Agent Reasoning Mechanism for Long-term Coalitions Based on Decision Making and Trust

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Overview

- Introduction to coalition formation
- What is new in this paper?
- Presentation of the paper
- Discussion and summary

Coalition Formation

What is coalition formation?

- Grouping of agents that agree to cooperate to execute a task or achieve a goal.
- Goal can be common to all agents or specific to every single agent (social rationality vs. individual rationality)

Most prominent example: Buying agents trying to achieve a lower price.

Coalition Formation

What are the issues in coalition formation?

- If agents are autonomous: How do they decide when to change the coalition structure? (i.e. when to quit/enter/create a coalition)
- There is no formal contract between agents – how is trust modelled?
- If a coalition strategy is beneficial for a single agent, this does not imply it is beneficial for the whole system/society.
- Excessive system dynamics (changes in the coalition structure) are not desirable in many cases.

What is new in this paper?

In coalition formation, there are two different perspectives:

- Microscopic: the focus is on the individual agent and the agent's utility.
- Macroscopic: the focus is on the global system optimality and/or stability.

This paper is the first that

- describes a coalition formation mechanism at agent level and evaluates the effects at system level (overall benefit, system dynamics);
- models long-term coalitions and decisions based on past experience (*trust*).

General Scenario & Assumptions

Scenario described in the paper:

- Self-interested agents in an electronic market.
- Agents trade certain goods, e.g. books.
- Agents try to maximize their own long-term utility.
- Special matchmaker agents bring together two compatible agents randomly.
- Agents can form new coalitions at any time without any fees. The coalitions in the system form a partition of the set of agents.

General Scenario & Assumptions

Why should an agent join/create a coalition?

- Customers agents can receive a certain percentage discount on every transaction within the same coalition.
- Vendor agents can increase their sales by having more interactions with customers.

$\Rightarrow$ Customer Relationship Management

(like in the real world)

Decision-Making and Trust

Which coalition should an agent join?

An agent wants to be in the same coalition as *trusted* agents.

First model: success probability

$$p_{ij} = \frac{n_{ij}+1}{N_{ij}+2}, \quad p_{ij} = p'_{ij} \cdot \frac{N_{ij}+1}{N_{ij}+2} + \frac{e_{ij}}{N_{ij}+2},$$

where n_{ij} is the number of successful interactions between agents i and j, N_{ij} is the total number of interactions, e_{ij} is the outcome of the last interaction.

Decision-Making and Trust

Second model: trust values

$$newTrust := d \cdot oldTrust + (1-d) \cdot newExperience,$$

where $d \in [0,1]$.

The trust approach is more general, since success probability can be modelled by $d := \frac{N_{ij}+1}{N_{ij}+2}$, giving

$$newTrust = \frac{N_{ij}+1}{N_{ij}+2} \cdot oldTrust + \frac{1}{N_{ij}+2} \cdot newExperience.$$

Coalition Selection Functions

To be computed: $trust(A_i, C)$, the trust that agent A_i has in coalition C.

Three different selection mechanisms presented:

$$soc_1 : \quad trust(A_i, C) = \sum_{A_j \in C} trust(A_i, A_j)$$

$$soc_2 : \quad trust(A_i, C) = |\{A_j \in C : \; trust(A_i, A_j) > 0\}|$$

$$ind : \quad trust(A_i, C) = \max_{A_j \in C} \{trust(A_i, A_j)\}$$

soc: society-oriented, *ind*: individual-oriented.

Actual Coalition Formation

Every agent selects the coalition it trusts most (according to soc_1, soc_2 or ind) and joins it.

If there is no coalition trusted coalition, the agent creates a new coalition and asks the agents in coalition 0 to join. They always agree.

changeCoalition(i): *// make coalition decision for agent* A_i

$k := argmax_C\{trust(A_i, C)\}$ *// select most trusted coalition*

if A_i is in a coalition $\wedge$ A_i is not member of k

agent A_i leaves current coalition

if k is not coalition 0 then A_i joins coalition k

else A_i forms a new coalition with members of coalition 0.

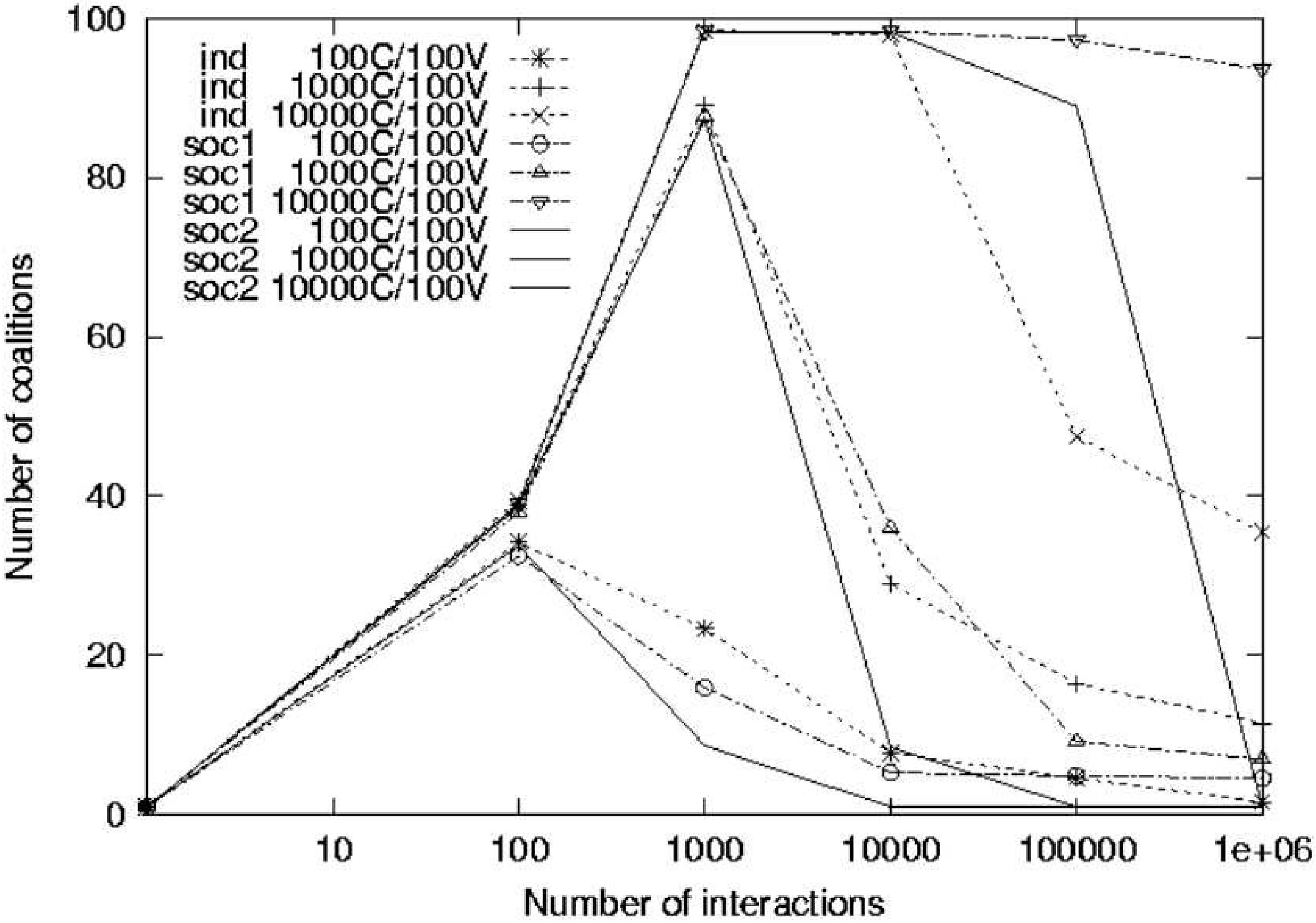
Experimental Setup

Fixed parameters for all simulation runs:

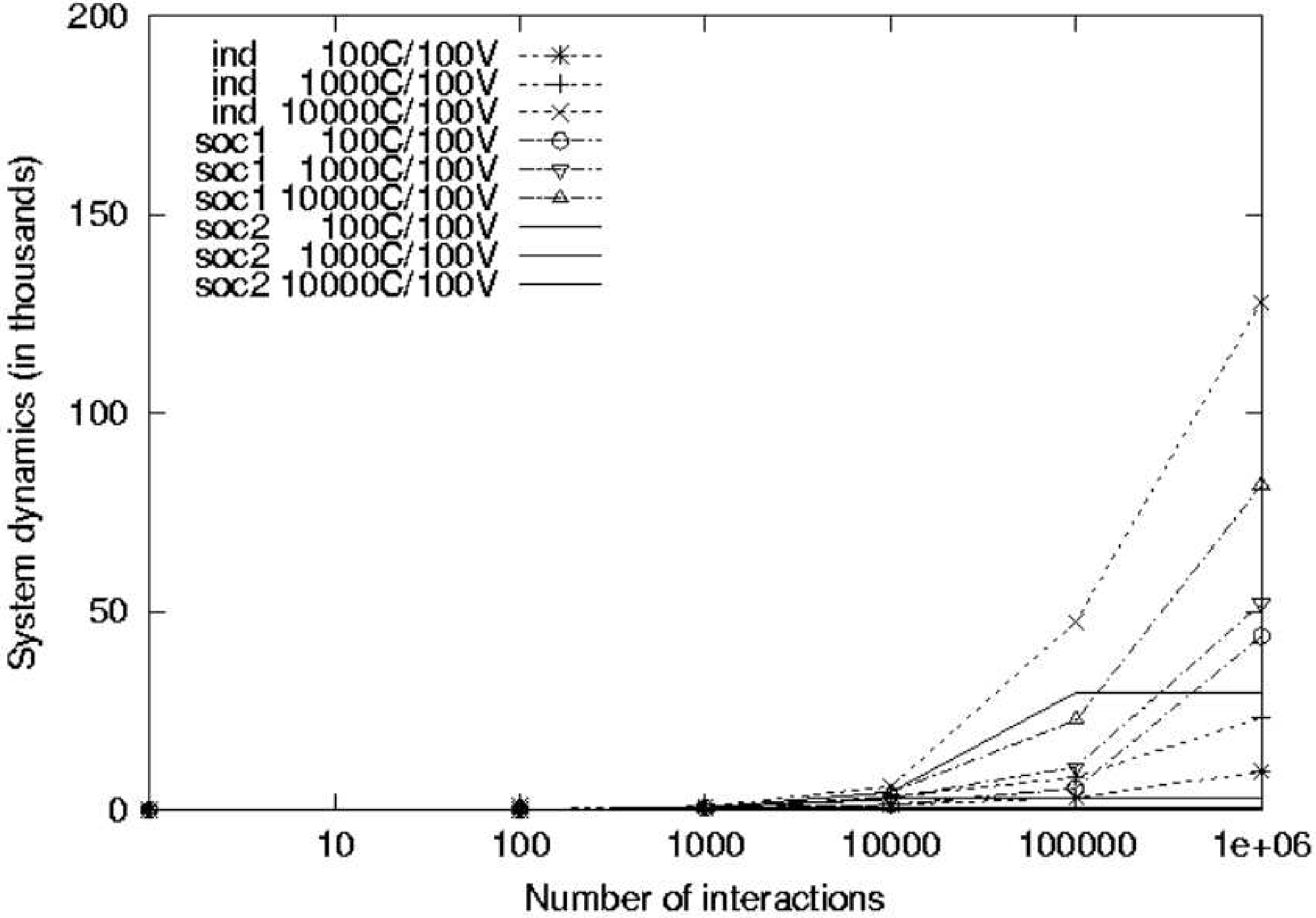
- Trust inflation rate $d := 0.5$.
- Evaluation of positive experience: $+0.2$.
- Evaluation of negative experience: -0.2.
- Discount rate: 5%.

The number of vendors is 100 in all runs. The number of customers is increased from 100 to $10,000$.

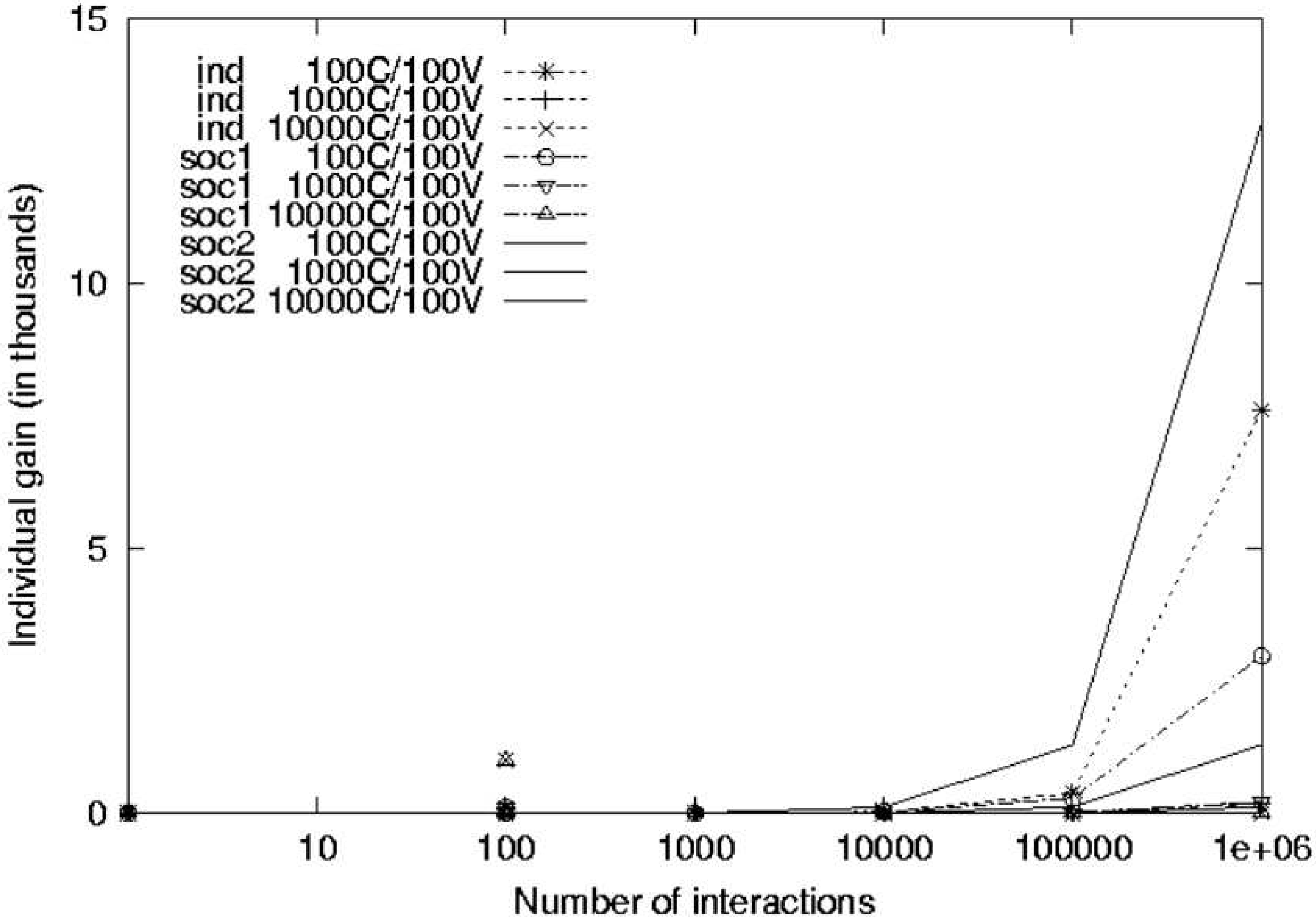
Evaluation: Number of Coalitions



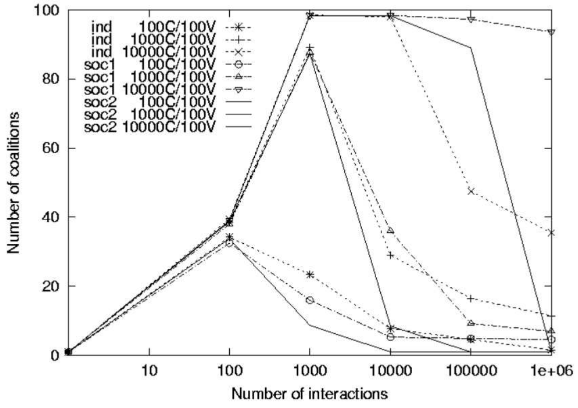
Evaluation: System Dynamics

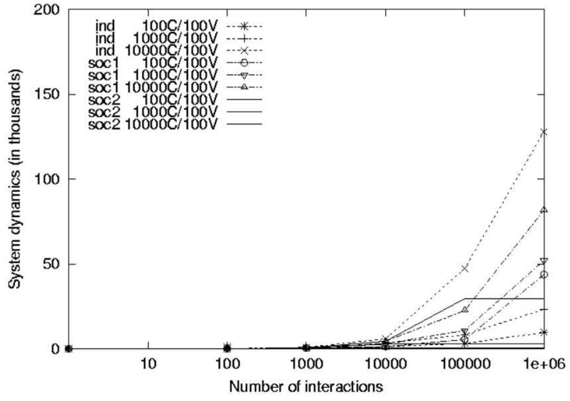


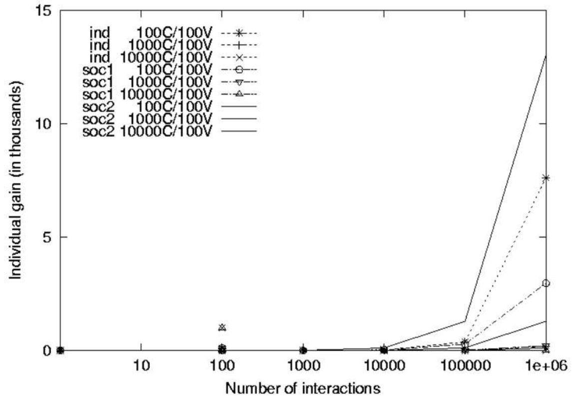
Evaluation: Individual Gain



Evaluation: Summarized







- Number of coalitions is limited by number of vendors, reaches a peak, drops down afterwards.
- Individual gain is highest for soc_2, medium for ind.
- Individual gain is directly related to the number of coalitions, (soc_2 leads to one single coalition after 10^6 interactions).
- System behavior is predictable: Little dynamics.

Issues with the Approach

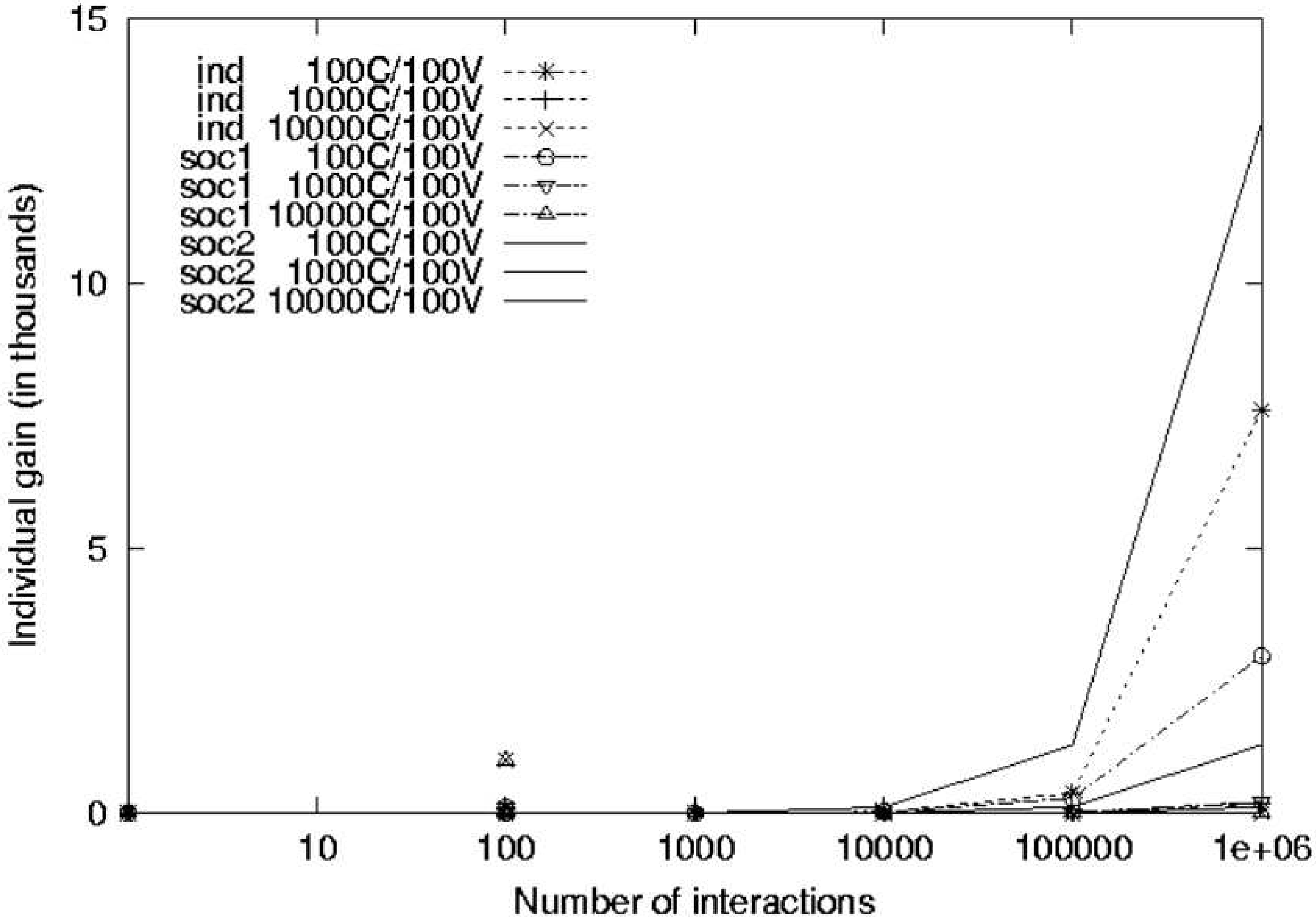
- Coalitions can be changed at no cost. (*Long-term* coalitions?)
- Agents do not communicate: Two agents that want to be in the same coalition could possibly never be.
- Prices and qualities are completely disregarded.
- Matchmakers do not use coalition information for their decisions.
- The benefits for the vendor agents are not evaluated – maybe the coalitions are not good for them at all.

Flaws in the Paper

- Frequent inconsistency between paper prosa and formulas.
- Important details, e.g. matchmakers, are not explained.
- All figures have the X-axis in logarithmic scale, which is never mentioned. And even the authors do not seem to be aware of this:

  The general trend of the curves is to grow very slowly from 1 to 10,000 interactions, after which they rise slowly until 100,000 interactions and highly until 1,000,000 interactions.

Flaws in the Paper



Summary

- First paper that describes a coalition formation procedure at agent level and evaluates the system performance.
- First paper that describes a coalition formation mechanism that is based on trust.
- Different reasoning mechanisms are presented and compared to one another at the system level.
- Shortcomings in the approach, some of them are remedied in subsequent papers.
- Some major flaws in the paper regarding the graphs, also in later papers.

References

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