A Self-Organizing and Collective-Intelligence approach to the Peer-Review Process

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1. The Peer Review Process

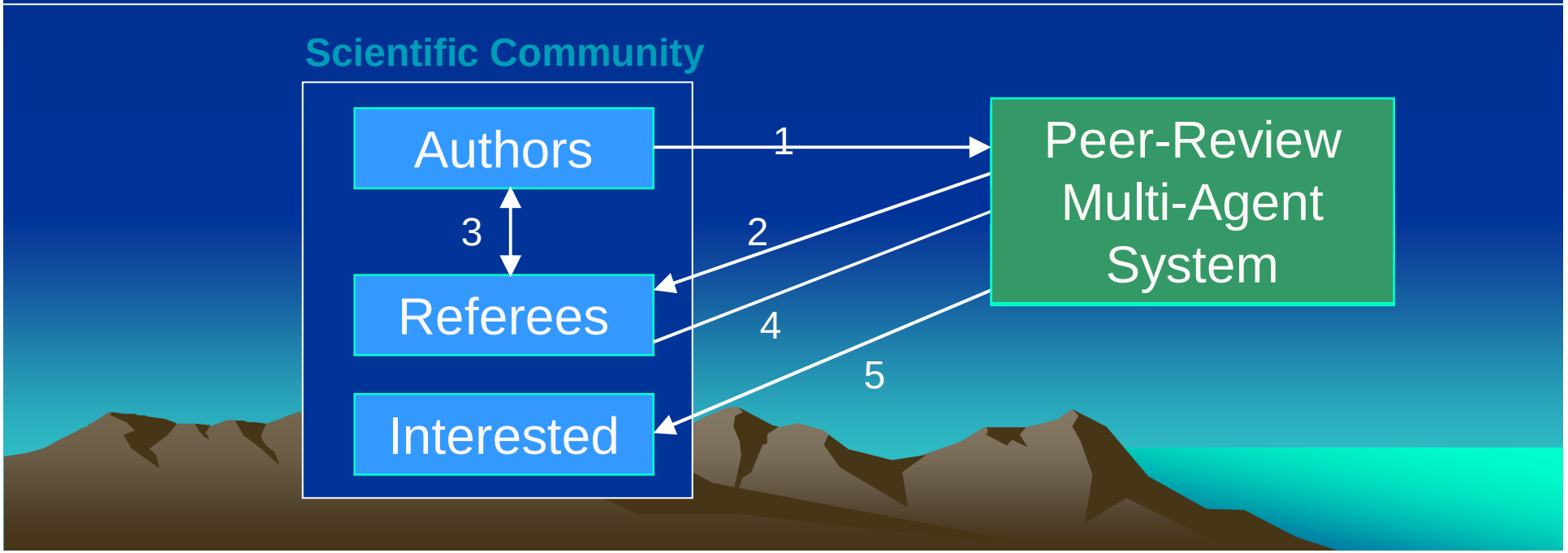
- **Peer-Review Process**: “A scholarly process used to screen submissions for publication and proposals for funding.”
  - *– modified from WikiPedia*

    Journal and funding agencies find peers in the community to determine the quality of work.

2 .Standard Peer-Review Process

** the remainder of the talk will be in terms of manuscript publishing*

1. Scientist(s) requests publication of manuscript
2. Editors locate scientists in the community to review manuscript
3. Reviewers (referees) ‘collaborate’ with author(s) to increase quality of work
4. Reviewers (referees) accept/reject publication based on journal standards
5. Publisher disseminate the manuscript to the interested scientists



3. Peer-Review Limitations

- **Time to print**: several months to years from submission to print
  - a major reason for the pre-print culture (arXiv, CiteBase, e-print servers, etc.)
- **Reviewer bias**:
  - work that is not in accord with referee research may be rejected
- **Peer collaboration**: with an average of 3 or 4 reviewers per manuscript, getting enough feedback to ensure quality work may not always be there
  - another major reason for the pre-print culture

4. Peer-Review Limitations (cont.)

- **Human effort and time**: editors and peer-reviewers are usually scientist with many other obligations
- **Cost to the community**: journals cost money to publish and manage and this cost is passed back to the interested community members
  - major reason for the **O**pen **A**rchives **I**nitiative

5. Mediators of the Current Process

The editor/publisher teams currently mediate the entire process from:

- ~~receiving preprints~~
- locating referees
- ~~distributing referee comments~~
- decision-making on acceptance
- ~~putting the manuscript into print~~
- finding an interested community

6. Mediation through Self-Organization

- **Self-Organization**: create a medium to allow for the scientific community to be self-managing.

  To provide a computational infrastructure that supports the peer-review process which does not include the publishers (and their associated costs) and to provide funding agencies an infrastructure to decrease the human-overhead required to organize proposal reviews.

7. Collaboration through Collective-Intelligence

- **Collective-Intelligence**: capitalizing on the heterogeneity of skills in a population in order to yield solutions to problems that are more optimal than what any member could provide working alone [Steinbock, Rodriguez, et.al 2001]

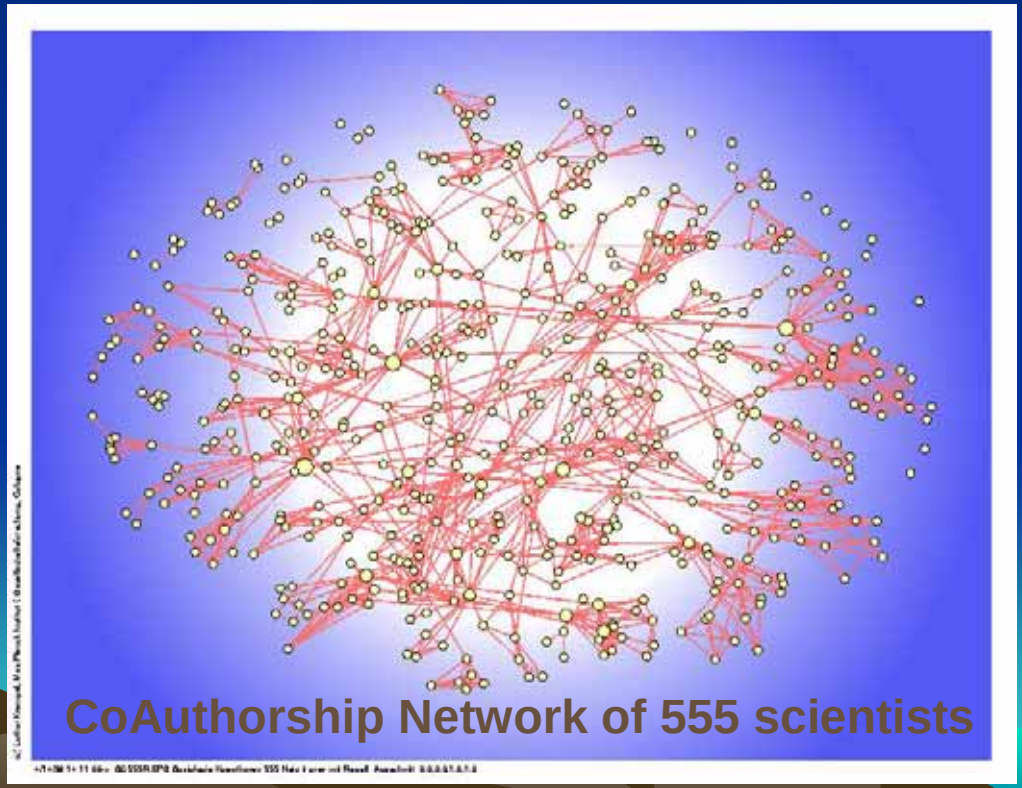
  To provide a medium that promotes variable user participation in the review process (i.e. spell/grammar checking, math checking, experiment re-doing, etc.).

  “More eyes on the code, the less bugs.” – Linus Torvalds

8. Mediators of the Future Process

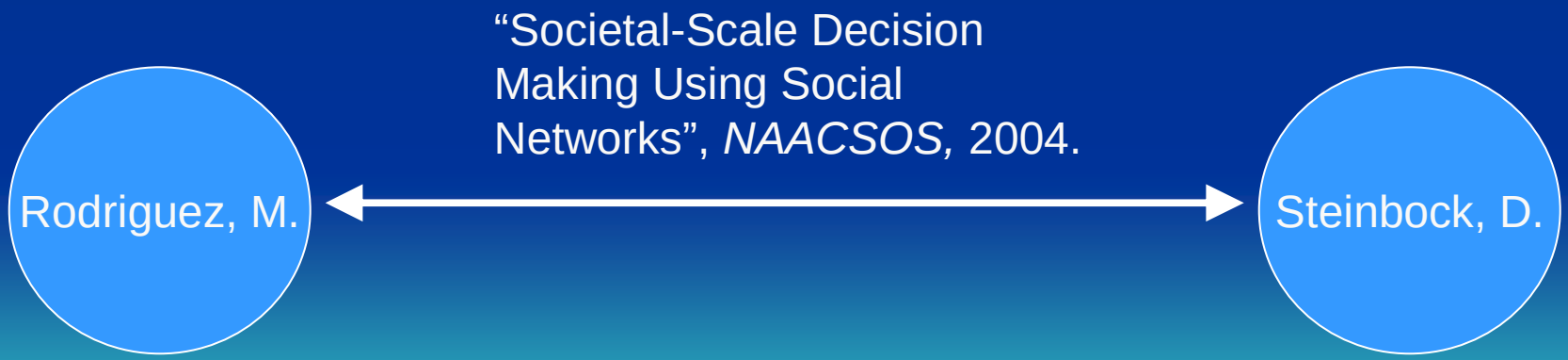
- **Social Network Analysis** (SNA): can provide the necessary tools to support referee identification, collective decision-making, and paper dissemination. [Rodriguez *in progress*][Steinbock & Rodriguez 2004]
- **Multi-Agent System** (MAS): open-system architecture for understandability and flexibility. [Griss 2003]

Social-Network Algorithms to support the Peer-Review Process



9. Co-Authorship Networks

- **Co-Authorship Networks**: each time two scientists collaborate on a paper they create a link between them within the greater scientific communities social-network.



10. Co-Authorship Networks (cont.)

- **Expertise**: connections in a social-network are based on similarity of the domain of that network [McPherson, et.al. 2001]. For co-authorship networks this implies similar research interests.
- **Trust**: connections in a social-network can represent trust within that domain [Newman 2003]. For co-authorship networks this implies trust of expertise.

e.g. if two scientists coauthor 10 publications together it is implied that they trust the expertise of the other (relative to that domain).

11. Social Network Algorithms

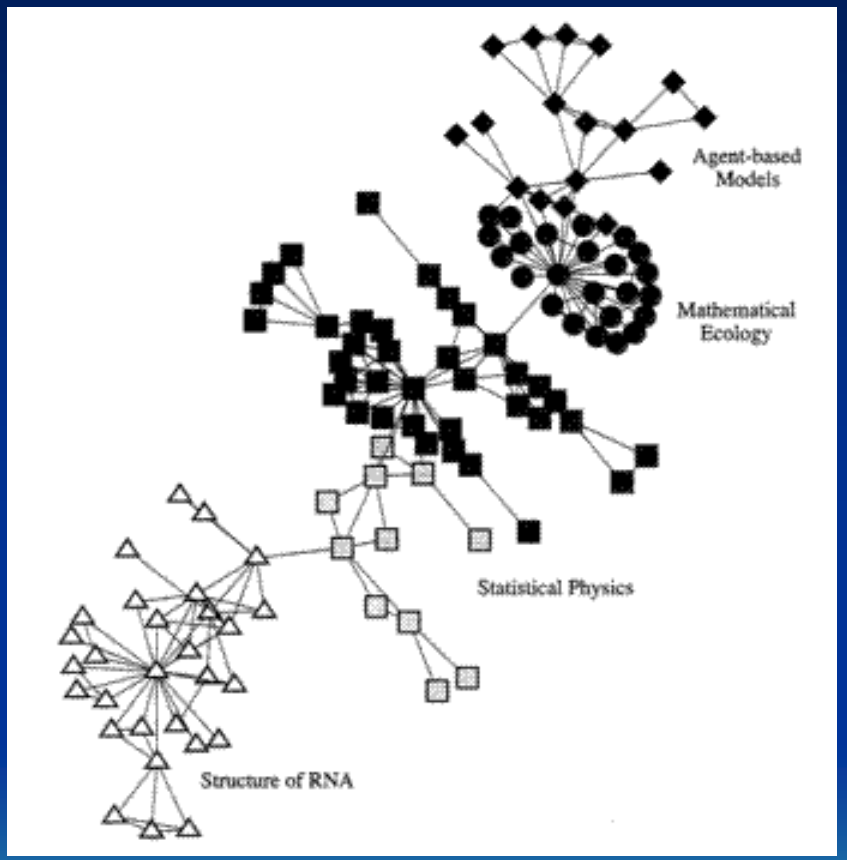
- Identify referees
- Determine an individuals influence in decision-making
- Identify potentially interested members of the community

Parsed coauthorship data has been provided by Mark Newman (Santa Fe Institute) from the entire arXiv pre-print repository as of 2001.

CiteBase has also provided this project a list of over 1million coauthorship links to update the 2001 listing.

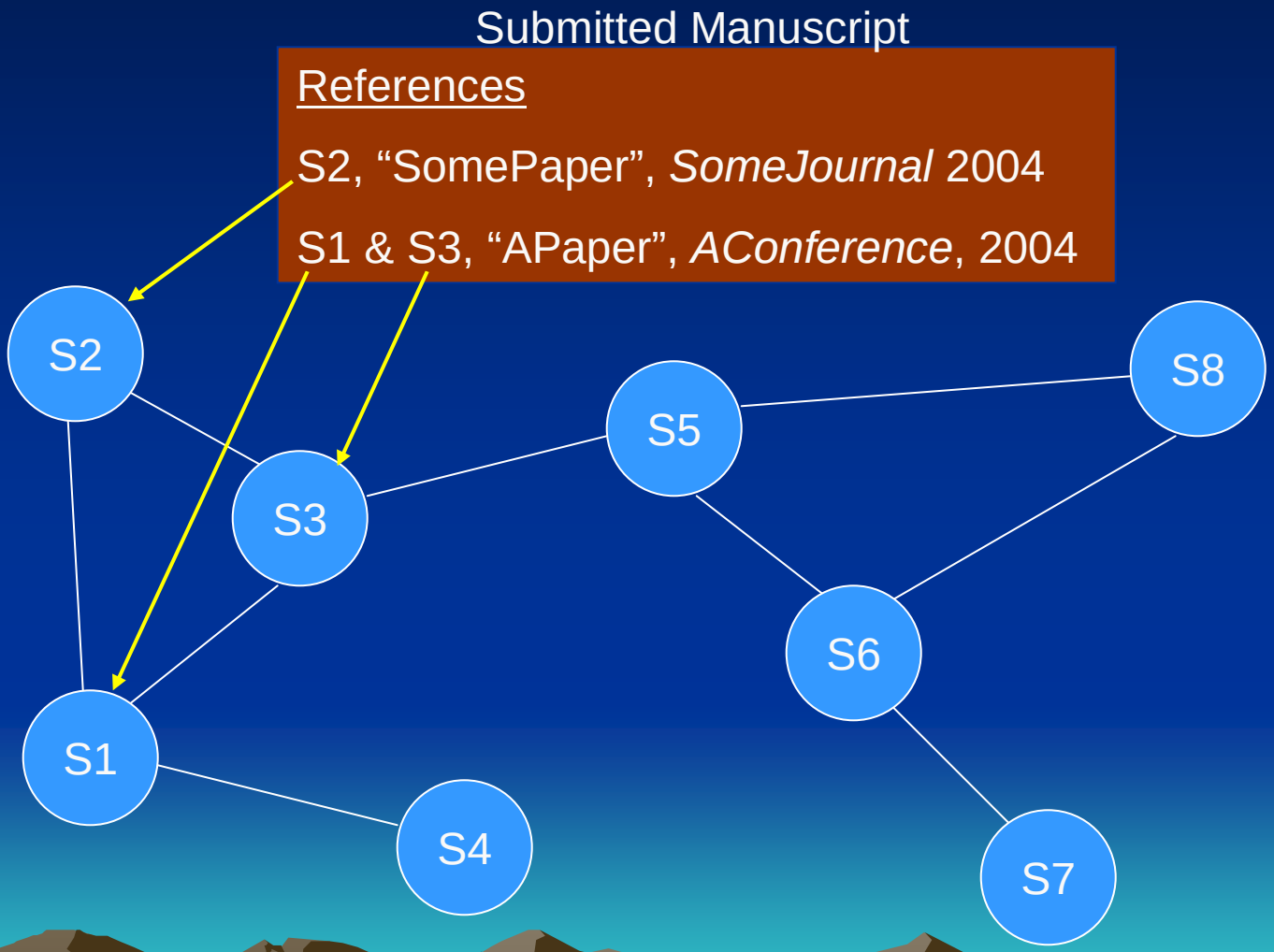
12. Referee Identification

- **Locating referees**: identifying expertise through network structure (cliques). [Newman 2001-2004]



In this way, more referees could be identified (>4) and could potentially contribute to review. Thus reducing requirements of a single individual and increasing the amount of comments.

13. Referee Identification (cont.)



Spreading activation identifies cliques and recurrent areas of the network

14. Experiment #1 (algorithm vs. editors)

- Contact a journal to ask them for previous ‘competency surveys’.
- Use arXiv to gather preprints within that journals domain and run referee identification algorithm.
- Contact potential referees and have them fill out the ‘competency survey’ for that pre-print.
- Statistical T-Tests to determine if the algorithm works better than the editor at identifying competent referees.

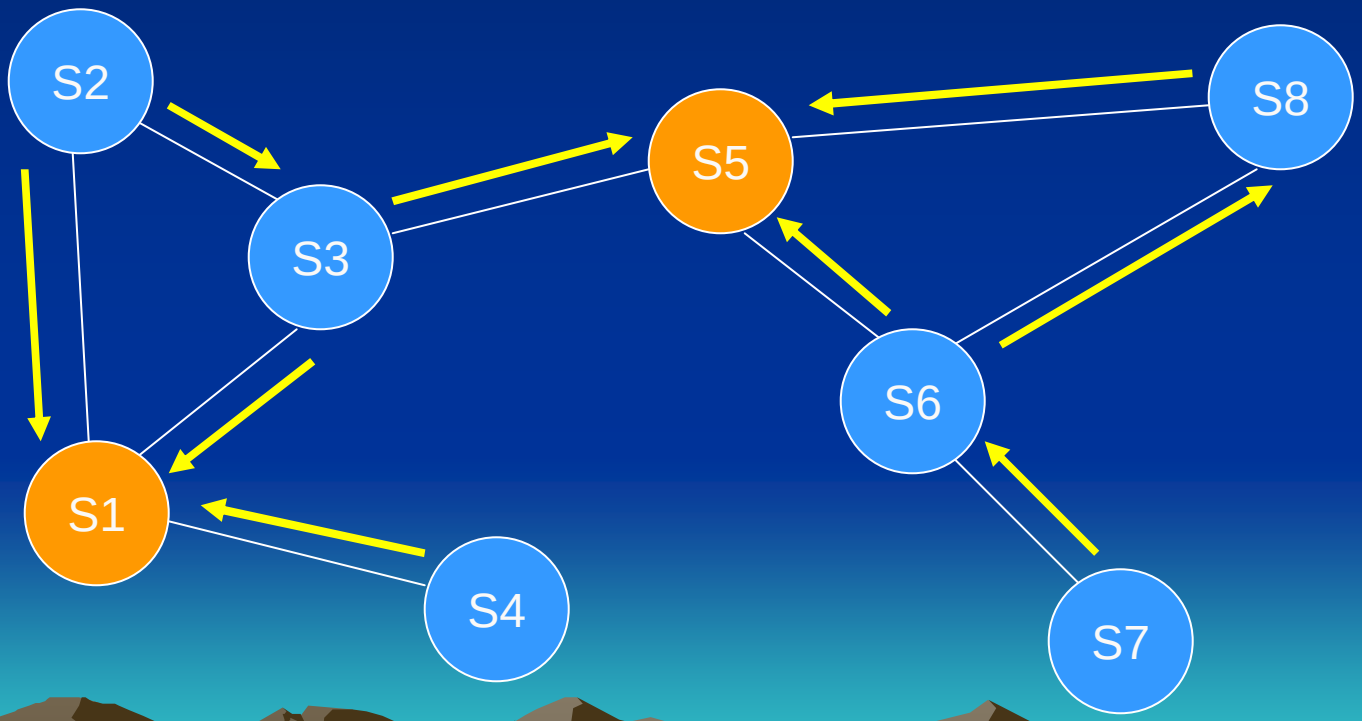
15. Individual Influence

- **Decision-making authority**: Individual centrality identifies trust/expertise within the collective. [Rodriguez & Steinbock 2004a&b]

  With the potential for multiple referees it is important to gauge the relative ‘visibility’ of their comments and ‘weight’ of their acceptance/rejection recommendations.

16. Individual Influence (cont.)

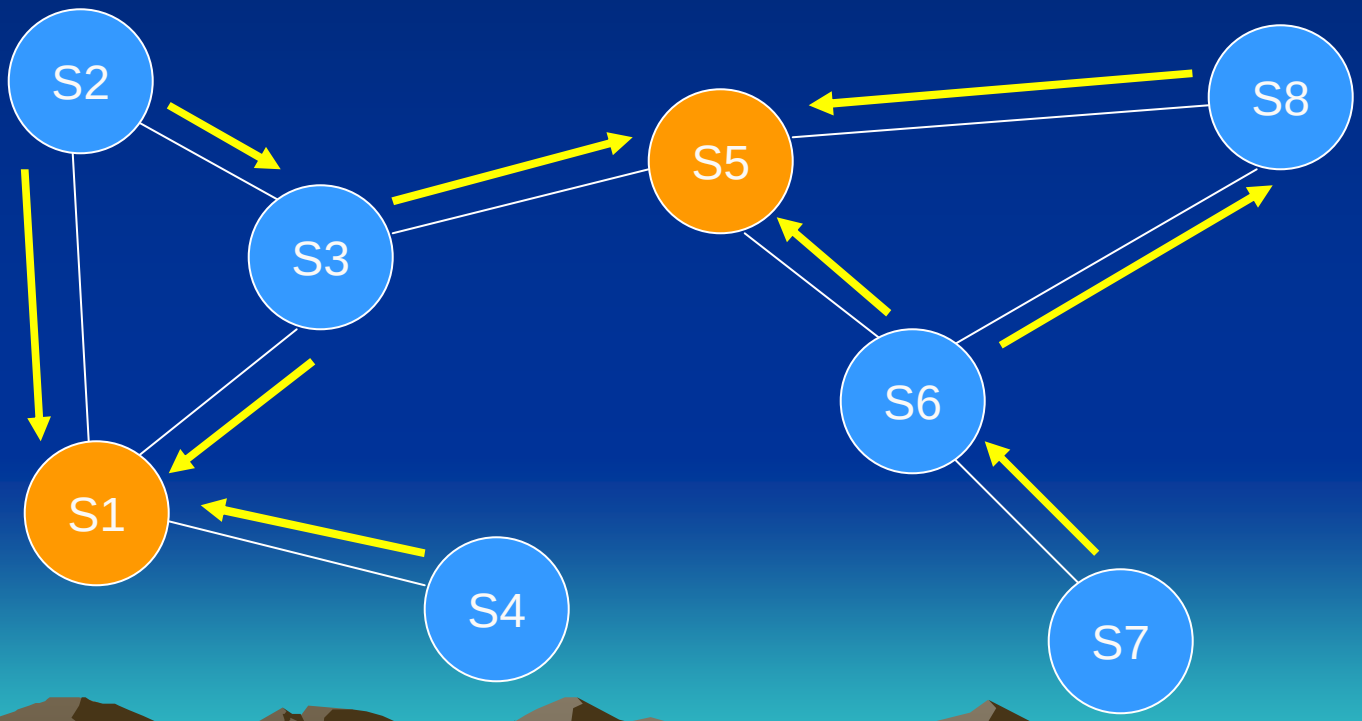
The flow of power to participating members. Power gives ‘visibility’ to comments and ‘weight’ to acceptance/rejection decision-making.



Particle energy goes from source (non-participating) to sink (participating) nodes

17. Individual Influence (cont.)

Biasing the initial populations energy distribution allows the collective decision-making to be biased towards the perspective of the individuals conducting research within the manuscripts domain.

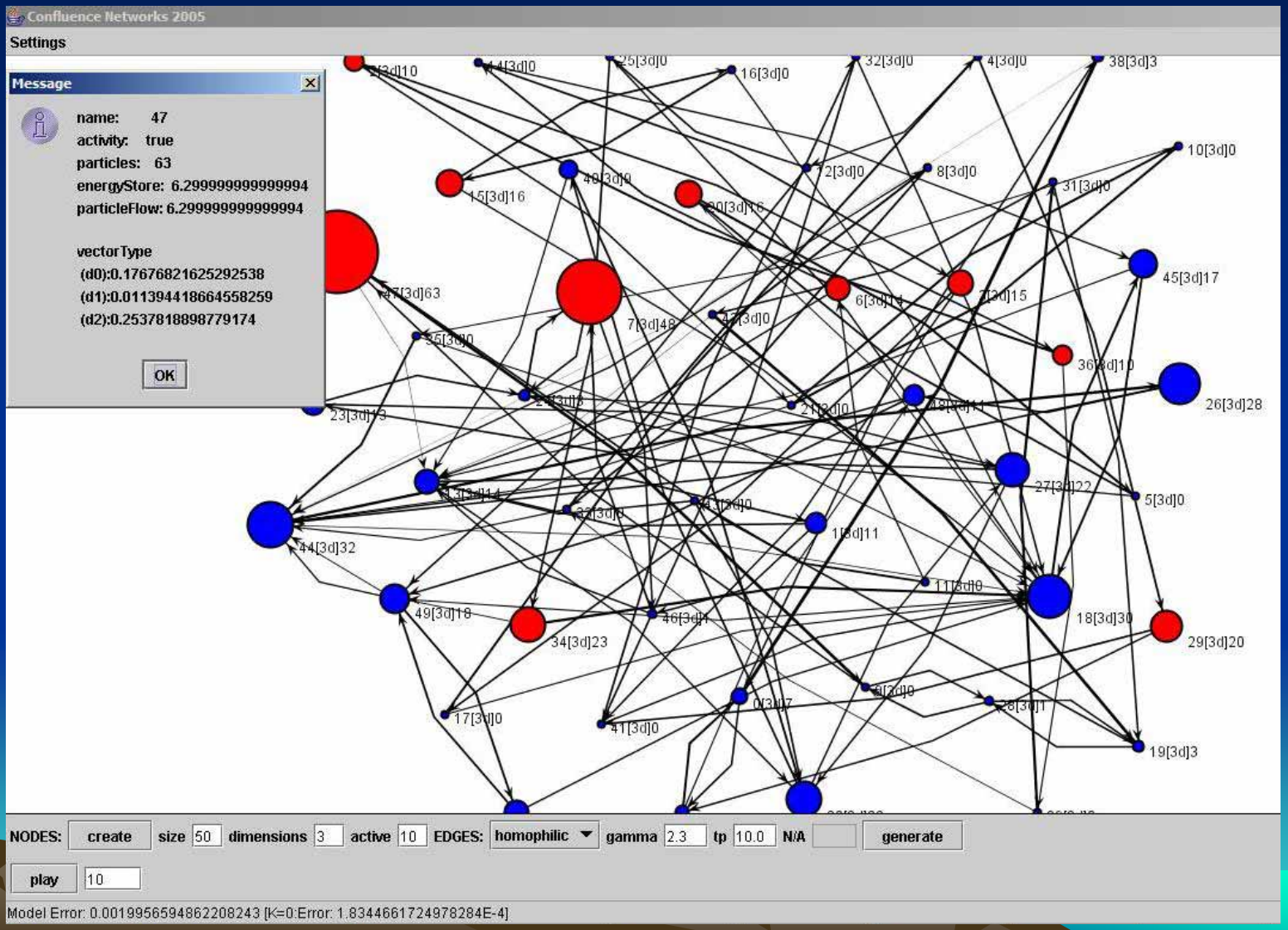


Particle energy goes from source (non-participating) to sink (participating) nodes

18. Experiment #2 (fluctuating participation simulation)

- Select a small domain within the coauthorship network (simulation over a 1000 node becomes computationally intensive).
- ‘Walk the network’ giving the members of the community generated ‘opinions’ that slightly vary over every edge.
- Simulate a decision-making process to determine the error between the decision made by the whole community and the decision made by randomly selected active participants. [Rodriguez & Steinbock 2004]

19. Simulation Package



20. Manuscript Distribution

- **Publication dissemination**: community structure identifies sub-domain groups. Paper ratings (decision ‘score’) can help determine the papers diffusion potential. [Rodriguez *in progress*]

  Information dissemination is about finding the balance between accuracy of mapping and ‘noise’ or randomness to promote the spread of potentially novel of ideas across domains [Van Overwalle, Heylighen, Heath 2004]

21. Experiment #3 (algorithm vs. Google Scholar)

- Gather a massive collection arXiv preprints and run the spreading activation algorithm.
- For a single scientist that has many preprint potentials, go to their website and find keywords.
- Use Google Scholar and gather papers according to the keywords.
- Contact scientist to determine the relatedness of each paper (blind to spreading activation papers and Google Scholar papers)
- T-Tests to determine if the algorithm has a comparable or better level of dissemination accuracy than Google Scholar.

Multi-Agent System Architecture for the ‘Plug & Play’ of Features

22. Multiple System Instantiations

- the peer-review process can be organized in many different ways depending on the desires of the system administrator.
  - dropping in agents into the agent-society to provide particular functionality
  - single agent can serve multiple system (i.e. CiteBase coauthorship agent can provide e-services to multiple systems)
- **Standard**, **Fully-Open**, **Hybrid**
  - Multi-agent system architecture will define an agent-society capable of performing all types of particular instantiations (system-flexibility)

23. Standard

- Automatically identify the top 4 referees.
- Distribute manuscript to referees.
- Gather their comments and distribute to author.
- Gather referee's final acceptance/rejection decision.
- If accepted, electronically publish the paper and run algorithm to automatically solicit interested readers.

24. Fully-Open

- Allow any member in the scientific community to comment and vote on all submitted manuscripts.
  - Collective intelligence approach in that ‘the more-eyes, the less-bugs’ [Linus Torvalds]
- Utilize decision-making algorithm to determine an individuals visibility in the system.
  - The more influential in the domain, the more visible ones comments and the more weight ones decision’s can have.
- Electronically publish the paper if accepted and automatically solicit interested readers.

25. Hybrid

- Allow the 4 selected referees to be ‘influenced’ by the community at large (ie. bias referee who is ‘in tune’ with community)?
- Allow entire community to comment, but only referees to decision-make?
- Allow only scientists in the domain to participate in peer-review?
- Allow for ‘appeals’ to the community at large?

All a matter of ‘tuning’ the agents and permitting some agents into the society as opposed to others.

26. Other Potential Modifications

- **Gradient**: no concept of ‘accept’ and ‘reject’ only that papers have variable dissemination potential through their associated ‘validation’ score.
- **Manuscript-Domains**: with fully electronic system allow multiple types of ‘manuscripts’ (software, video, data, etc.) and/or categories of manuscripts (essays, failed experiments, etc.) [InterJournal, 2001]
- **Collective-Reflective**: allow the community to use the system to decision-make as to the parameters governing their peer-review process [Kiemen, Rodriguez *in progress*]

27. The Thesis Contract

- Problem-domain analysis
  - Huge body of literature devoted to this issue.
- Define and validate the referee identification algorithm, the decision-making authority algorithm, and the publication dissemination algorithm.
- Develop the author identification and paper dissemination software tool for public use by editors and funding agencies.
- Develop the social-network simulation package
- Define the system architecture
  - multi-agent system agent society specification
  - describe methods to get various system instantiations
  - articulate necessary protocols for extensibility

28. Benefits to Science

- Allow the scientific community to become a self-managed publishing organization in order to provide the community with free scholarly work without sacrificing the scrutiny of the peer-review process.
  - Solves many of the limitations articulated: time to print, collaboration, reviewer bias, human time, and cost.
- Algorithms may prove successful in other large-group decision support systems (i.e. open source development).

29. Conclusion

- What about Journal-Impact score? How does such a system effect these ideas?
- What about ‘deconstructed journals’ [Smith 1999] as containers within the journal-less environment?
- The role of AuthorRank and Coauthorship networks [Bollen 2005]
- If social-network are effective mediums for expertise identification, distribution of decision-making power, and dissemination of information then this work may be generalized to other societal-scale social-software systems.

30. Conclusion (cont.)

- Thanks for coming…Good life.