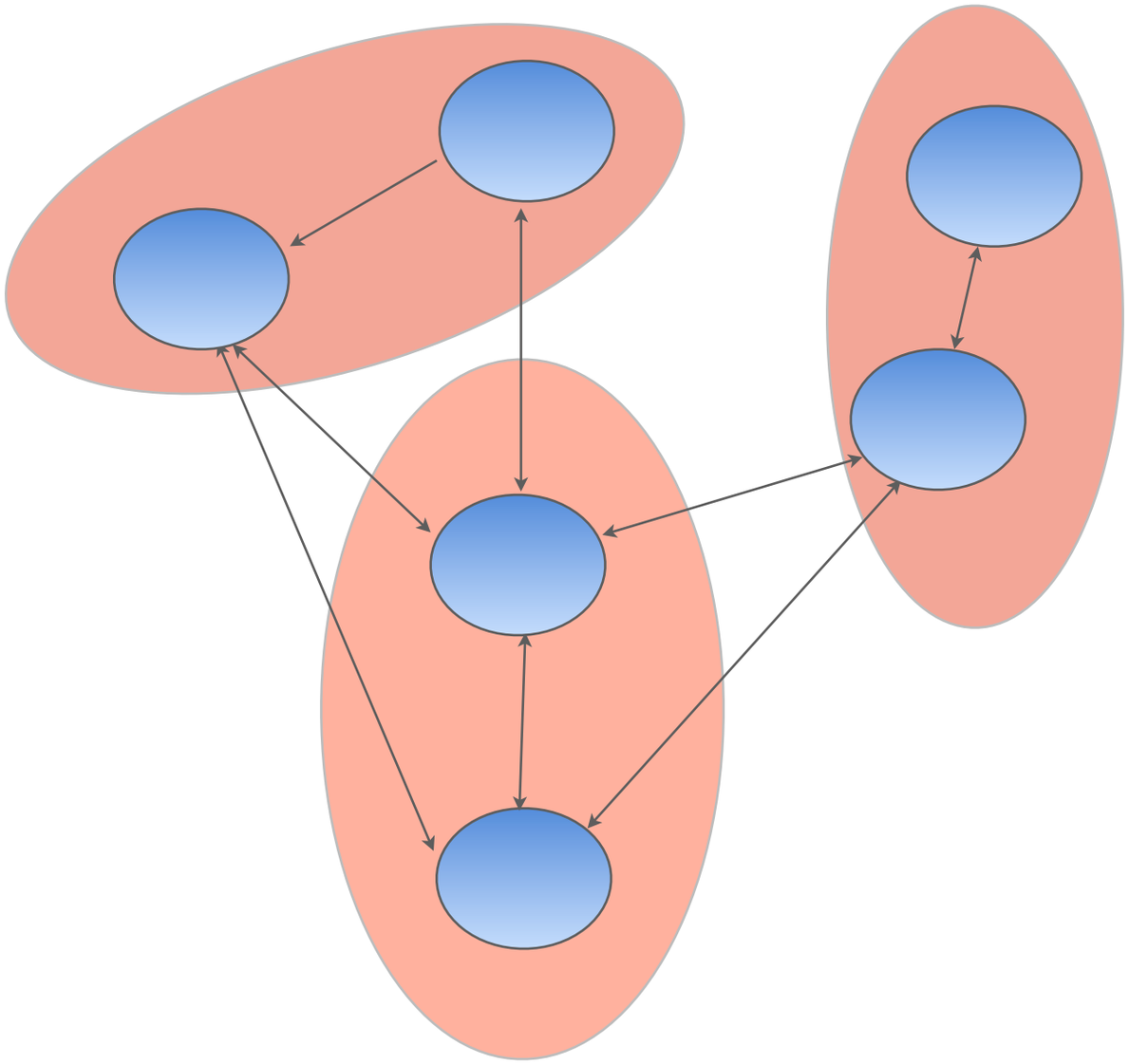
- Different Levels



Farsighted Social Environments



Myopic Social Environments



Environments With Myopic Agents

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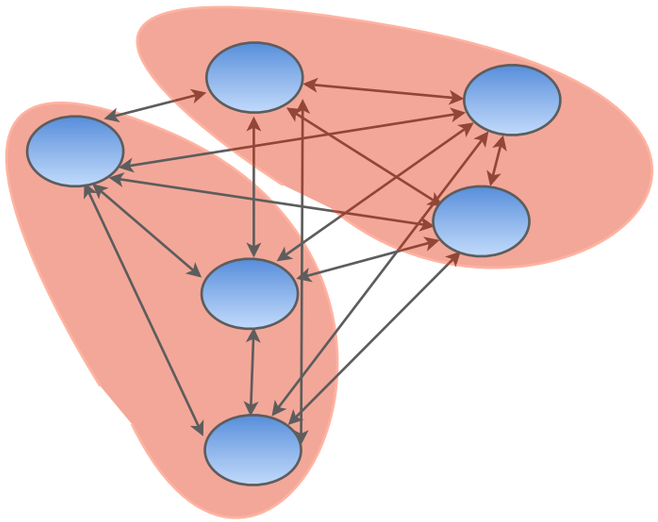

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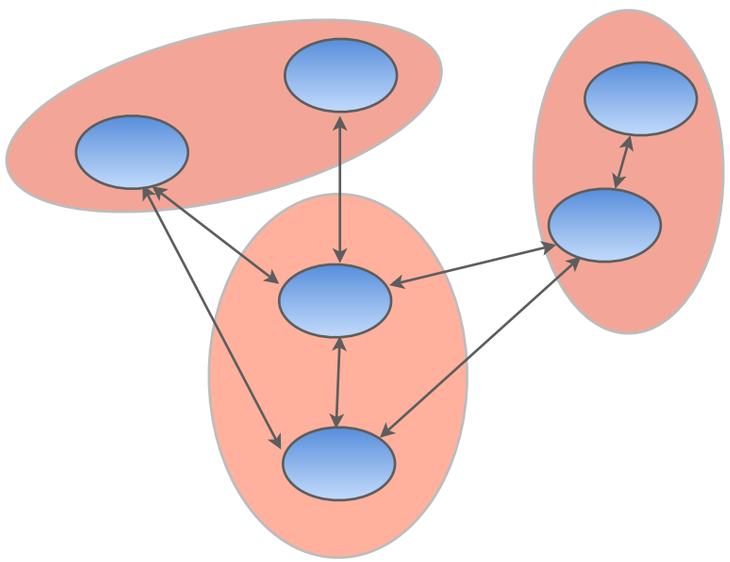

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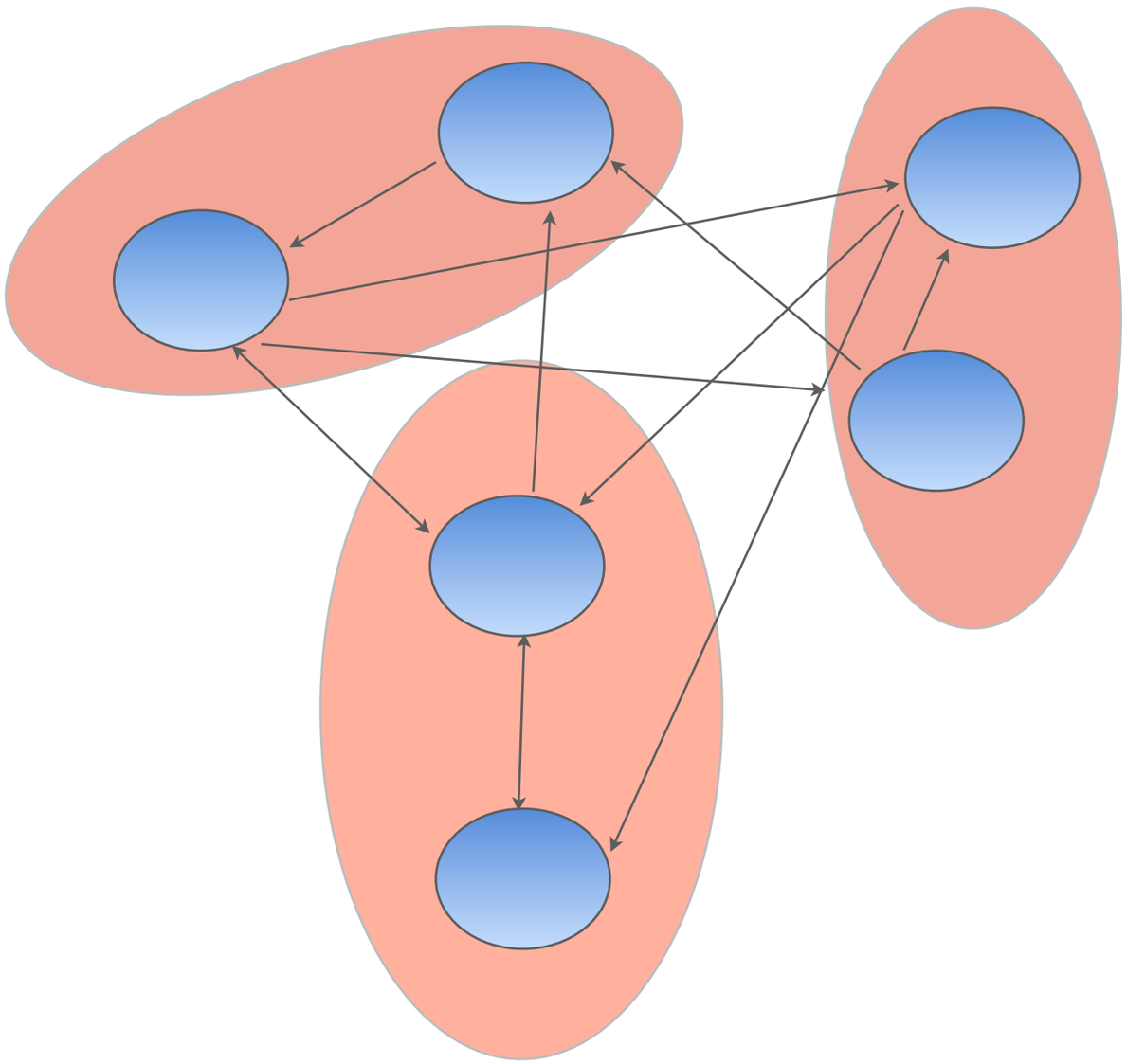


Environments With Myopic Agents

- Social Adaptation Mechanisms
  - Which events trigger adaptation?
  - Which agents are reinforced?
  - What is the reinforcement value applied?

$$PL_{\sigma_{wz}} = < \sigma_{ab}, \sigma_{cd}, \ldots, \sigma_{xy} >$$

$$PL_{\sigma_{wz}}(x).Reinf \longrightarrow \mathbb{R}$$

Environments With Myopic Agents

- Social Adaptation Mechanisms
  - R - Random
  - K - Progressive
  - M - Selective
  - P - Selective with control

Environments With Myopic Agents

- Social Adaptation Mechanisms
  - P - Selective With Control

$P\prime = sort(P, PL)$

comment: Sort the partners by decreasing order of reinforcement in the priority list

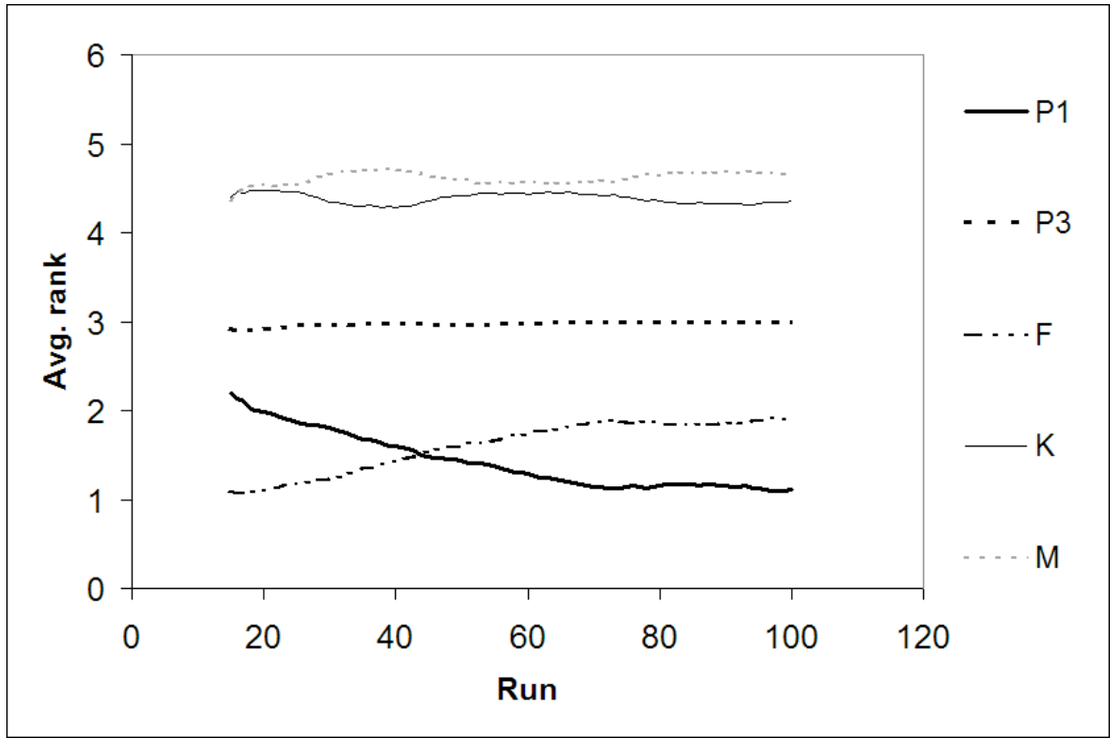
$CounterReinf = 0$

for each $p \in P\prime$

do
- $cr = p.Reinf + R$
- **if** $cr \leq PL(\alpha).Reinf$
  - **then** $p.Reinf = p.Reinf + R$
  - **else**
    - **if** $CounterReinf < MaxReinf$
      - **then**
        - $p.Reinf = p.Reinf + R$
        - $CounterReinf = CounterReinf + 1$

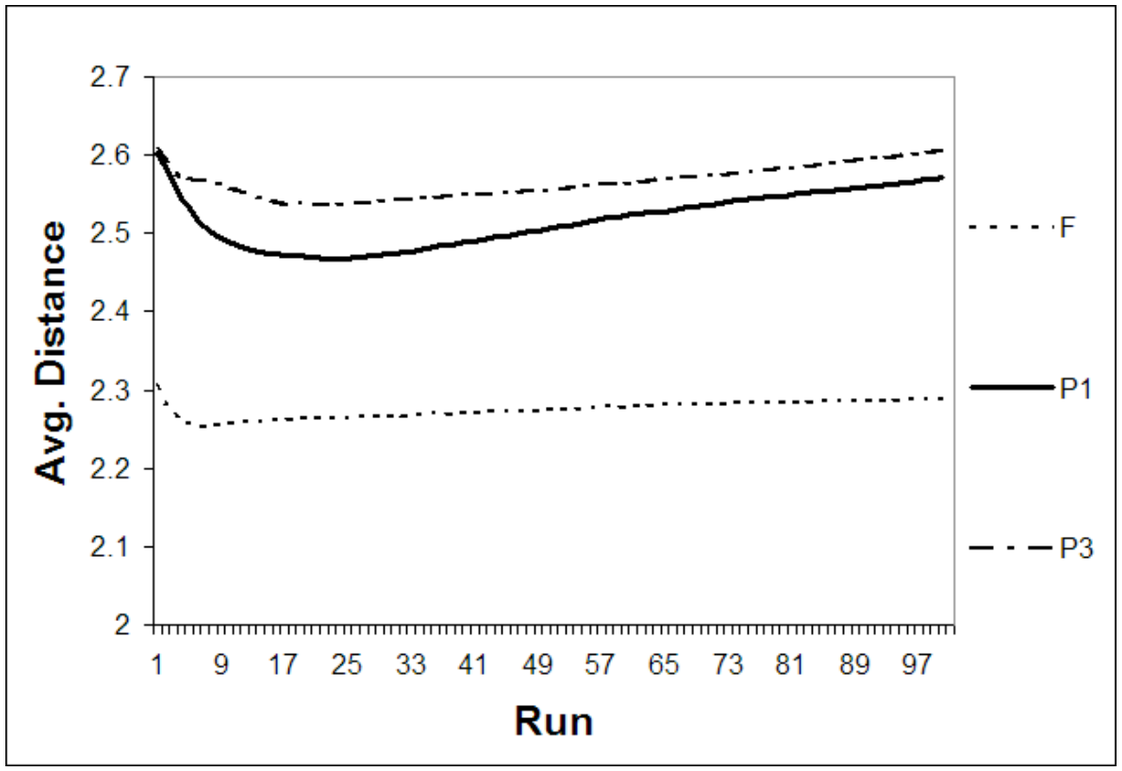
Environments With Myopic Agents

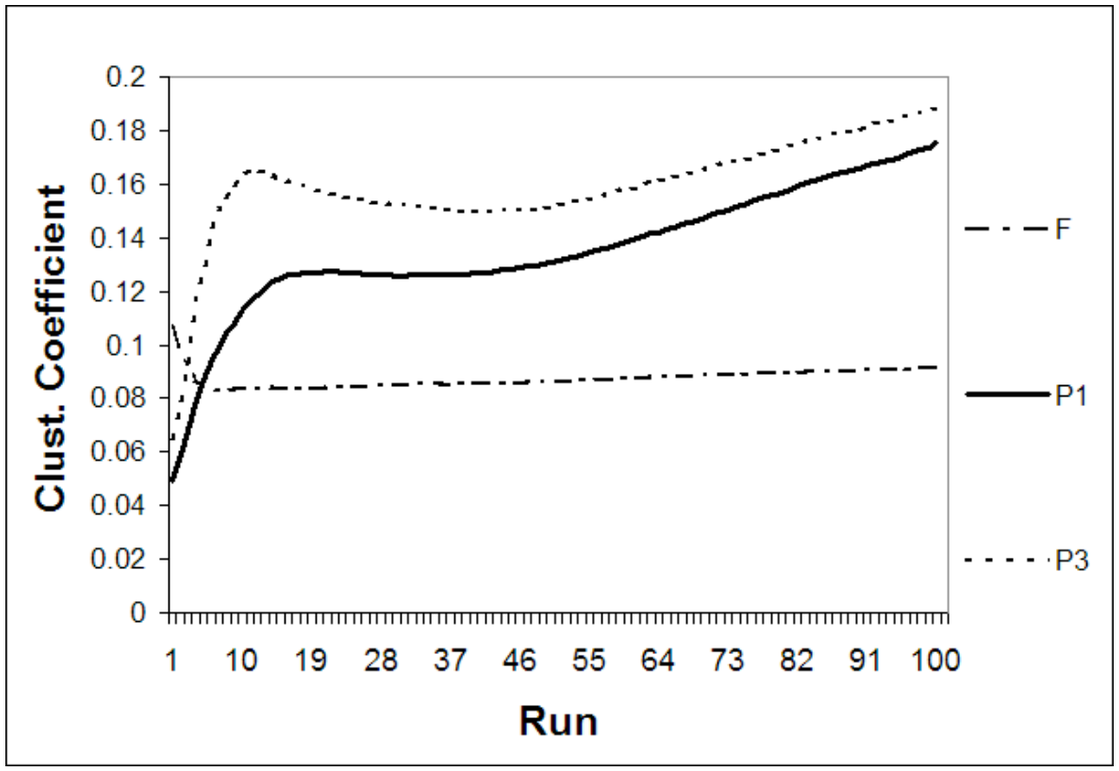
- Social Adaptation Mechanisms
  - Performance Comparison



Environments With Myopic Agents

- Social Adaptation Mechanisms
  - Social Network Analysis





Environments With Myopic Agents

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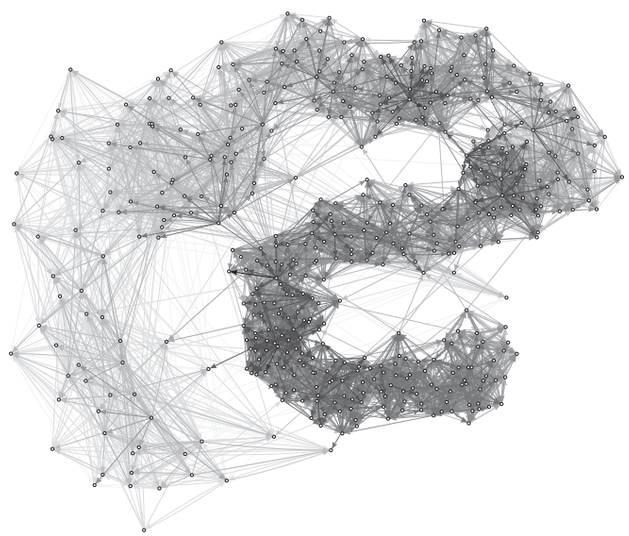
  - Social Network Analysis



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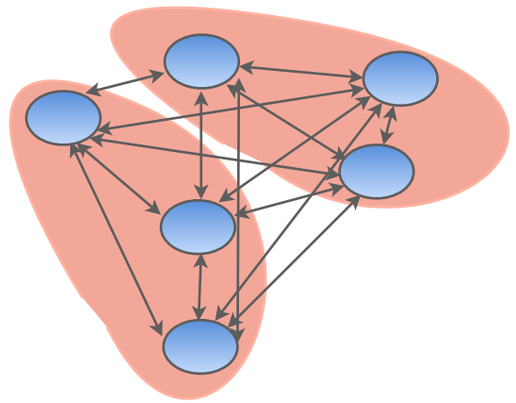
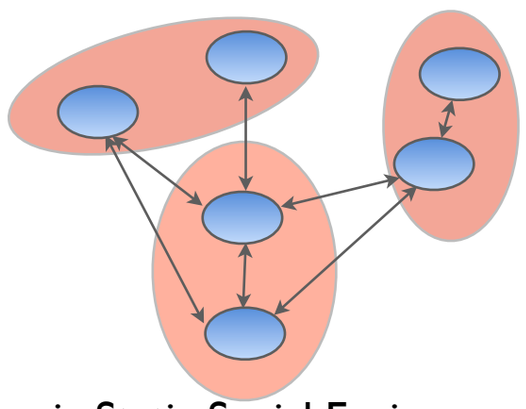
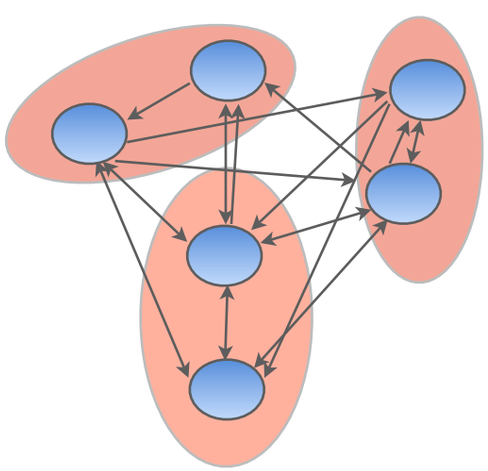
Environments With Multiple Simultaneous Tasks



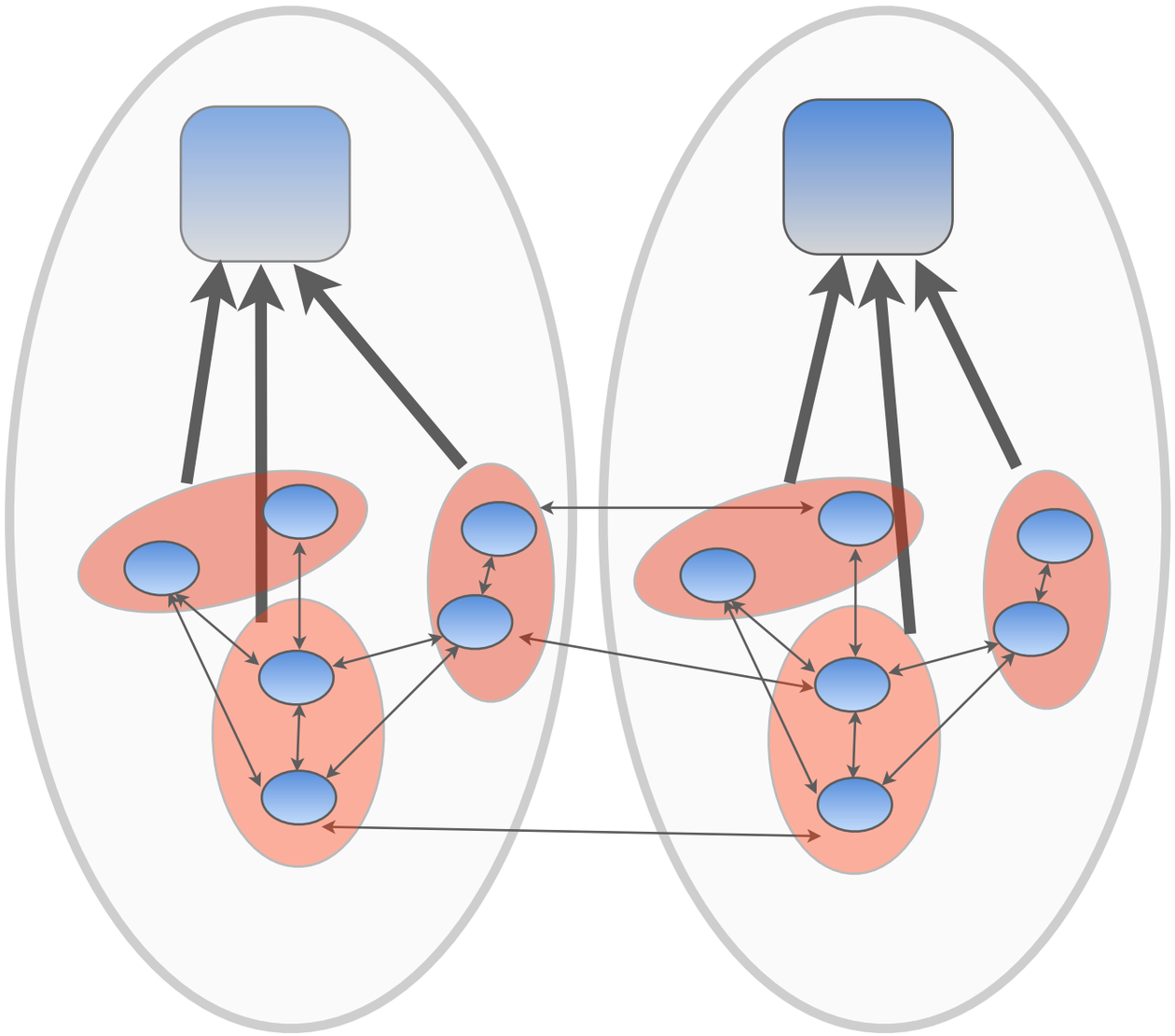
Farsighted Social Environments



Myopic Static Social Environments



Myopic Dynamic Social Environments



Multiple Simmultaneous Request Environments

Environments With Multiple Simultaneous Tasks

- Intra Market Strategy
  - Score Maximizing
- Inter Market Strategy
  - S - Score
  - R - Ranking
  - RSz - Ranking + Size

Environments With Multiple Simultaneous Tasks

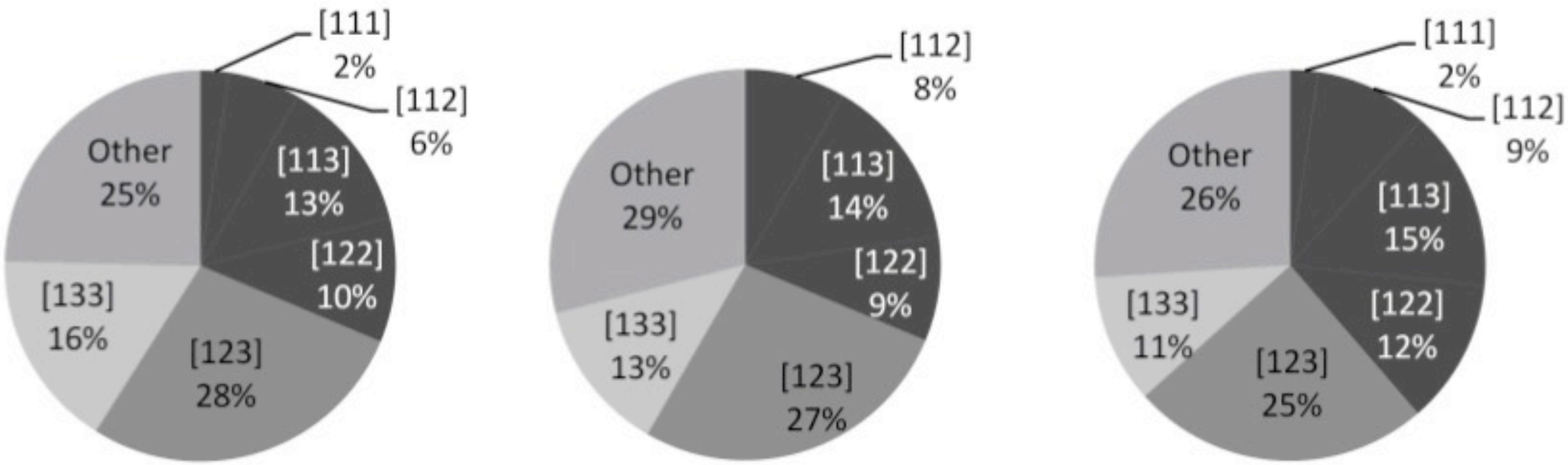
- Stability Analysis
  - S, R. Converge
  - RSz. Does not necessarily converge

Environments With Multiple Simultaneous Tasks

- Performance Comparison Between Strategies
  - Variables studied
    - Strategies
    - Requests similarities
    - Social network density

Environments With Multiple Simultaneous Tasks

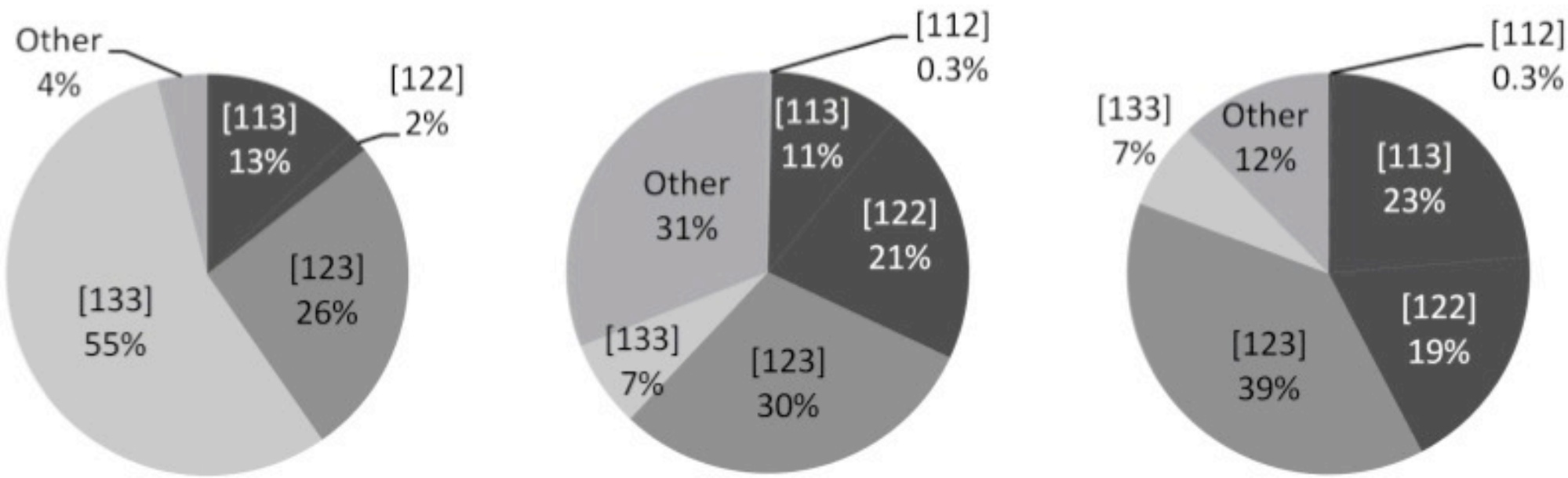
- Performance Comparison Between Strategies
  - Connection effect



(g) S, NI , Minimal (h) R, NI , Minimal (i) RSz, NI , Minimal

Environments With Multiple Simultaneous Tasks

- Performance Comparison Between Strategies
  - Strategy effect



(a) S, NI, Farsighted (b) R, NI, Farsighted (c) RSz, NI, Farsighted

Document
Part VI

General Conclusions

- It is possible to negotiate complex tasks using an iterative RFP protocol and a coalition formation mechanism
- Agents can effectively negotiate complex tasks under the basis of incomplete data and incomplete social sight
- Social structures can be considered in large scale negotiation models, for being exploited by effective adaptation mechanism

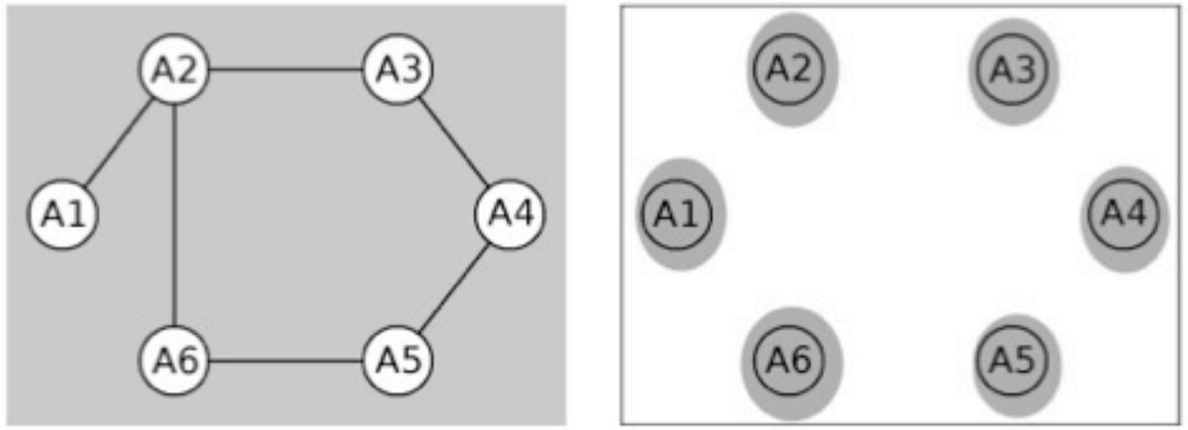
Future Work

- Continuous negotiation instead of episodic
- Overlapping coalitions
- Dynamic capabilities
- Idiosyncratic choices
- Complete characterization of multiple market environments
- Application of the model to solve problems

Trust Reputation

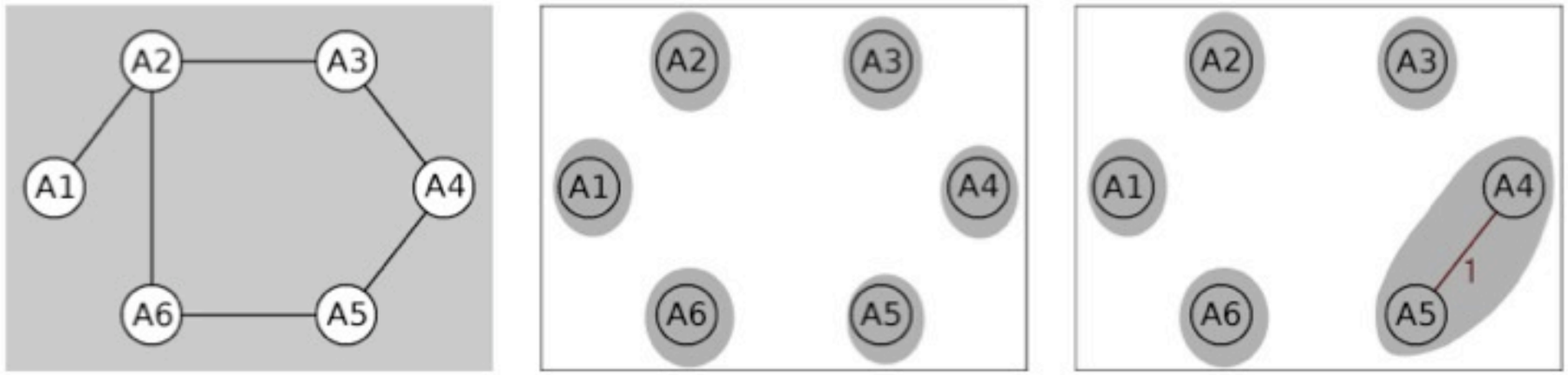
Thank you for your attention.

Environments With Myopic Agents



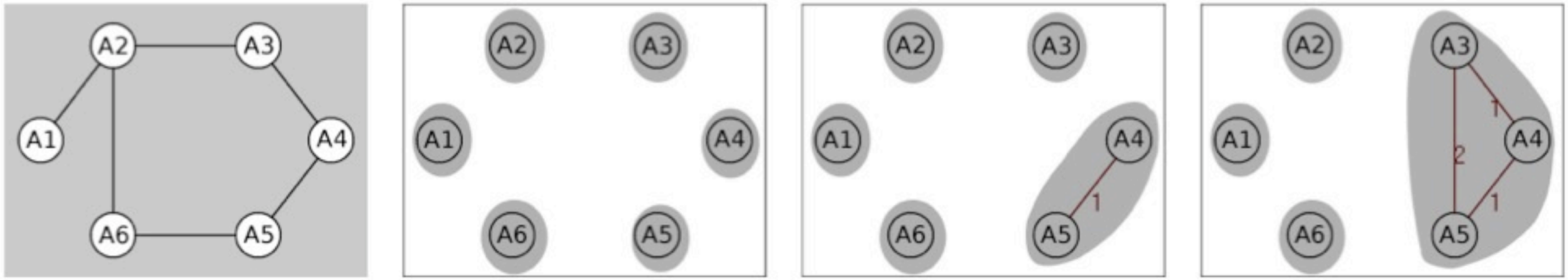
(a) Social network (b) Initial partition

Environments With Myopic Agents



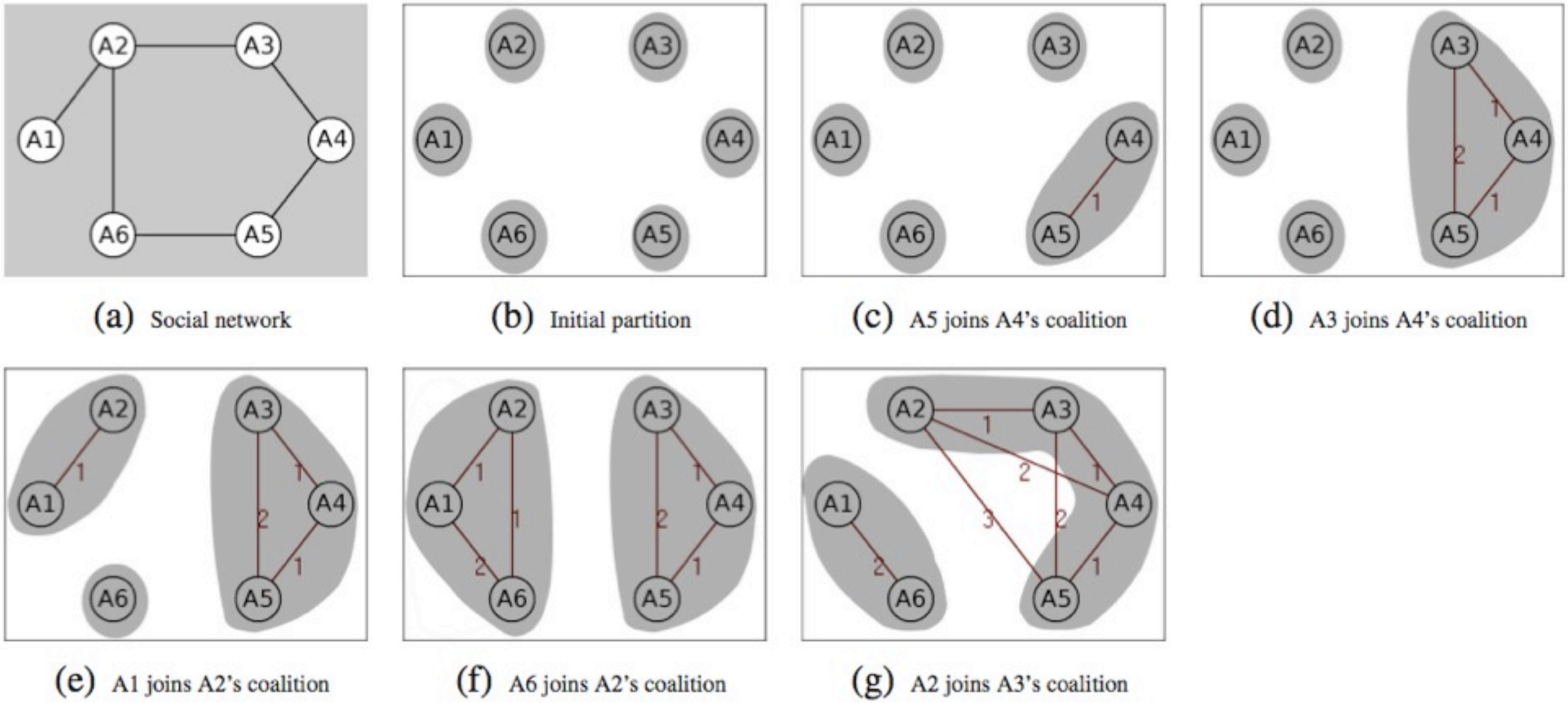
(a) Social network (b) Initial partition (c) A5 joins A4's coalition

Environments With Myopic Agents



(a) Social network (b) Initial partition (c) A5 joins A4's coalition (d) A3 joins A4's coalition

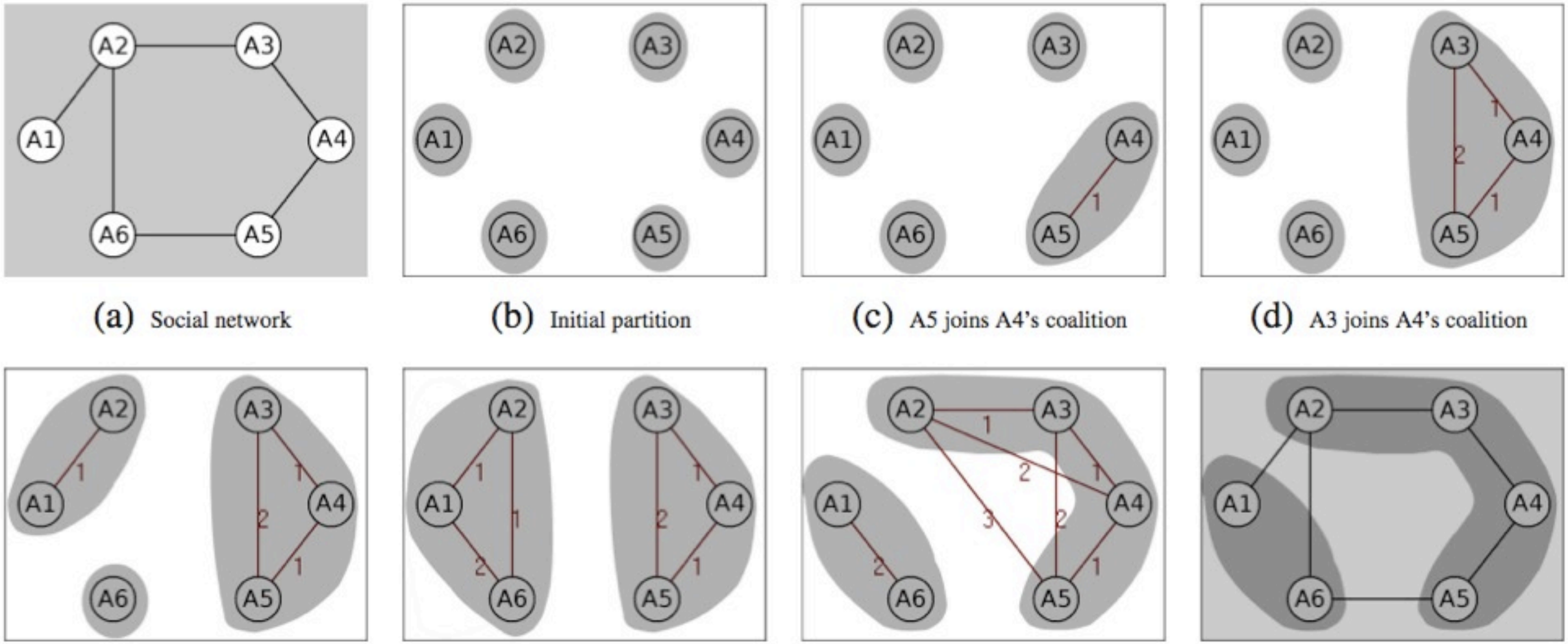
Environments With Myopic Agents



(a) Social network (b) Initial partition (c) A5 joins A4's coalition (d) A3 joins A4's coalition

(e) A1 joins A2's coalition (f) A6 joins A2's coalition (g) A2 joins A3's coalition

Environments With Myopic Agents



(a) Social network (b) Initial partition (c) A5 joins A4's coalition (d) A3 joins A4's coalition

(e) A1 joins A2's coalition (f) A6 joins A2's coalition (g) A2 joins A3's coalition (h) social net & coalitions

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- MERIDA-CAMPOS , C., AND WILLMOTT, S. Modelling coalition formation over time for iterative coalition games. In Proc. 3rd Int. Joint Conf. On AutonomousAgents & Multi Agent Systems (AAMAS'04) (2004), IEEE Computer Society, pp. 572–579. New York, USA.

- MERIDA-CAMPOS , C., AND WILLMOTT, S. Agent compatibility and coalition formation: Investigating two interacting negotiation strategies. In Agent Mediated Electronic Commerce VIII (TADA/AMEC). LNAI 4452 (2006), pp. 75–90. Hakodate, Japan.

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- MERIDA-CAMPOS, C., AND WILLMOTT, S. The impact of betweenness in small world networks on request for proposal coalition formation problems. In Proceedings of the 10th. International Congress of the Catalan Association of Artificial Intelligence, Andorra (Sant Julià de Lòria, Andorra, 2007).

- MERIDA-CAMPOS, C., AND WILLMOTT, S. Stable collaboration patterns of self-interested agents in iterative request for proposal coalition formation environments. In Proceedings of the 3rd International Conference on Self-Organization and Autonomous Systems in Computing and Communications (SOAS-2007) (Leipzig, Germany, 2007). (**Best Student Paper Award**)

- MERIDA-CAMPOS , C., AND WILLMOTT, S. Stable coalitions under different demand conditions in iterative request for proposal environments. International Transactions on Systems Science and Applications 4, 2 (2008), 194–204.

- RUBIO-LOYOLA, J., MERIDA-CAMPOS, C., WILLMOTT, S., ASTORGA, A., SERRAT, J., AND GALIS, A. Service coalitions for future internet services. In IEEE International Conference on Communications ICC 2009 (Dresden, Germany, 2009). To be published

Contributions

- An iterated RFP market type protocol that lets agents create coalitions dynamically to address complex tasks
- A social network based model to capture agent information limitations in RFP and coalition formation systems
- A successful adaptive strategy for agents to participate in large scale markets
- Graph based analysis techniques to analyze coalition formation model outcomes
- A metric on the exploitation of a social network that measures the historical average degree
- An application of the studied model in the context of Future Internet Networks