DELIS

Dynamically Evolving, Large-scale Information Systems

SLAC and SLACER:

Simple copy & rewire algorithms for trust and cooperation in P2P

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Information Society
Technologies

Self-Organising Cooperation in Peer-to-Peer Systems

- Algorithm based on social simulation models of “tags”
  - Introduced by Holland early 1990’s
  - Developed recently by Riolo; Axelrod, Cohen and others…
- Tags are observable “markings”, labels or social cues, attached to agents (e.g. hairstyle, dress, accent)
- In an evolutionary algorithm tags evolved just like any other artificial gene in the “genotype”
- They are displayed directly in the “phenotype”
- When agents bias interactions towards those with similar tags, even selfish evolution selects for cooperative and altruistic behaviour

Self-Organising Cooperation in Peer-to-Peer Systems

We translated the tag algorithm into a network

- nodes move to find “better” neighbors
- producing a kind of evolution in the network
- “bad guys” become isolated

Results in a “duplicate and re-wire” rule

- Producing a kind of “group selection” between clusters
- a functional reason for temporal structures found in the “natural” networks?

SLAC Algorithm

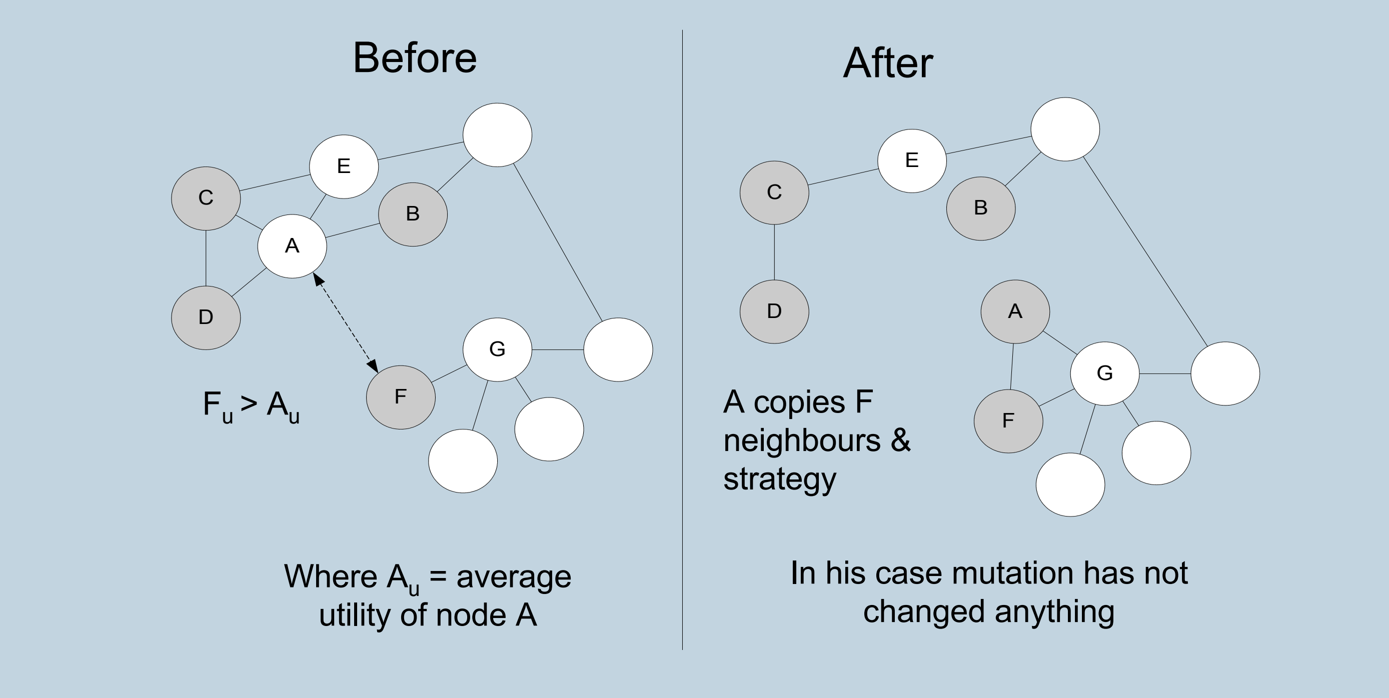
Basic Algorithm that runs on each node:

- Periodically **do**
  - Compare “utility” with a random 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 algorithm

Self-Organising Cooperation in Peer-to-Peer Systems

"Reproduction" = copying a more successful node



Before

$F_u > A_u$

Where A_u = average utility of node A

After

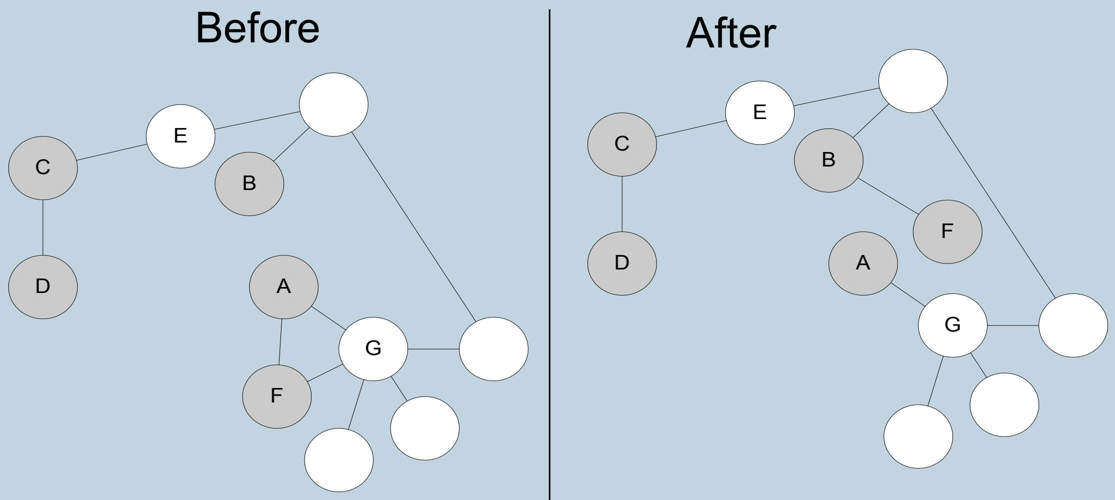
A copies F neighbours & strategy

In his case mutation has not changed anything

SLAC algorithm

Self-Organising Cooperation in Peer-to-Peer Systems

“Mutation of the neighbourhood” = random movement in the net



Mutation applied to F’s neighbourhood

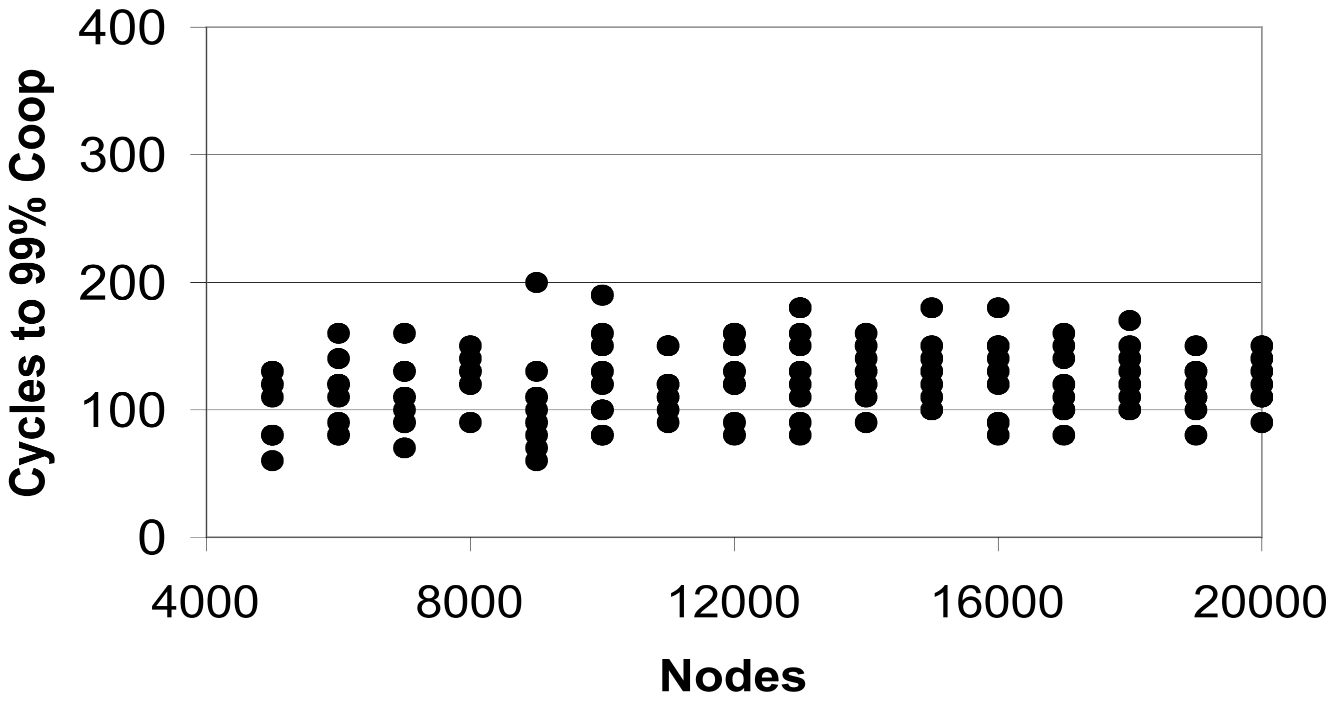
F is wired to a randomly selected node (B)

SLAC Applied to the PD

Applied to a simulated Prisoner's Dilemma Scenario:

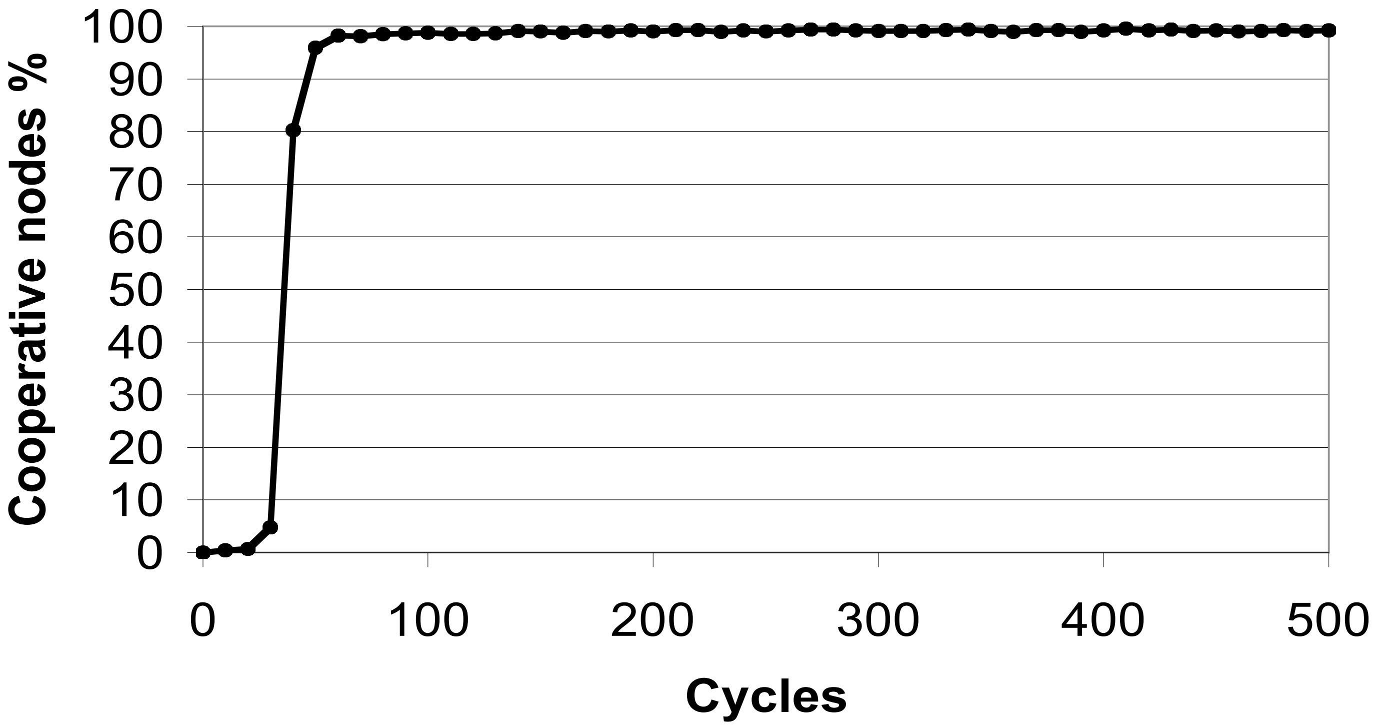
- Where selfish behavior produces poor performance – Nash Eq.
- Nodes store a pure strategy, either cooperate or defect
  - *Play the single round PD with randomly selected neighbours*
  - *Using their strategy*
- We take average payoff as the node utility
- Mutation of strategy: flip strategy
- Nodes randomly selected to play a random neighbours some number of times each period

Cycles to High Cooperation

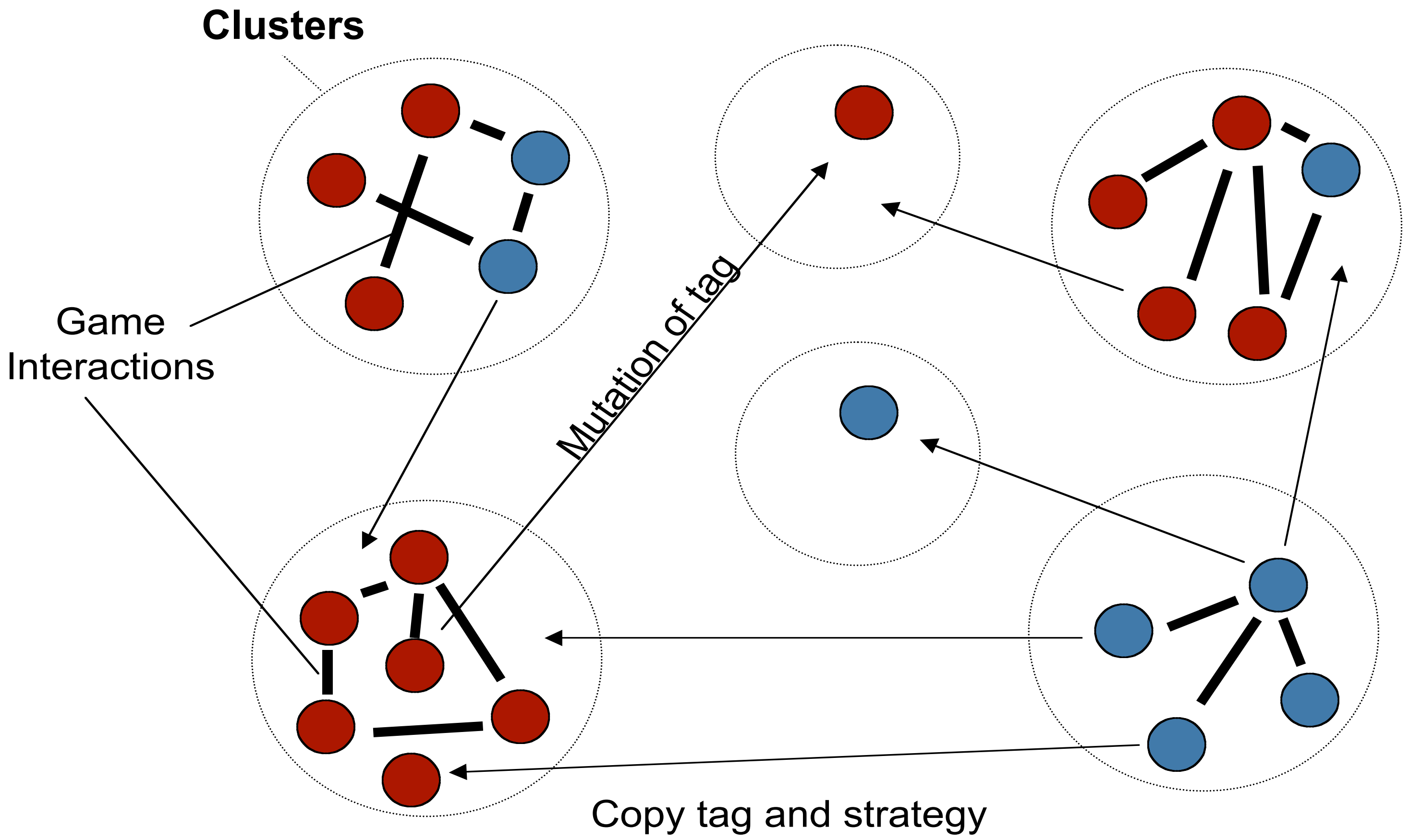


SLAC Applied to PD

Typical Individual Run



How Does SLAC Work?



Clusters

Game Interactions

Mutation of tag

Copy tag and strategy

SLAC Applied to File Sharing P2P

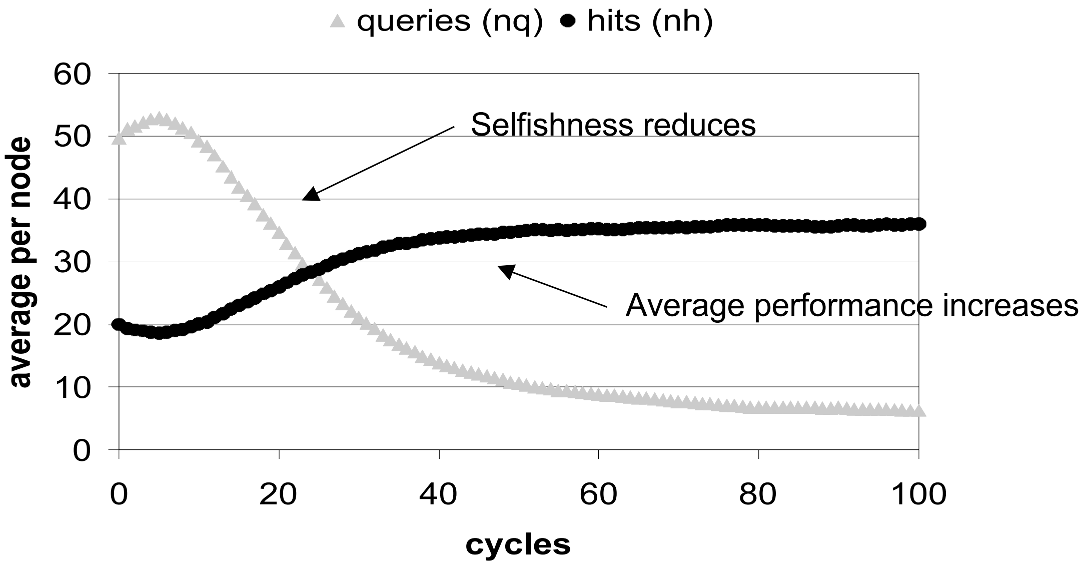
Applied to a simulated P2P File Sharing Scenario:

- Simplified form of that given by Q. Sun & H. Garcia-Molina 2004
- Nodes control how much capacity devoted to generating or answering queries based on *P* = [0..1]
  - *P* =1.0 *selfish* (only generates queries)
  - *P* =0.0 *altruist* (only answers queries)
- We take as node utility the number of *hits*
- Mutation of strategy: change *P* randomly
- Flood fill query method, TTL's etc

SLAC Applied to P2P File Sharing

Self-Organising Cooperation in Peer-to-Peer Systems

Some simulation results



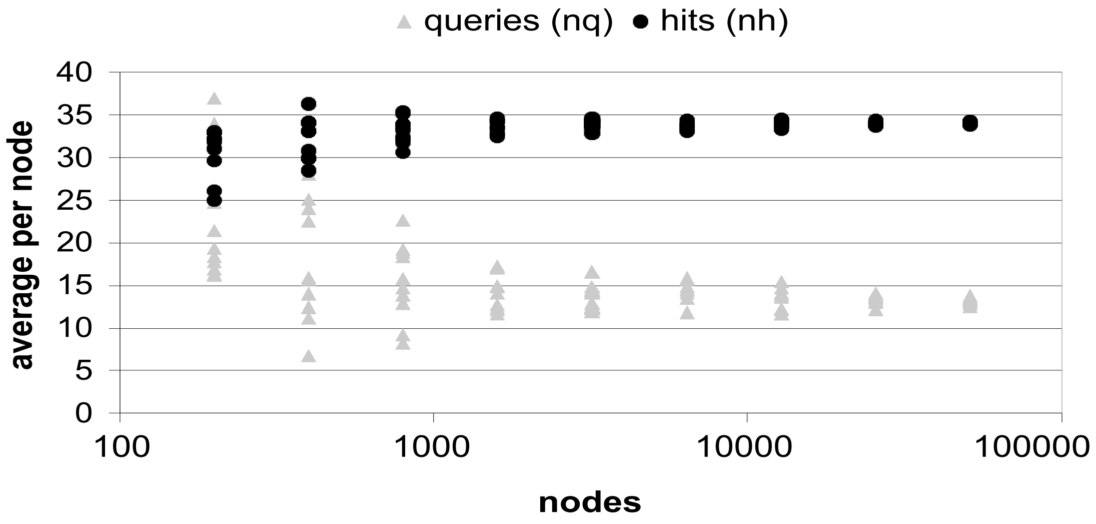
A typical run for a 10^4 node network

SLAC Applied to P2P File Sharing

David Hales (University of Bologna)

Self-Organising Cooperation in Peer-to-Peer Systems

Some simulation results



Results showing number of queries (nq) and number of hits (nh) (averaged over cycle 40..50) for different network sizes with10 individual runs for each network size

SLAC to SLACER

- SLAC is OK for some tasks – as we have seen
- But produces disconnected components
- This is no good when we want
- An "Artificial Friendship Network" to span the network
- Connected – such that all nodes are linked with short path
- Chains of trust between all nodes – preferably short also
- To achieve this we modify SLAC and introduce SLACER

SLACER algorithm

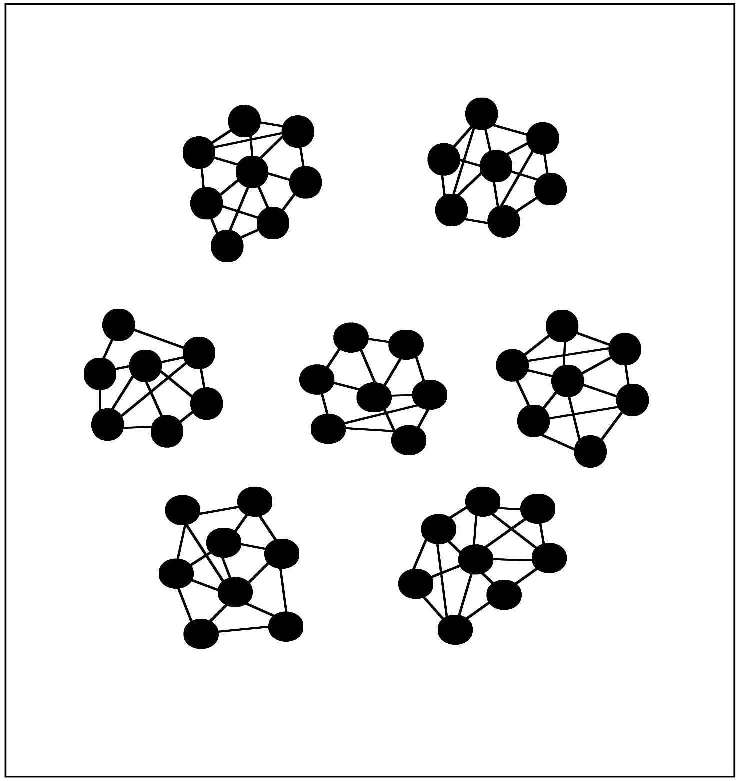
Basic Algorithm

- Periodically **do**
  - 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):

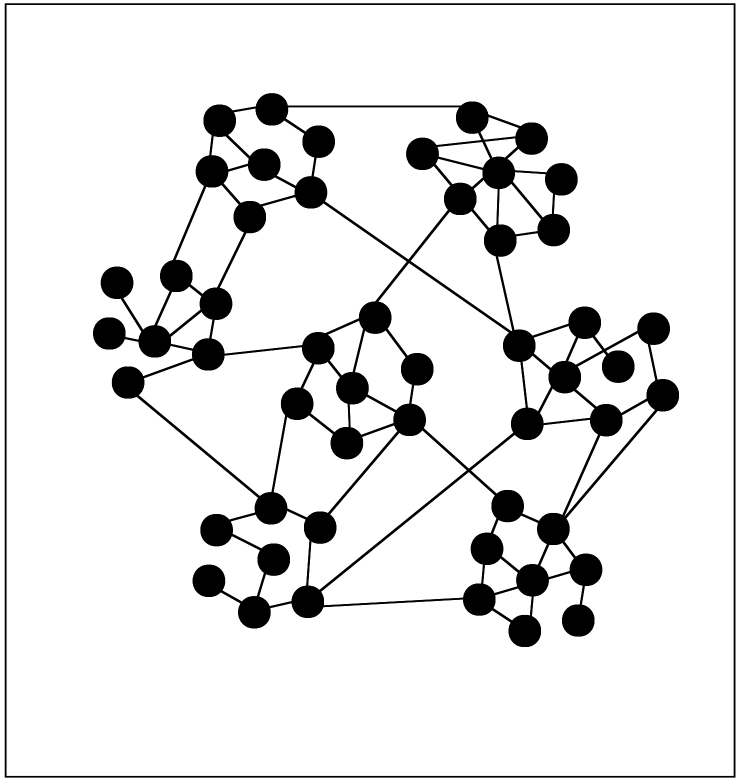
      change strategy (behavior)

      change neighborhood (links), *probabilistically retaining some existing links*
  - **fi**
- **od**

SLAC to SLACER

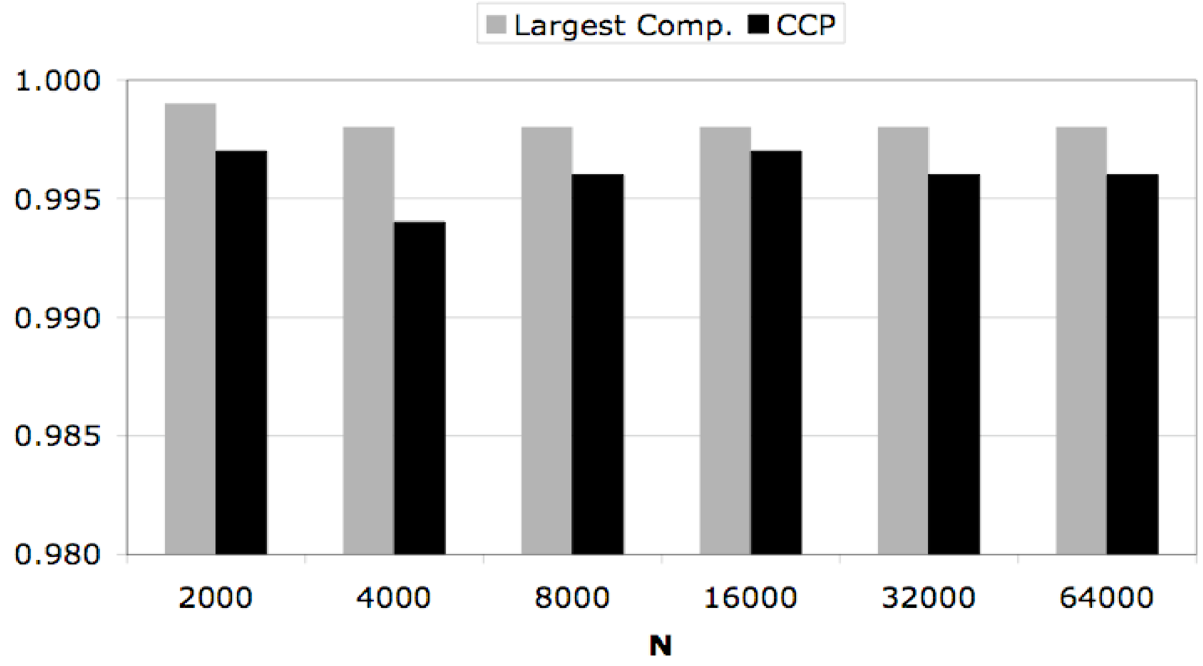


SLAC



SLACER

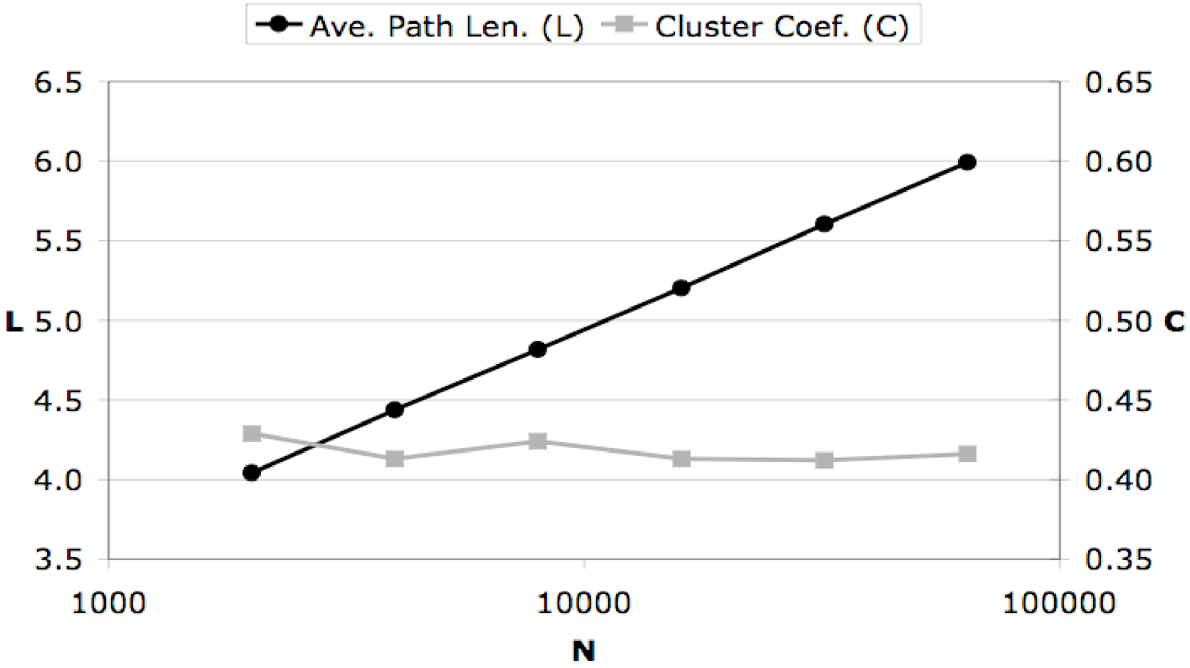
SLACER – Rome Results



SLACER – Future Applications

- By establishing a fully connected “Artificial Social Network” (ASN)
- This can be used as input to existing P2P applications
- Specifically those that assume or require trusted social networks as input
- Currently harvested from e-mail contacts or “buddy lists” in chat applications
- Example: Collective spam filtering:
- *J. S. Kong, P. O. Boykin, B. Rezei, N. Sarshar, and V. Roychowdhury, “Let you cyberalter ego share information and manage spam,” 2005. Available as pre-print: http://xxx.lanl.gov/abs/physics/0504026.*

SLACER – Some Results



Conclusion

- Simple copy and rewire algorithm
- No need for centralized trust or enforcement mechanism
- No need for knowledge of past interactions
- Process cooperative behavior even when nodes behave in an egotistical way, locally and greedy optimizing
- Works through a kind of “group selection” – dynamic coalitions?
- Can produce trusted and cooperative Artificial Social Networks
- Could be applied to existing protocols with minor modification
- Available on open source P2P simulation platform Peersim. http://www.peersim.sourceforge.net

Related Publications

References

- *Hales (2004) "From Selfish Nodes to Cooperative Networks", Fourth IEEE International Conference on Peer-to-Peer Computing (p2p2004), IEEE Press*
- *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 (to appear) Artificial Friends: Self-Organizing Artificial Social Networks for Trust and Cooperation – IEEE Int. Systems.*
- *Hales, D. & Patarin, S. (2005) Feature: Computational Sociology for Systems "In the Wild": The Case of BitTorrent. IEEE Distributed Systems Online, vol. 6, no. 7, 2005.*

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peersim.sourceforge.net

SLAC and SLACER

- Fini

The End

Thank you!