Applying a Socially Inspired Technique (Tags) to Improve Cooperation in P2P Networks

IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART A: SYSTEMS AND HUMANS, VOL. 35, NO. 3, MAY 2005

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MNet Lab Meeting December 30, 2005

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Introduction

- A simple algorithm that use a “tag” model maintains highly cooperation.
- Three models are presented：TagWorld, NetWorld, and FileWorld.
- The technique is scalable, robust ,and decentralized; and it requires no central servers.

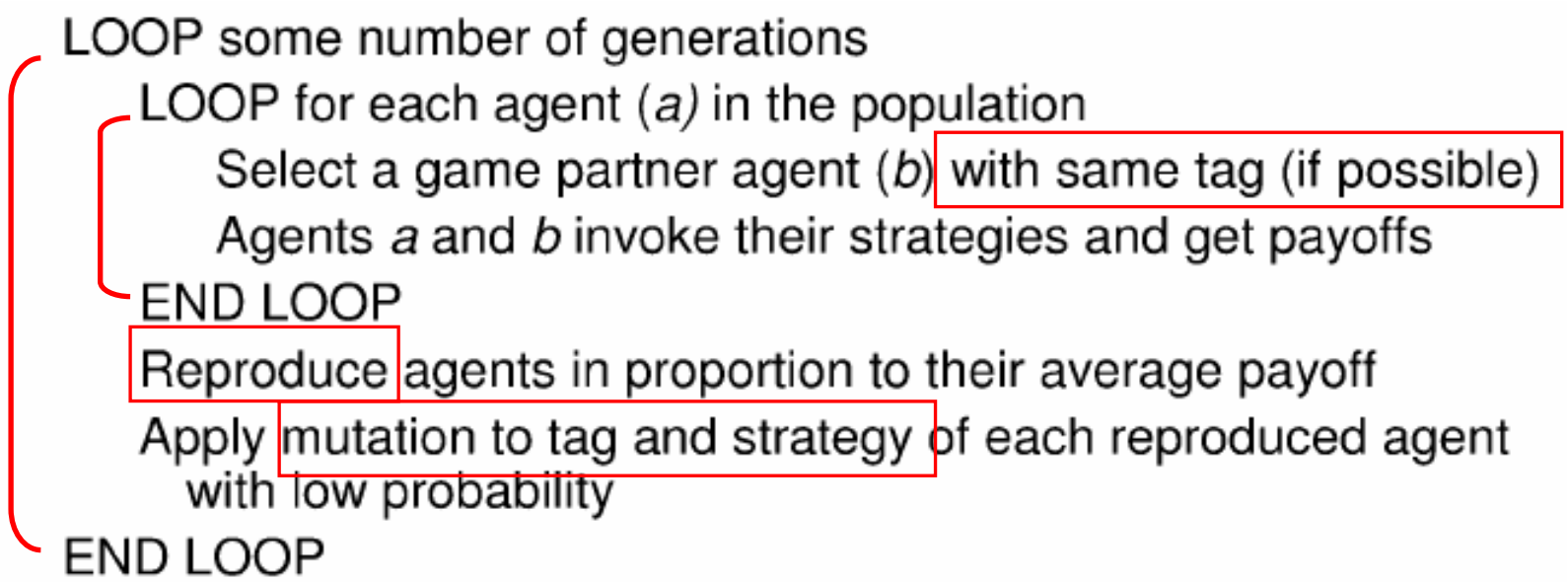
TagWorld

- Tags : cooperate without space or memory
  - Tags are markings or social cues that are attached to individuals (agents) and are observable by others.
- PD (Prisoners' Dilemma)
  - Cooperate (C)
  - Defect (D)
- T =3 (temptation)
- R =2 (payoff)
- P =0 (punishment)
- S =-1 (sucker)
- T>R>P>S
- 2R > T+S

A / B	Cooperate	Defect
Cooper-ate	(2,2)	(3, -1)
Defect	(-1,3)	(0, 0)

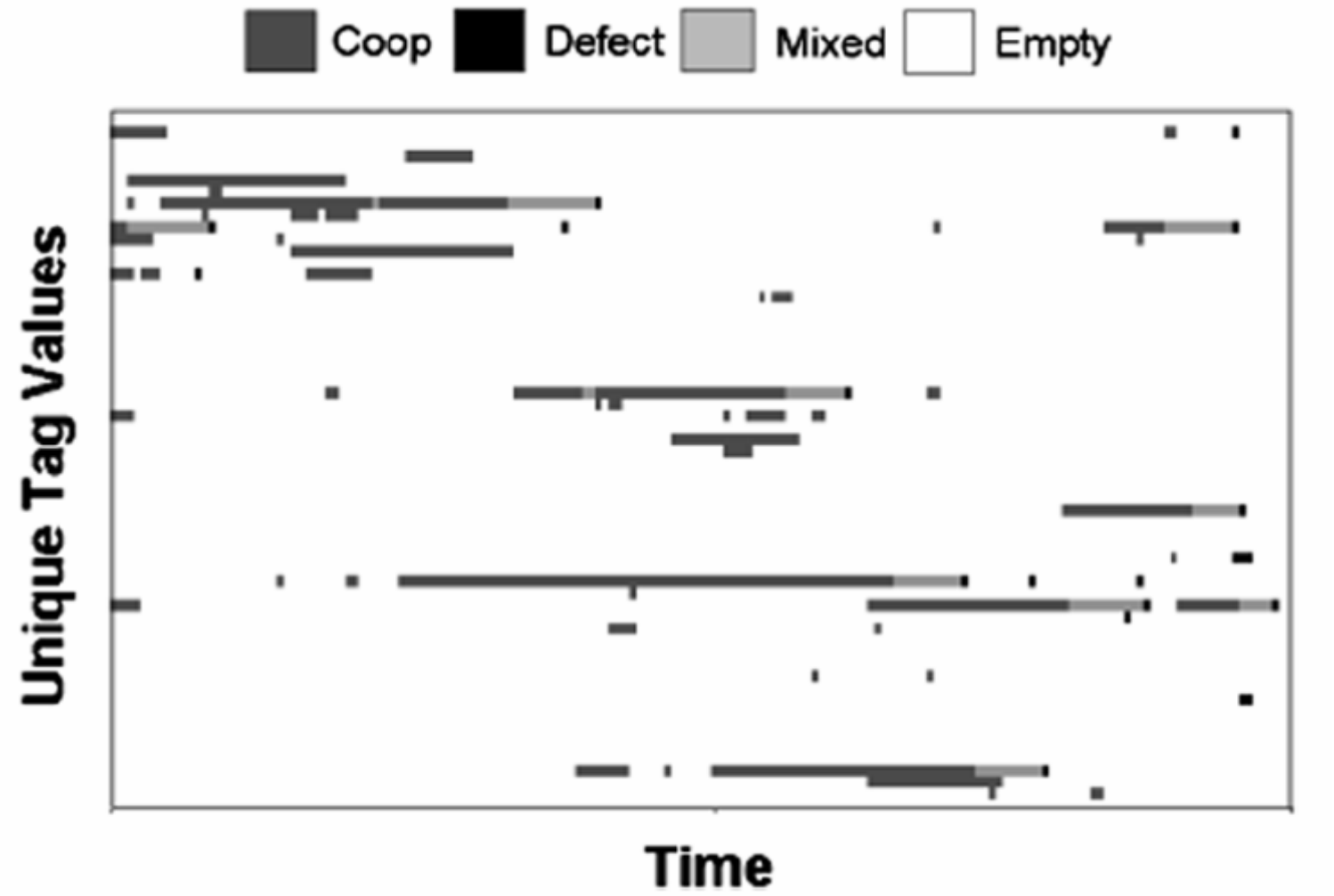
TagWorld - Description

- Each agent is represented by a small string of bits.
  - One is the strategy bit (1→play C 0→Play D)
  - Other bits are the "tag".



TagWorld - Results

T =1.9 ,R=1 ,P=S=0.0001



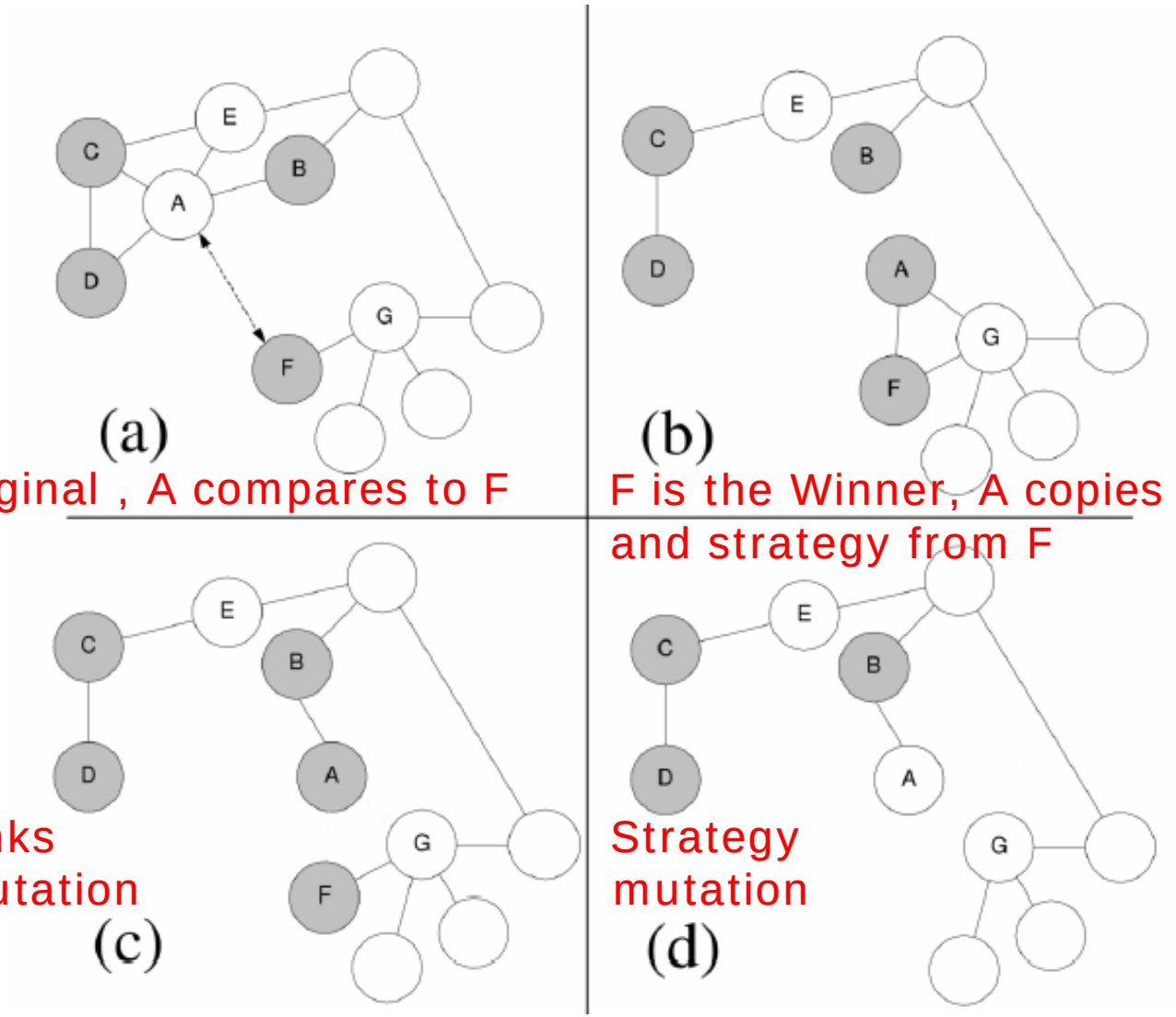
TagWorld - Discussion

- Agents with the same “tag” can be seen as the same “group” or “tribe”
  - A cooperative group will get higher average payoffs than a defect group.
  - C group reproduces more agents than D group.
  - If tag were removed, then all group became D group.
- A selfish agent in a C group will get huge payoffs.
  - It will reproduce many copies of itself.
  - The group is dominated by the newly D agents.
  - The agent destroys its group very quickly.

NetWorld - Description

- From Tags to Networks
  - Consider a P2P network, each node has some neighbors.
  - The link between two nodes is symmetric.
- How is the “tag”?
  - Each node in the P2P network maintains a neighbor list table that is something similar to tag.
- ERA (Evolutionary Rewiring Algorithm)
  - In NetWorld, nodes don’t reproduce.
  - Using ERA will copy strategy and “tag”.

NetWorld - ERA



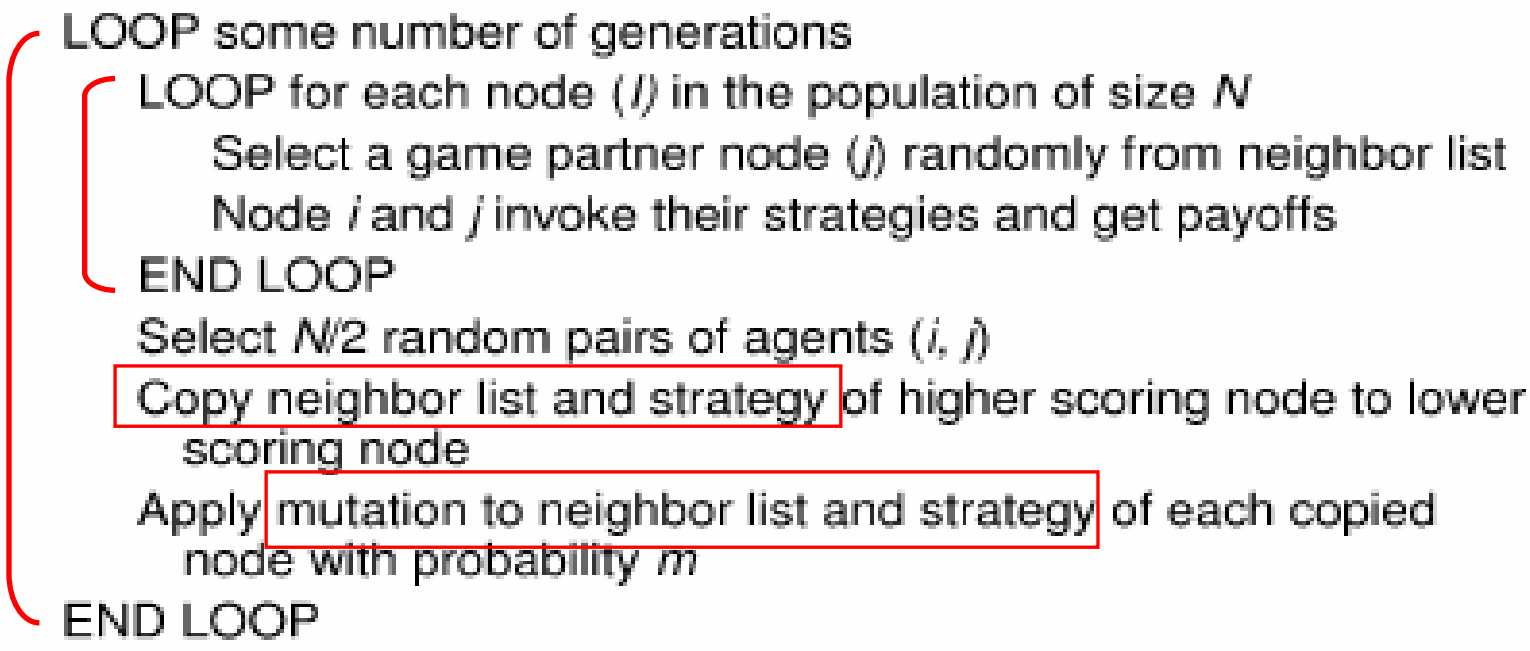
Original , A compares to F

F is the Winner, A copies links and strategy from F

Links mutation

Strategy mutation

NetWorld - pseudo code



- There is a little bit difference from Tag to Network
  - Tag (neighbor list) needn't be the same.
  - Groups may have overlap, and boundaries are not absolute.

NetWorld - Results

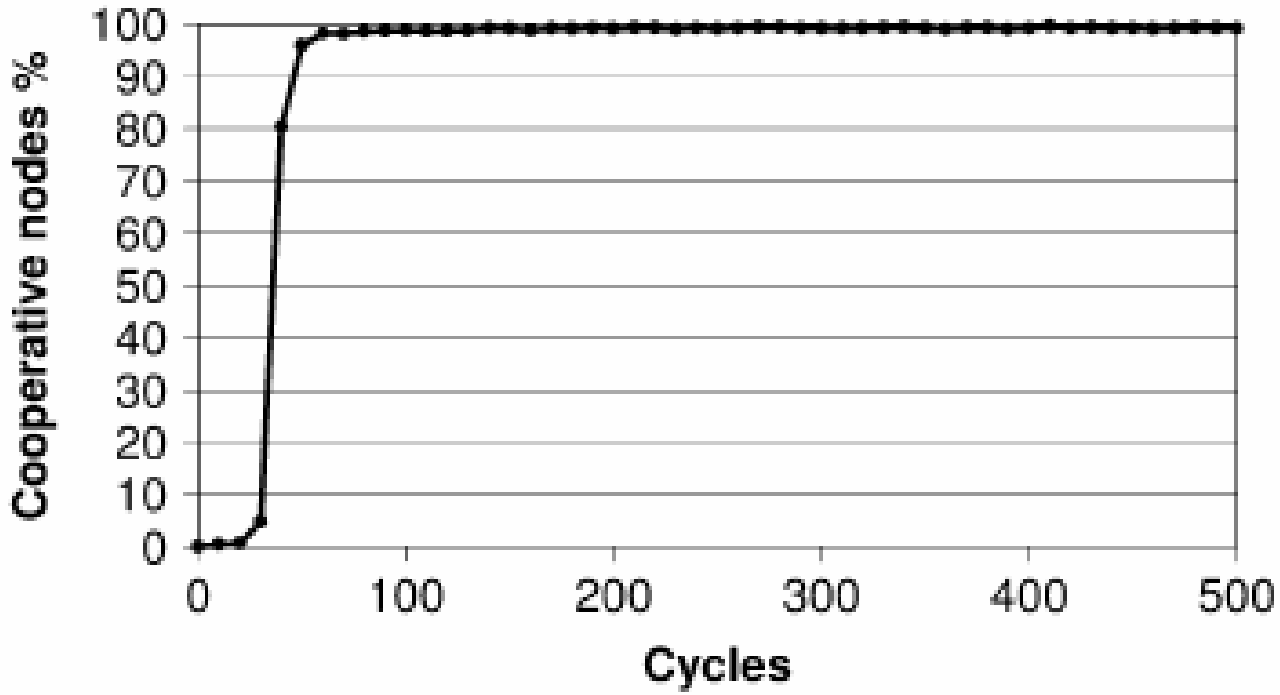


Fig. 6. Shows a typical NetWorld time series ($N = 10\,000$ nodes) giving the percent of cooperative nodes at each cycle.

NetWorld - Results

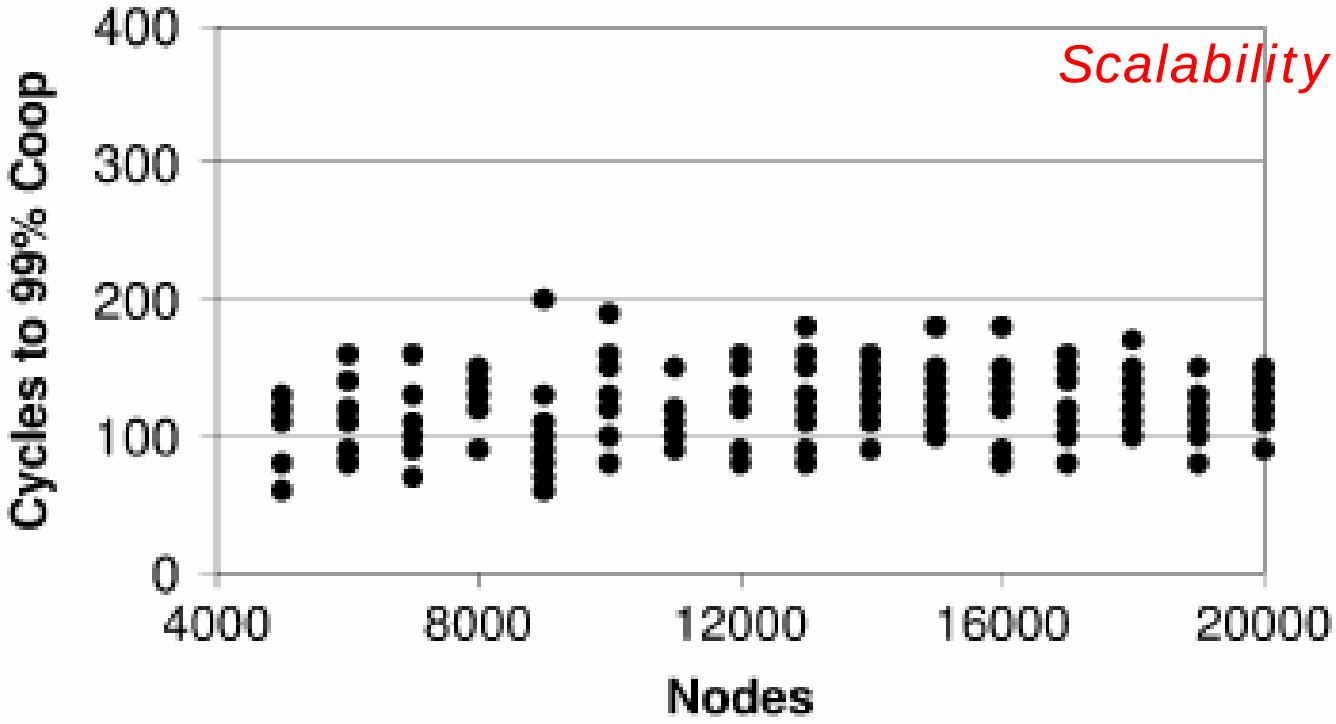


Fig. 7. Number of cycles before 99% of nodes are cooperative for various values of N in NetWorld. Each dot is an individual run.

FileWorld - From PD to File Sharing

- Consider a flooding based P2P system.
  - Nodes periodically generate queries to neighbors, and neighbors will do one of the three reactions:

    “Hit” “Forward” “Ignore”

- Modify of nodes
  - Each node i ,has an answering power Ai and a questioning power Pi ,and capacity Ci.
  - Ai and Pi are real values in the range [0,1]

FileWorld - Nodes

- Parameters – Ai, Pi, Ci
  - Ai：a probability that the node can produce a “hit” to a query.
  - Pi：the utility of generate queries
    - The capacity was divided into two parts.
    - Pi * Ci：generates new queries
    - (1-Pi)*Ci：reserved to handle queries
  - If a node receives a query and there is no reserved capacity, it will “ignore”; otherwise ,it will “hit” or “forward” depending on Ai.
  - Using Pi to show that how selfish the node is.
    - If Pi=1, it uses all capacity to generate new queries.
    - If Pi=0, it uses all capacity to process queries from neighbors.

FileWorld - Adapted ERA

- Utility - total number of hits obtained by a node in the time period
  - N/2 pairs of nodes are selected from the population randomly.
  - Node i compares to node j
    - If Ui > Uj, then node j drops all existing links and copies node i's links and additionally links to node i itself. And set Pj = Pi
- Mutation
  - With probability m, Pi is changed to a random value between 0 and 1.
  - With probability 10m ,node i will replace a link from the population.

FileWorld - Simulation Environment

- Initial value
  - Ai=0.4(fixed) , Ci=100, Pi will be adapted by node
  - TTL = 3
  - Maximum degree of a node is 20. A new link will replace a existing link.
- Fired node - approximate reality
  - Nodes selected randomly from population are “fired” nodes.
  - If the node still has the capacity ,it generates one query ,or does nothing.

FileWorld - Metrics

- nq , nh
  - nq：average number of queries per node generates in a cycle.
  - nh: average number of hits per node generates in a cycle.

- Baseline
  - Without ERA, nq=49.45 and nh=20.13

FileWorld - Results

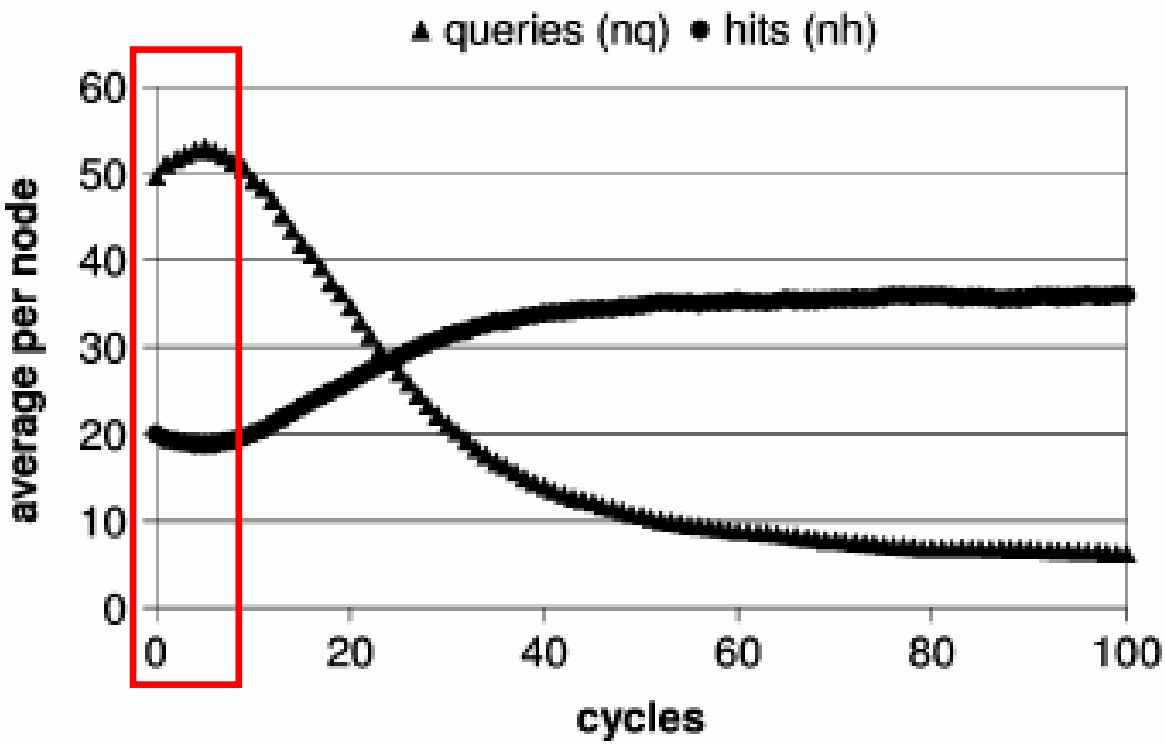


Fig. 8. Typical run for a 10^4 node network. Notice that nq and nh values initially get worse than the baseline values ($nq \approx 50, nh \approx 20$) but then quickly improve.

FileWorld - Results

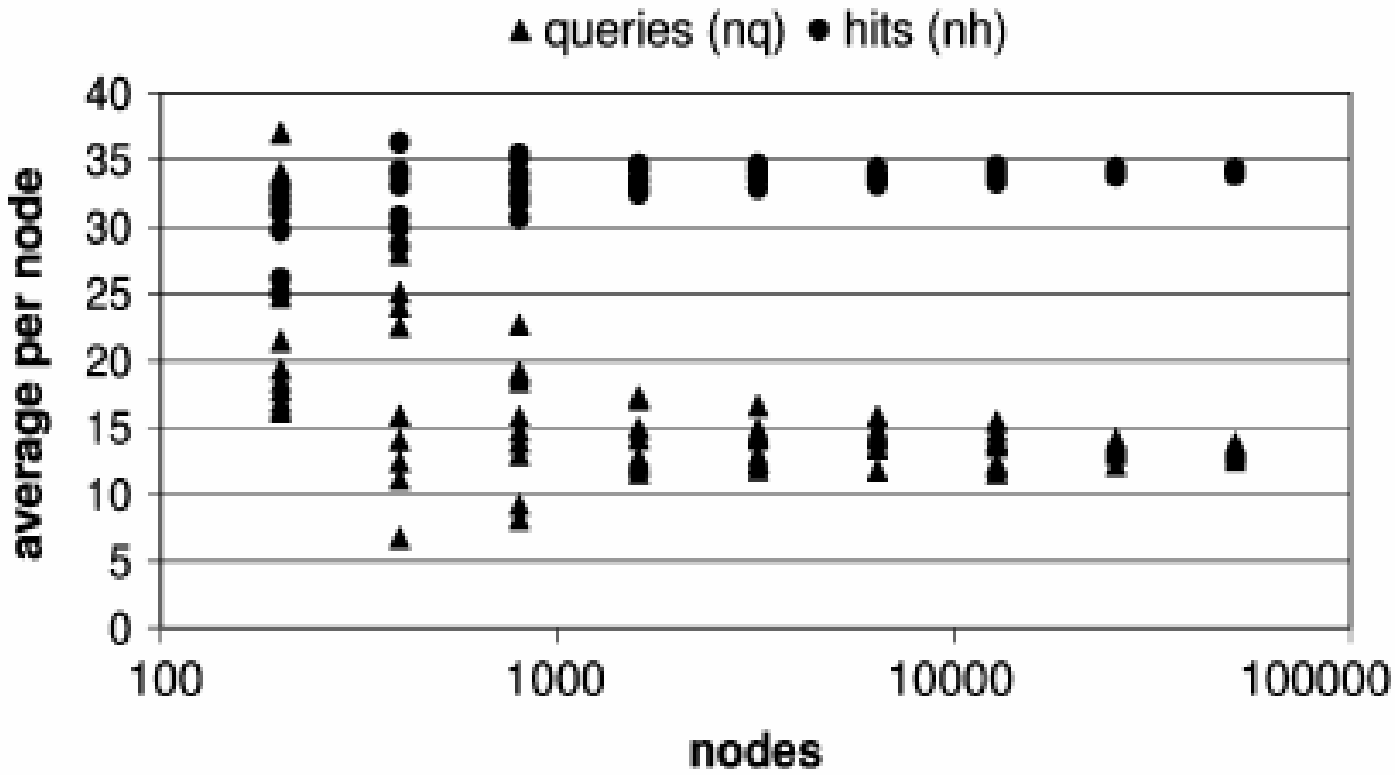


Fig. 9. Values of nq and nh (averaged over cycles 40..50) for different network sizes. Ten independent runs for each network size.

FileWorld - Results

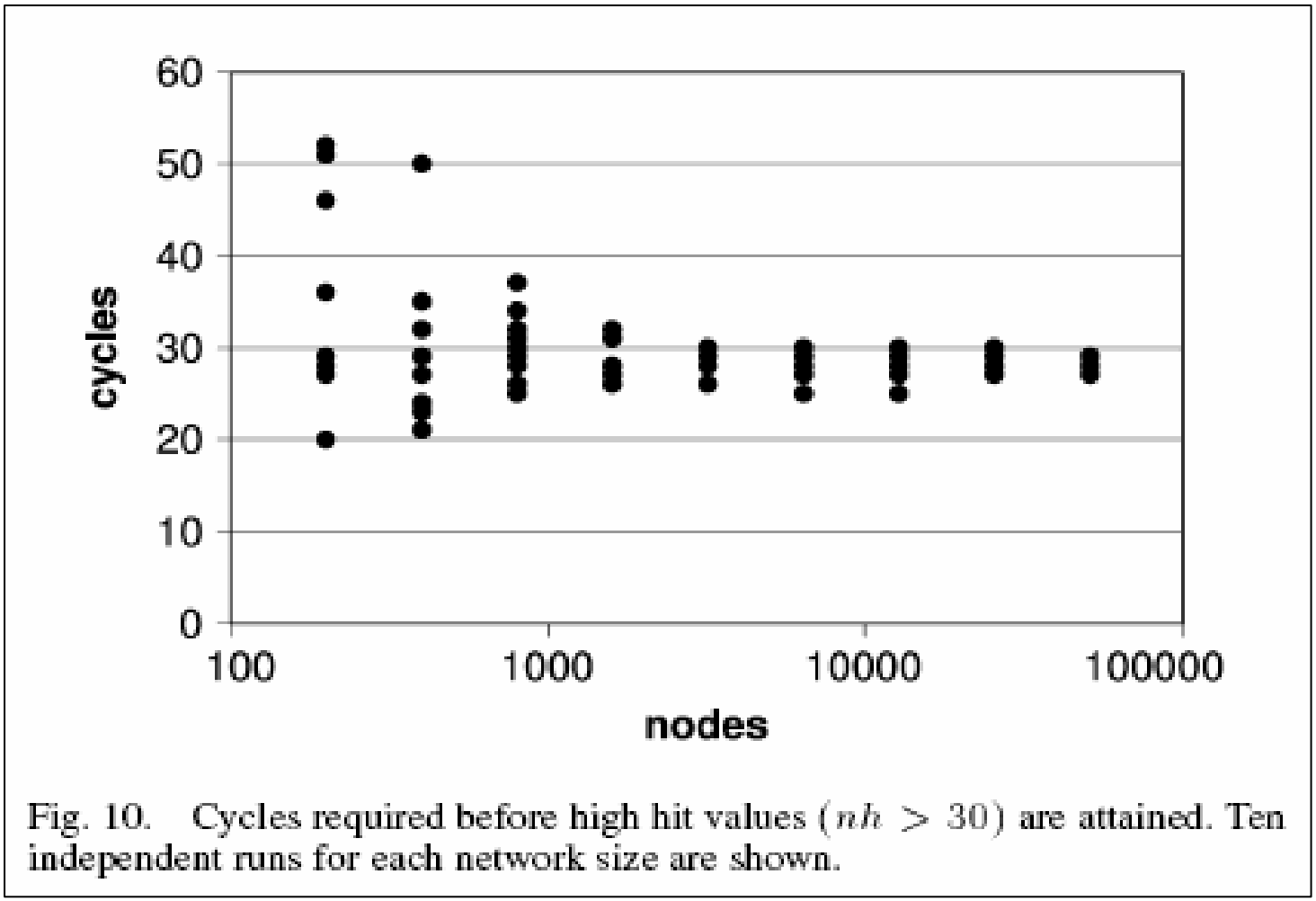


Fig. 10. Cycles required before high hit values ($nh > 30$) are attained. Ten independent runs for each network size are shown.

Comparison

Model	TagWorld	NetWorld	FileWorld
Tag	bit strings	neighbor list	neighbor list
Score	PD game	PD game	Utility
Re-production	copy itself	movement (learning link & strategy)	movement (learning link & Pi)
Mutation	tag & strategy bit	clear the neighbor and + 1 random node & strategy bit	replace a link & Pi

Conclusion & Future work

- ERA is an effectively incentive algorithm, and a very selfish node will lose neighbors quickly; therefore, the node will copy behavior of his neighbor who has high utility, and ERA achieves cooperation.
- Open issue
  - Utiltity
  - Reproduction
  - Non-adaptive agents

Discussion

- A process of thought
  - PD → Tag → Network → File (P2P)
- A special concept of group
  - Same behavior nodes
  - Learning
- Not complete & problem
  - Answering power Ai should be different by each node.
  - File structure is not implemented.
  - Network topology changes rapidly.