DELIS

Dynamically Evolving, Large-scale Information Systems

Self-Organising Networks of Services without Money or Contracts

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First International Workshop and Summer School on SSME,
Crete, 30th May to 3 June 2007

Information Society Technologies

Money? It's a gass!

David Hales (University of Bologna)

I'm going to talk about a zero (0) trillion dollar a year business!

Intro.stuff – who am I?

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- My history… my great grand supervisor was **Alan Turing**
- Comp. Sci., A.I., Social Simulation, back to Comp. Sci.
- Currently work in **Ozalp Babaoglu's** group in Bologna, Italy
- People say, (yesterday) it takes 10 years to make real change in a corporation => maybe corporations (as we know them) are finished? Certainly tradition academic disciplines are out-of-date!
- Is it those old out-of-date structures that are holding us back?
- Furthermore, do we need concepts of "money", and "contracts" to move forward with self-organising and emergent services?
- Can a "science of services" be a radical agenda? I say yes!
- Prince Kropotkin and mutual aid… anarchic systems?
- This is not as silly as it sounds. It's about hope and efficiency.

Why am I here? (Reality)

- Met Christos in Brussels Brainstorming for FP7
- EU put us in a room – I learned of SSME!
- Is this real? Or is it marketing hype? I think it's real
- Situation: Christos, myself and many others brainstorming has lead to proactive call 3 of FET "science of complex systems for socially intelligent ICT"
- As you heard yesterday from Aymard de Touzalin from the EU – that call is now accepted as a 20M euro call 1 NoE + IP's
- One reason I am here is to get people who are interested in an IP in that call together informally and then to move a proposal forward
- Note: not just EU people, the FP7 encourages non-EU partners to participate and there are reciprocal arrangements with national funding bodies…. But ask this to Aymard…
- Particularly interested in a sciences of services input from IBM in a consortia for EU project funding if we can arrange this…

Here's the Science bit…

Evolutionary Models

- Recent evolutionary models demonstrate desirable properties of cooperation and coordination
- Based on ideas coming from evolutionary / bounded rationality approaches (Simon, Arthur, Axelrod et al)
- Such models relax assumptions of “ideal” rationality
- Consider agents operate using simple heuristics
- Often collective learning via a (cultural) evolutionary approach
- The idea that (potentially random) innovations in agents are copied by others (in some way) if they improve utility (defined in some way)

Group-like Selection Models

- Recent models that dynamically structure populations into groups
- Apparently selecting for “group-level” utility
- But based only on individual selection and “goals”
- Individuals move between groups and select behaviour within the group based on improving their individual performance
- When tested in “social dilemma” type scenarios...
- Groups emerge and behave cooperatively / altruistically because:
  - groups containing non-functional individuals (bad-guys) eventually die out
  - hence exploiting a group is not sustainable
  - a dynamic ecology of groups emerges

Group-like Selection Models

- Recent group selection models:
  - Tag-based systems (Holland, Riolo, Axelrod)
  - Network re-wire (Hales, Santos et al,)
  - Group splitting model (Traulsen, Nowak)
- Key aspects of such models are:
  - how group boundaries are defined and formed
  - how individuals move between groups
  - the kinds of interaction between individuals within groups
- Here we concentrate on network re-wire model:
  - proposed as a basis for P2P protocols
  - applied to file-sharing, job-sharing, replica management
  - but still very much at the “abstract” level, several open issues

Peer-to-Peer Systems

- We developed a network re-wire model for use in peer-to-peer (P2P) systems
- P2P are generally open systems of client programs running on user machines with no central authority or control (e.g. BitTorrent)
- Electronically mediated and semi-automated social systems
- Peer nodes maintain links to other nodes forming a graph topology
- Some general motivating questions are:
  - How can such systems come to self-organise, cooperate and coordinate to produce productive behaviour?
  - How can the negative effects of free-riding and selfish behaviour be avoided - promote social good?
  - How can such systems scale well in a robust way?
  - How can the effects of malicious behaviour be minimised?

SLAC Algorithm

Basic Algorithm or Protocol running in each node

- Periodically **do**
  - Compare “utility” with a random other node
  - **if** the other node has higher utility
    - copy that node’s strategy and links (reproduction)
    - mutate (with a small probability):
      change strategy (behavior)
      change neighborhood (links)
  - **fi**
- **od**

SLAC Applied to the PD

- Applied to a simulated Prisoner's Dilemma Scenario
- Where selfish behaviour produces poor performance – Nash Eq.
- Nodes store a pure strategy, either cooperate or defect
- Periodically play the single round PD with randomly selected neighbours
- Node Utility = average payoff obtained by node
- Mutation of strategy: flip strategy
- Mutation of links: re-write to a single random node

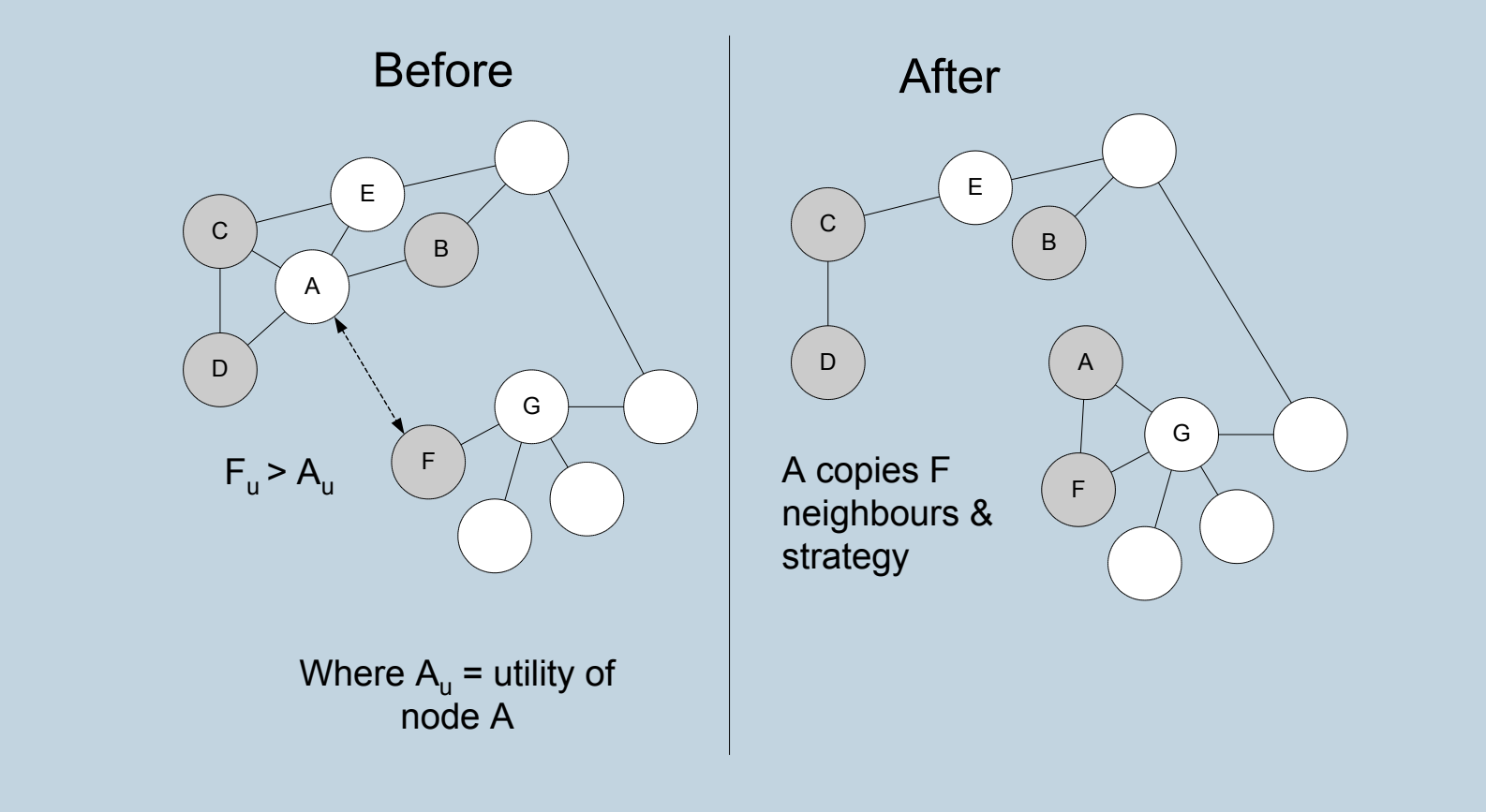
The Prisoner's Dilemma

Given: $T > R > P > S$ and $2R > T + S$

Player 1 / Player 2	C	D
C	R / R	T / S
D	S / T	P / P

SLAC algorithm

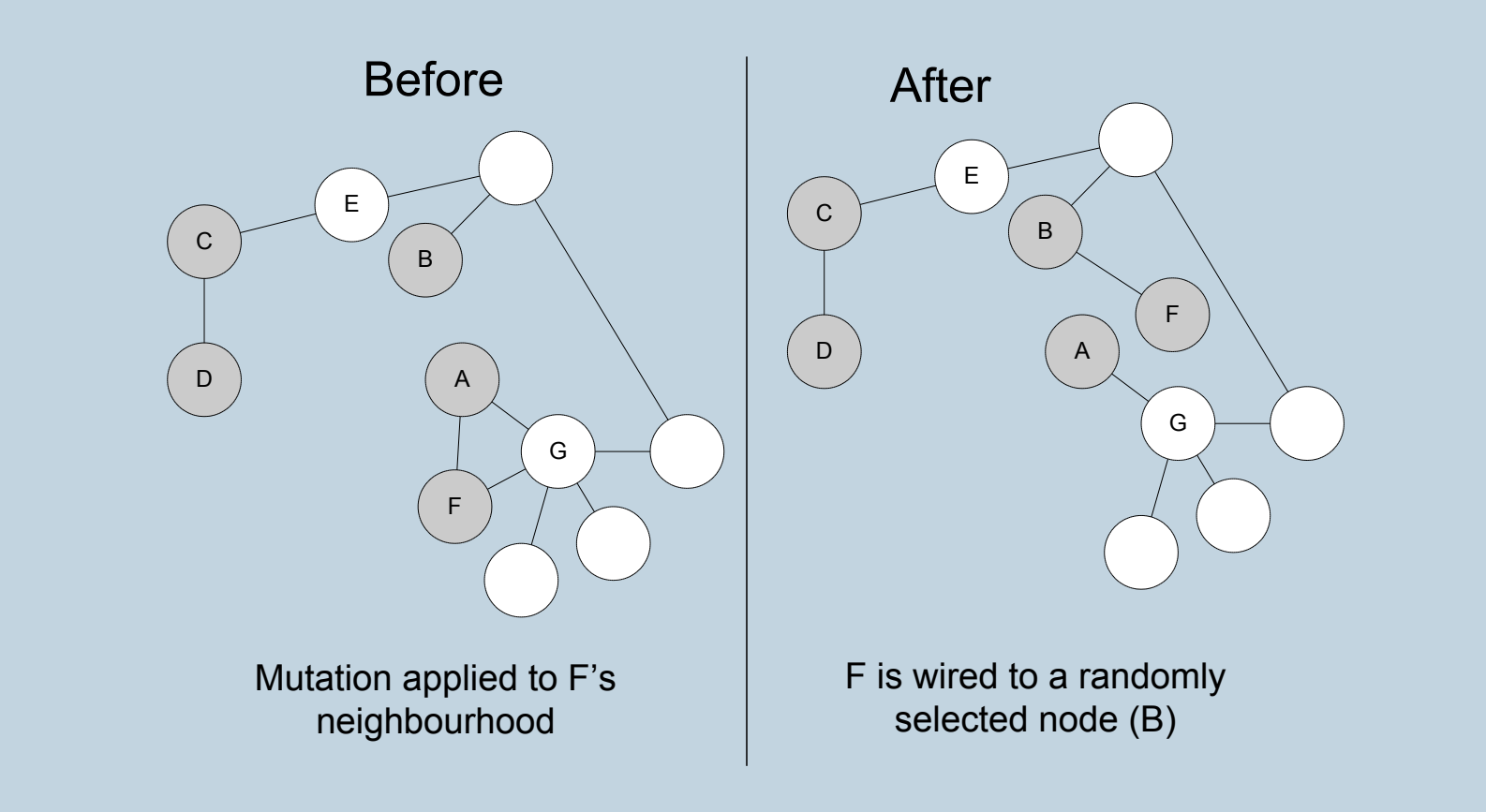
"Reproduction" = copying a more successful node



SLAC algorithm

Self-Organising Cooperation in Peer-to-Peer Systems

"Mutation of the neighbourhood" = random movement in the net



SLAC Applied to PD

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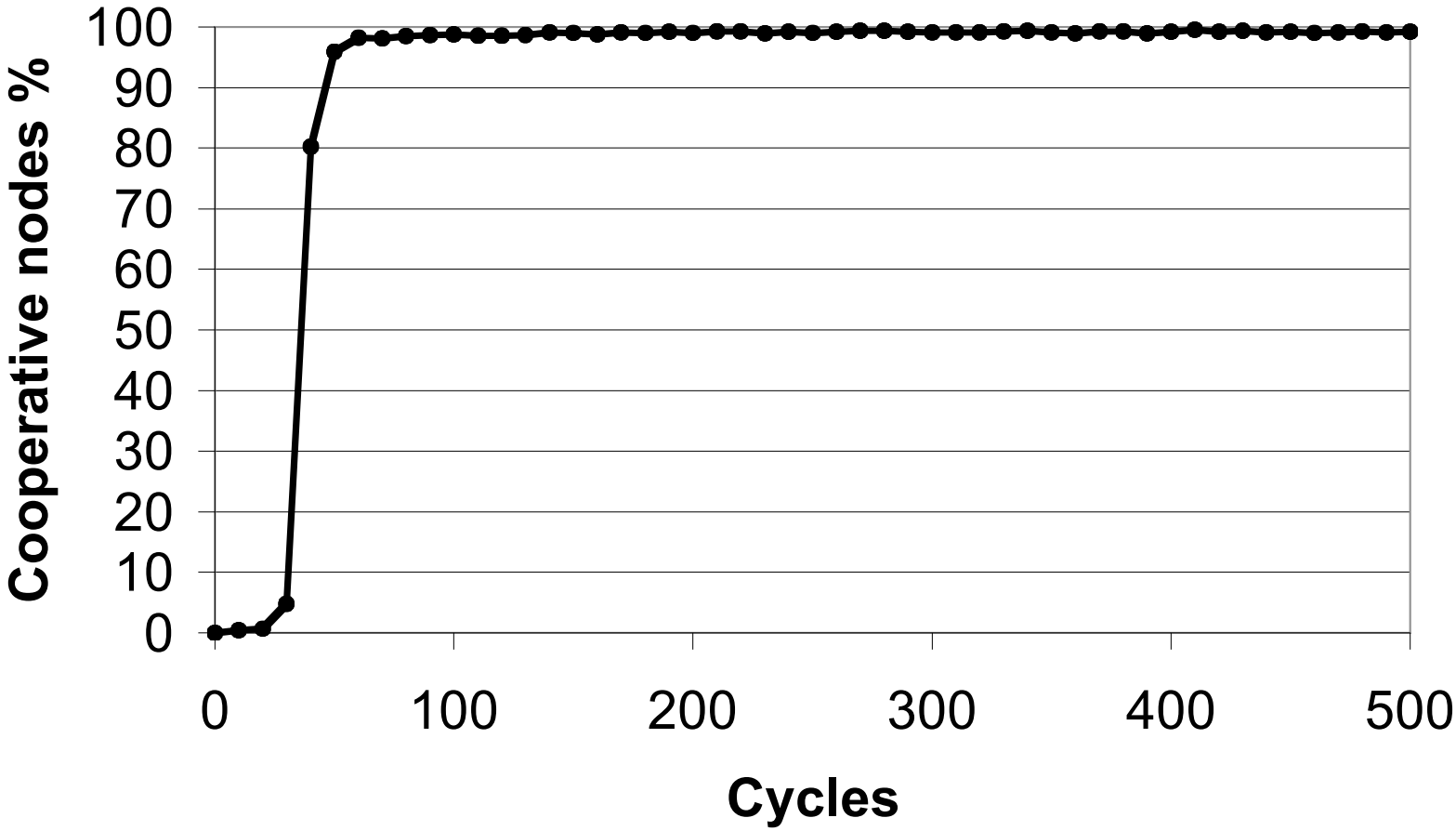
Typical Individual Run



How Does SLAC Work?

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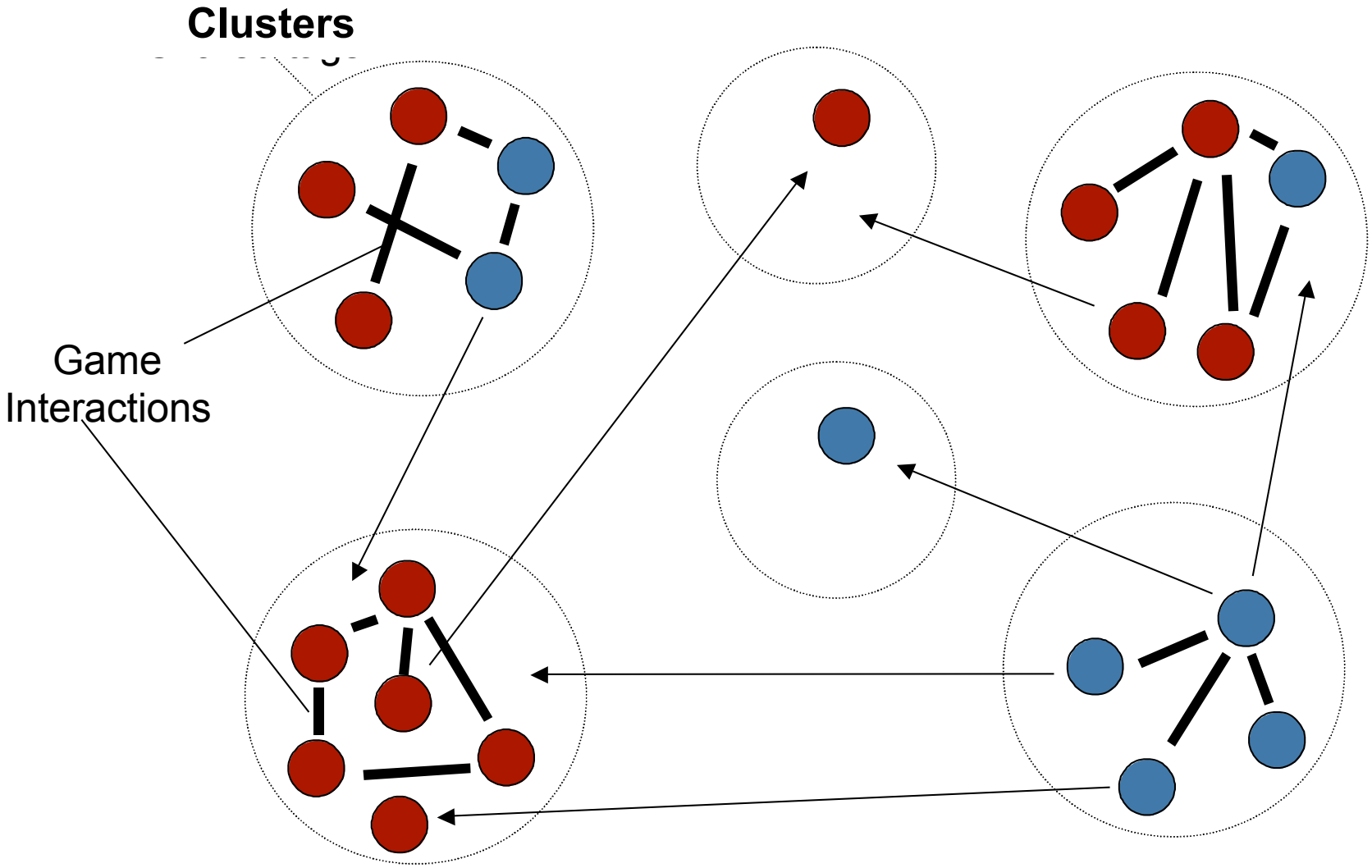
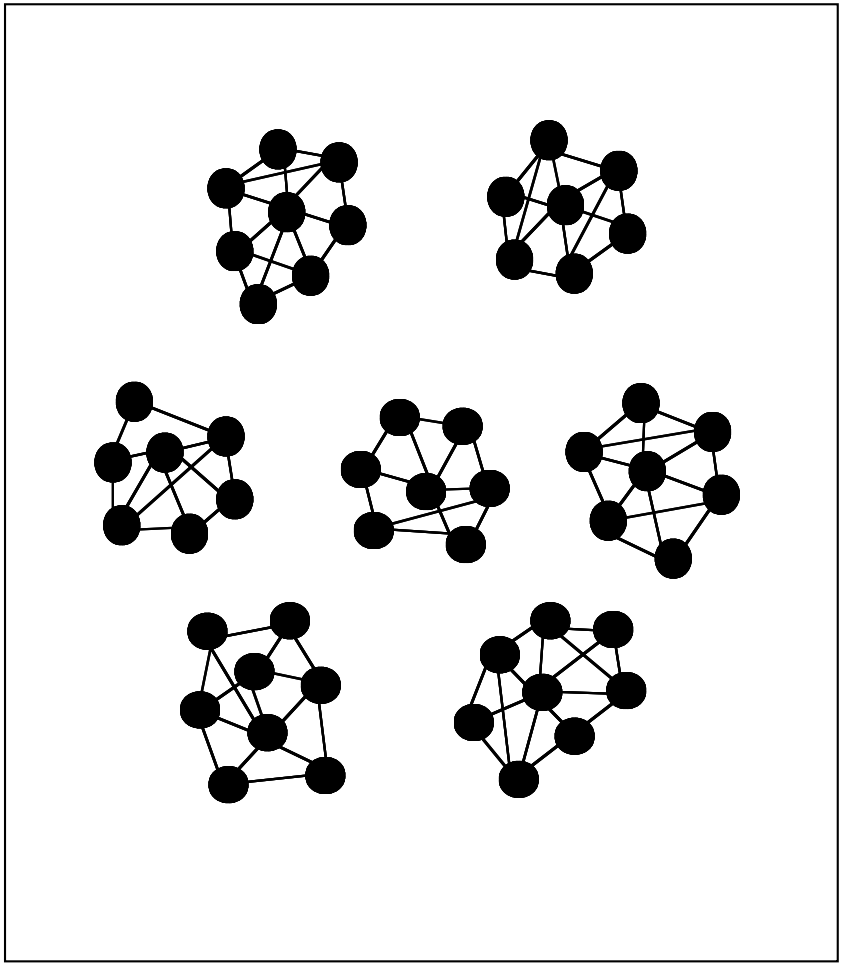


SLACER algorithm

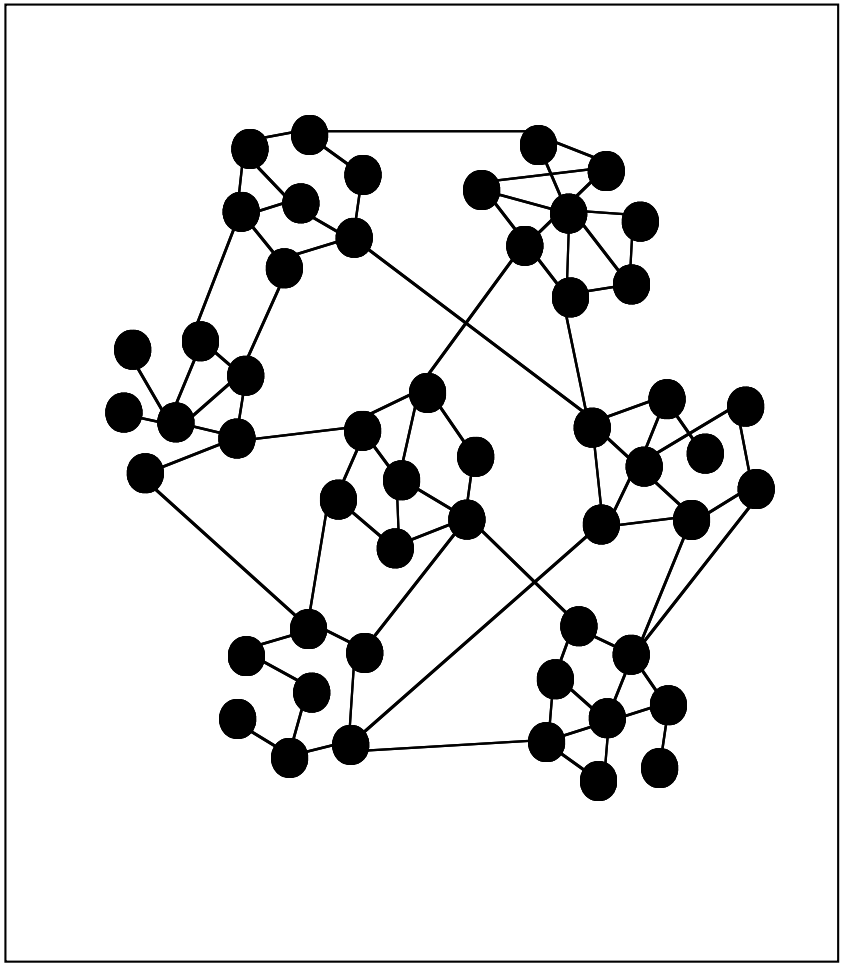
Basic Algorithm

- Periodically **do**
  - Each node compare “utility” with a random node
  - **if** the other node has higher utility
    - copy that node’s strategy and links, *probabilistically retaining some existing links*
    - mutate (with a small probability):
      change strategy (behavior)
      change neighborhood (links), *probabilistically retaining some existing links*
  - **fi**
- **od**

SLAC to SLACER

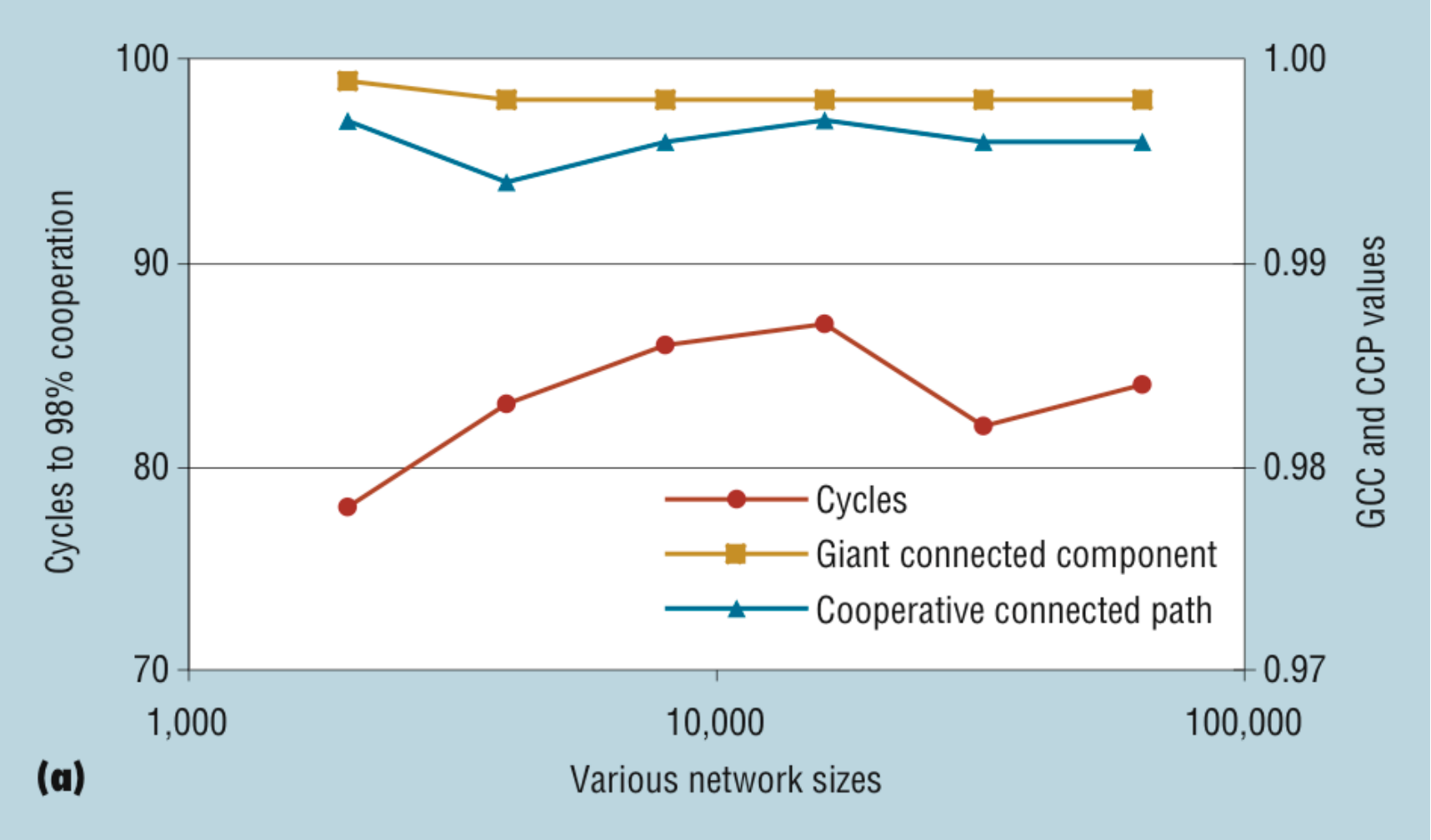


SLAC



SLACER

SLACER – Some Results



SLACER – Some Results

Groups with Specialisation

- SkillWorld: a slightly more complex coordination task requiring groups with diverse “skills”
- Each node stores one of 5 skills (this is fixed)
- Nodes receive jobs that require a single skill to complete
- If the receiving node does not have the required skill it looks for a neighbour having required skill and willing to complete the job
- nodes store an altruism flag indicating if they will perform jobs for others
- Any completed job earns the *original receiving node* utility
- Completing a job incurs a utility cost
- SLAC applied to the scenario produces clusters of altruistic specialists

SkillWorld Output

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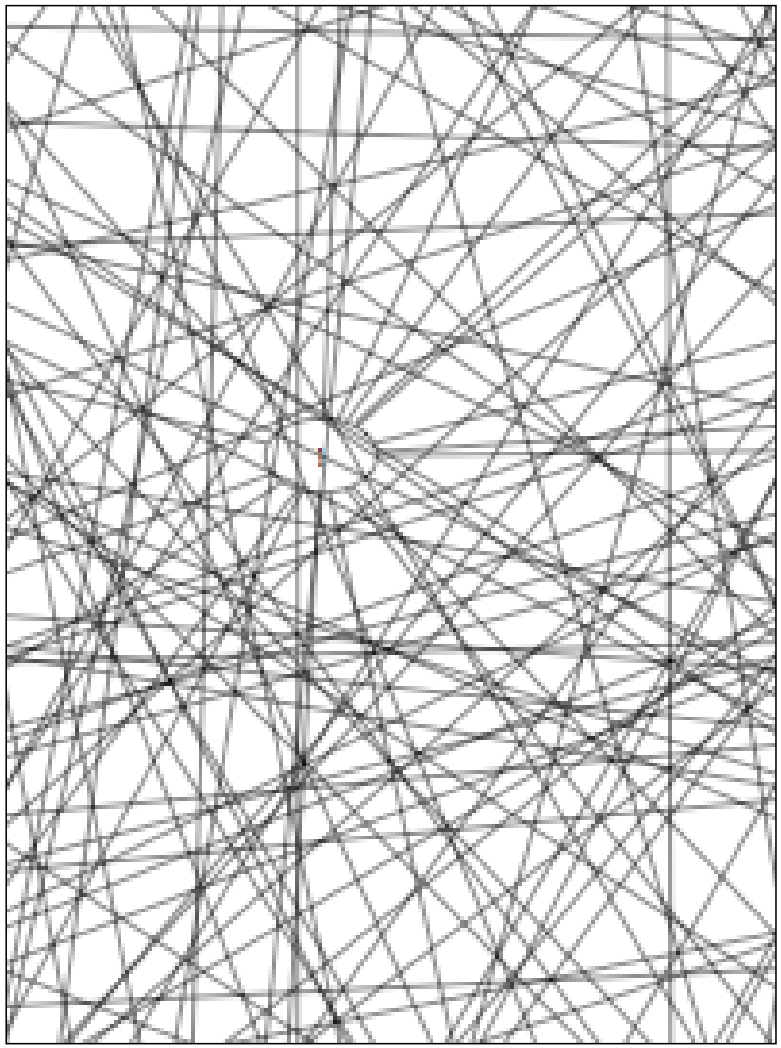
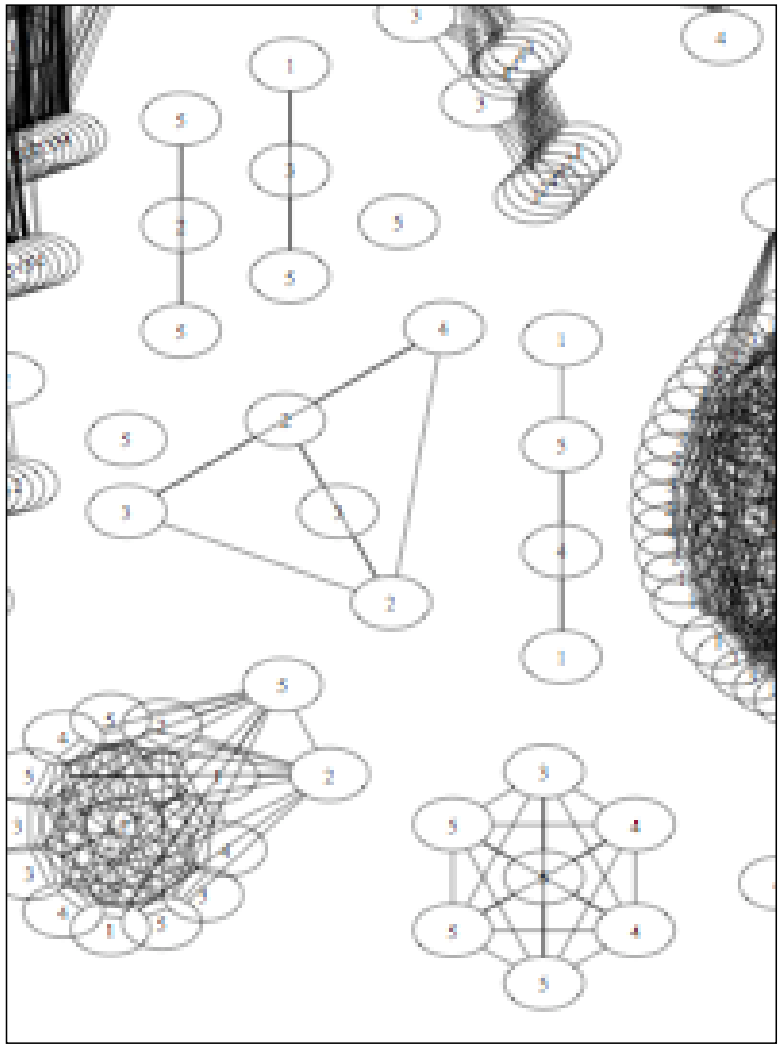


Cycle 0



Cycle 10

SkillWorld Output

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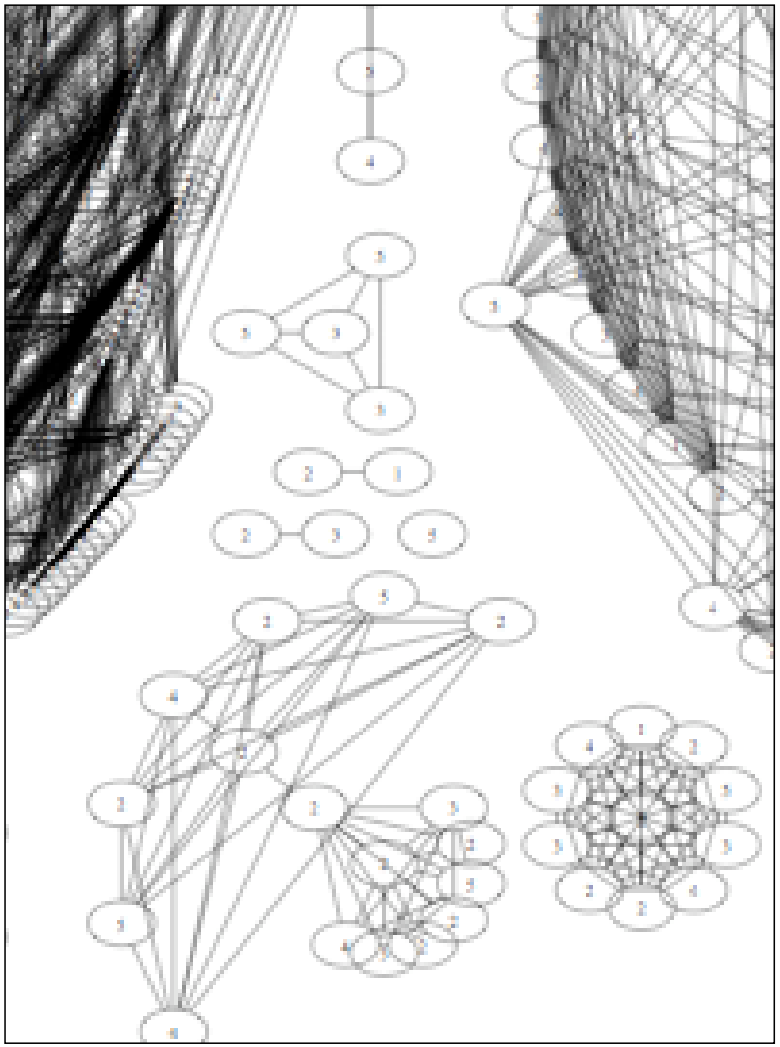
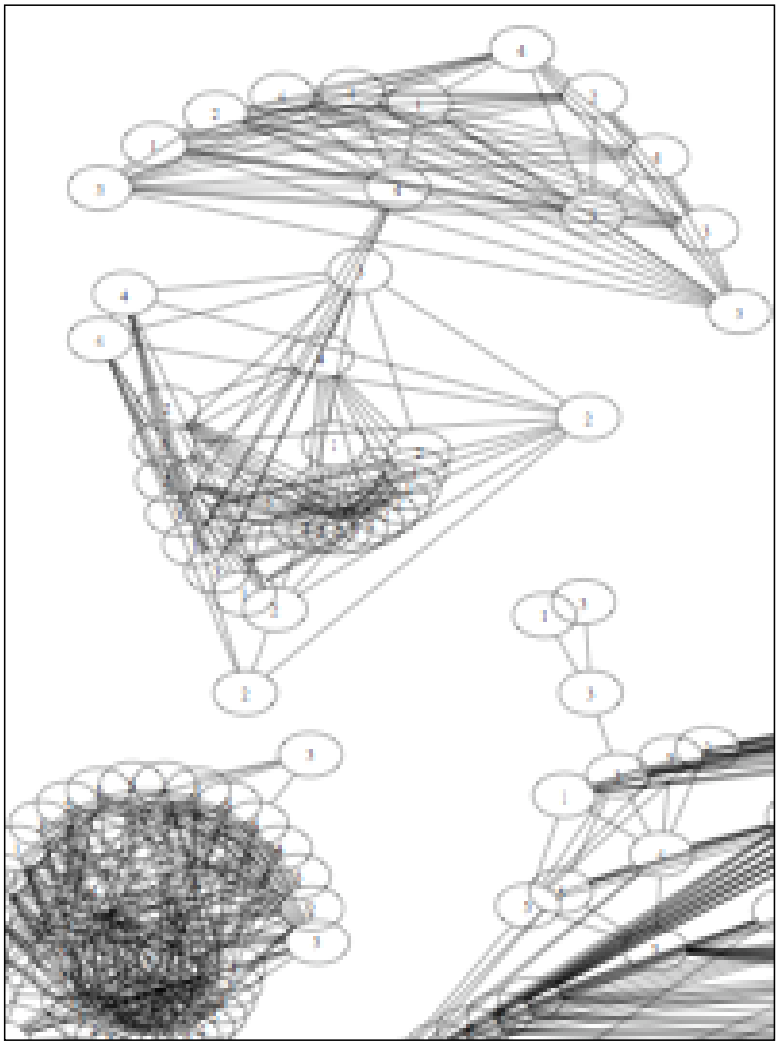


Cycle 20



Cycle 30

What has this got to do with SSME?

- These simple protocols organise appropriate social structures and behaviours in dynamic networks based on individual utility
- Even when nodes have the ability to behave selfishly, this evolutionary approach, based on “copying those doing better”, can work to coordinate productively
- Nodes do **not** know *a priori* the topology or behaviour required, it is learned - structure emerges
- Could similar kinds of protocol replace some of the functions of markets for the purposes of organising networks of services?
- Could such kinds of model represent the way humans may behave in highly dynamic service networks?

Rather Unjustified Speculation

- Rather speculative normative recommendations for people in such dynamic networks might be:
  - Do not be loyal to groups when you believe you can do better in another group, be prepared to move quickly
  - Be prepared to create new groups
  - When joining a group learn and practice group norms
  - Make joining your group beneficial and easy for new members
  - Do not spend too much time searching for better groups to join, rely on informal and chance contacts
- All this has to be qualified because no serious empirical work has been performed - future work (the BitTorrent global experiment!, recent small-scale pilot study with psychology students).

Experimental results with people

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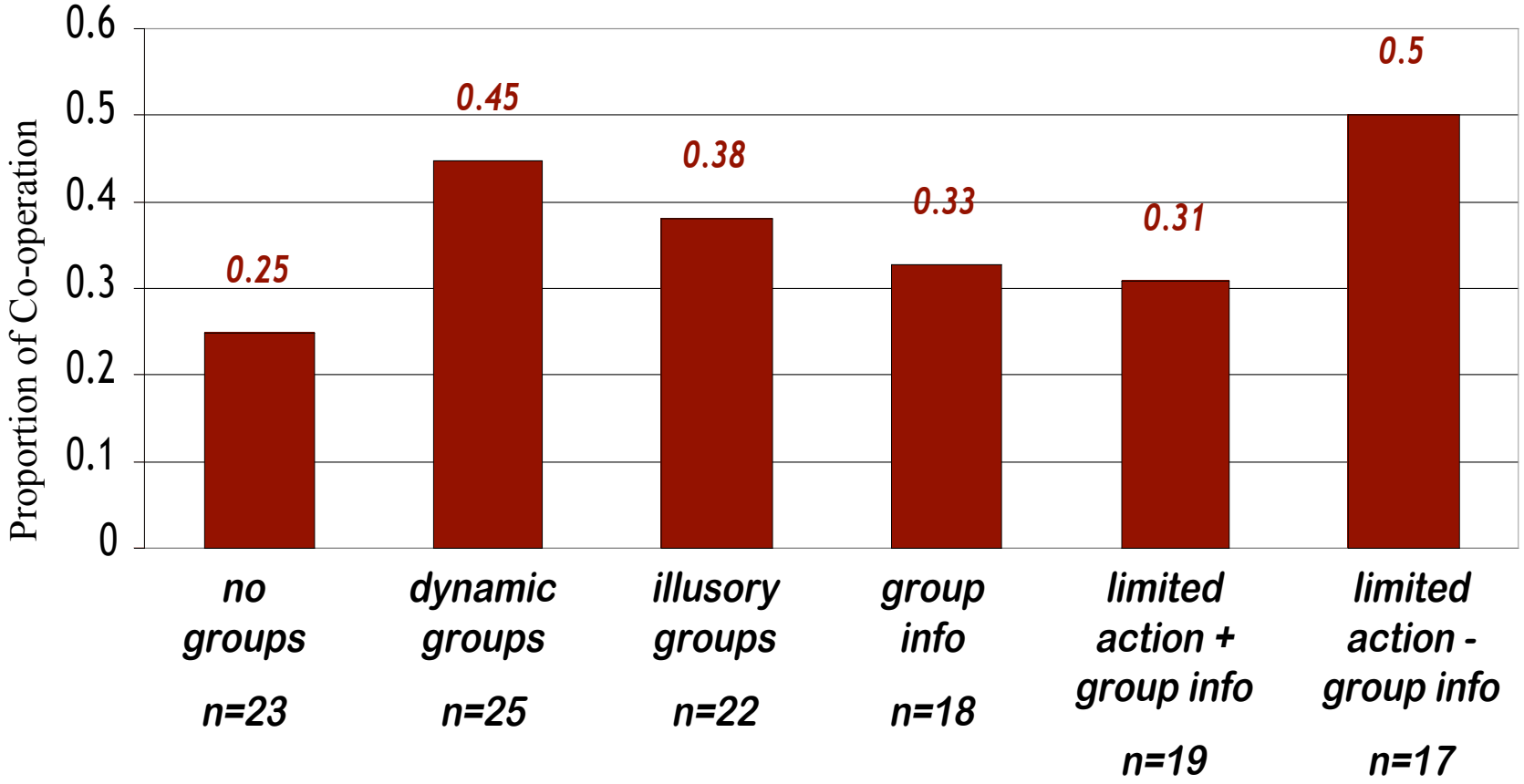

Pilot study. Joint work with Jeremy Goslin, Dept. of Psychology, University of Plymouth (paper forthcoming)

Conclusion

- Simple copy and rewire algorithm
- No need for centralized trust or enforcement mechanism
- No need for knowledge of past interactions
- Produces cooperative behaviour even when nodes behave in an egotistical way, locally and greedy optimizing
- Works through a kind of “group selection” – “tribal selection”
- But current models are very simple
- Can they be scaled up to more realistic task domains?
- On-going work: broadcasting (Stefano Arteconi), replica management (Andrea Marcozzi)
- Can such approaches be scaled up for general systems of services involving humans?
- A lot of research to do!

Some Recent Works

- Hales & Edmonds (2005) “Applying a socially-inspired technique (tags) to improve cooperation in P2P Networks”, IEEE Transactions on Systems, Man, and Cybernetics, Part A
- Hales & Arteconi (2006) “SLACER: A Self-Organizing Protocol for Coordination in P2P Networks”, IEEE Intelligent Systems, 21(2):29-35
- Mollona, E. & Hales, D. (2006) Knowledge-Based Jobs and the Boundaries of Firms. Journal of Computational Economics 27(1):35-62
- Hales, D. (2006) Emergent Group-Level Selection in a Peer-to-Peer Network. Journal Complexus 2006;3:108-118
- Hales, D. and Babaoglu, O. (2006) Towards Automatic Social Bootstrapping of Peer-to-Peer Protocols. In ACM SIGOPS Operating Systems Review, vol. 40, no. 3, July 2006.
- Hales, D., Marcozzi, A., Cortese, G. (2007) Towards Cooperative, Self-Organised Replica Management. To be presented at the First International Conference on Self-Adaptive and Self-Organizining Systems (SASO2007), July 2007, Boston, MIT

Calls for Participation!

- First IEEE International Conference on Self-Adaptive and Self-Organizing Systems (SASO), Boston, Mass., USA, July 9-11, 2007

  http://projects.csail.mit.edu/saso2007/

- The Fourth European Social Simulation Association Conference (ESSA), Toulouse, France, September 10-14, 2007

  http://w3.univ-tlse1.fr/ceriss/soc/ESSA2007/

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The End

Thank you!