The SLACER Algorithm

Stefano Arteconi

Dipartimento di Scienze dell'Informazione
Università di Bologna

Outline

- Cooperation in P2P Networks
  - Prisoners' Dilemma
- Slacer Algorithm
  - Sociological Inspiration
    - Tag Systems
  - Description
  - Performances

Cooperation in P2P

- P2P Networks
  - Decentralized
  - No central control
- Possibility to *free-ride*
- Act selfishly
  - Improve own performances
  - Degrade global performances
    - Leechers in a file sharing system

An Abstract Model: The Prisoners' Dilemma

Player 1 \ Player 2	C	D
C	R:3, R:3	T:4, S:0
D	S:0, T:4	P:1, P:1

- Tragedy of commons
- Both *C*
  - Higher total payoff
- At least one *D*
  - *D* gets the better payoff
  - Lower total payoff

- PD constraints
  - $T>R>P>S$
  - $2R>T+S$

Tag Systems

- Originate in Computational Sociology (Holland 1992)
- Tags are observable “markings
  - Hairstyle, Dress, ...
- Tags evolve just like any other artificial gene
- Limiting interactions between agents with similar tags leads to cooperative altruistic behaviour

Tag Systems' Agents

- Agents characterized by
  - Tag
  - Behavior
  - Utility
- Main agents features in tag systems
  - Interaction restricted to agents with similar tag
  - Selfish optimization through copy of tag and behavior of better performing agents
  - Periodic mutation of tag and behavior

From Tag to P2P

- Agents represented by nodes
- Tag represented by set of neighbors (view)
  - Interaction between neighbors
- Behavior
  - Application level behavior (i.e. share files or leech files)
- Utility
  - Evaluated at application level (i.e. number of files downloaded)

SLACER Algorithm

SLACER Outline

- Attempt to translate Tag Systems in P2P networks
- Nodes perform application task
  - Get utility value
- Strategy and Neighborhood of better performing nodes are copied

Network Evolution

- Nodes move to find better neighbors (higher utility)
  - Network topology evolves
- Group-like selection between clusters of nodes
  - Cooperative nodes group and spread
  - Selfish nodes become isolated

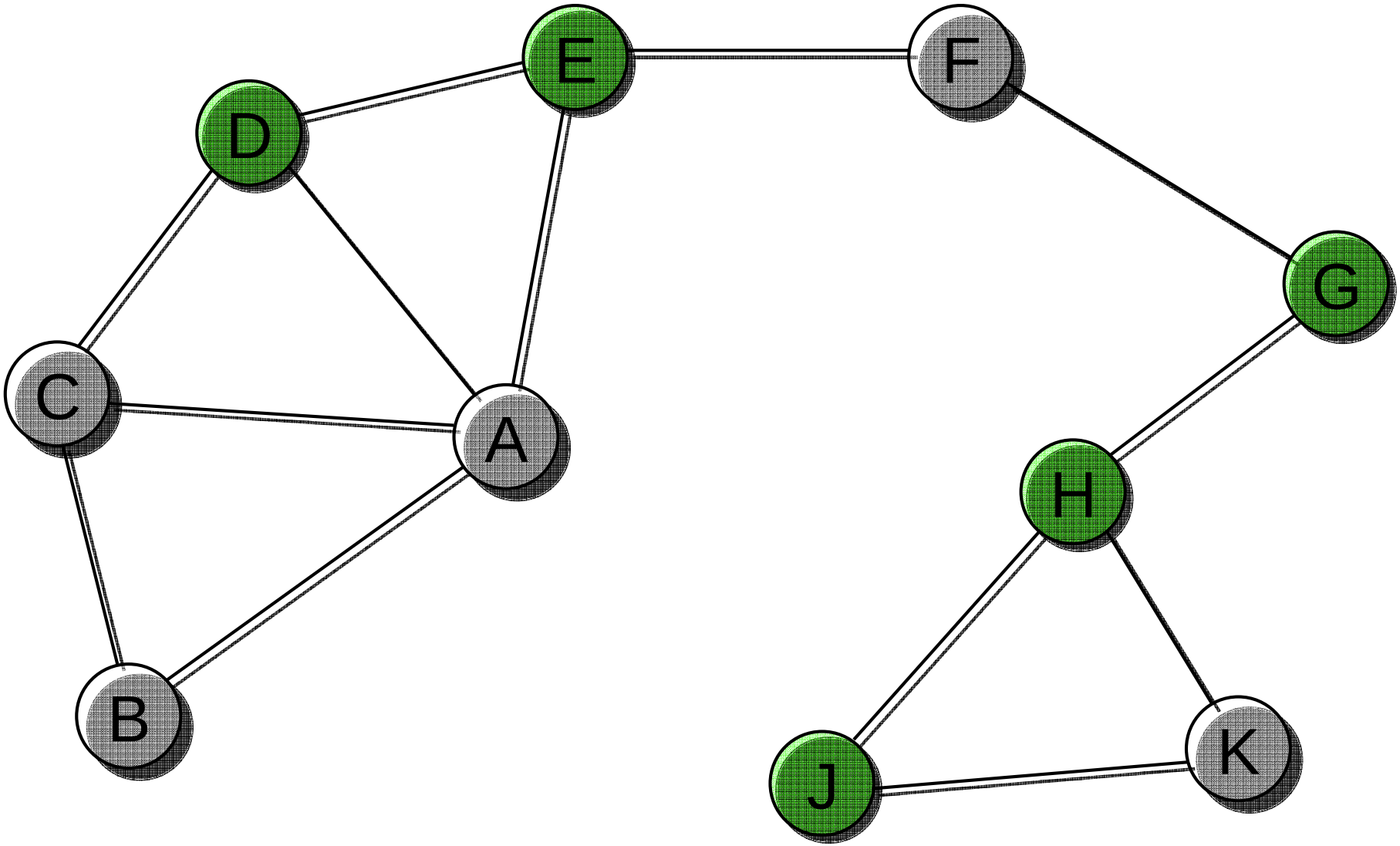
SLACER Pseudocode

Node *p* periodically executes the following:

q = SelectPeer()
if $\text{utility}_q > \text{utility}_p$
    drop each current link with probability *W*
    link to node *q* and copy its strategy and links
    mutate (with low probability) strategy and links
fi

Peer selection based on a random overlay network (newscast), whereas *copying*, *rewiring* and *mutating* are with respect to an application (strategy) over an “interaction network”

SLACER: Copy and Rewire



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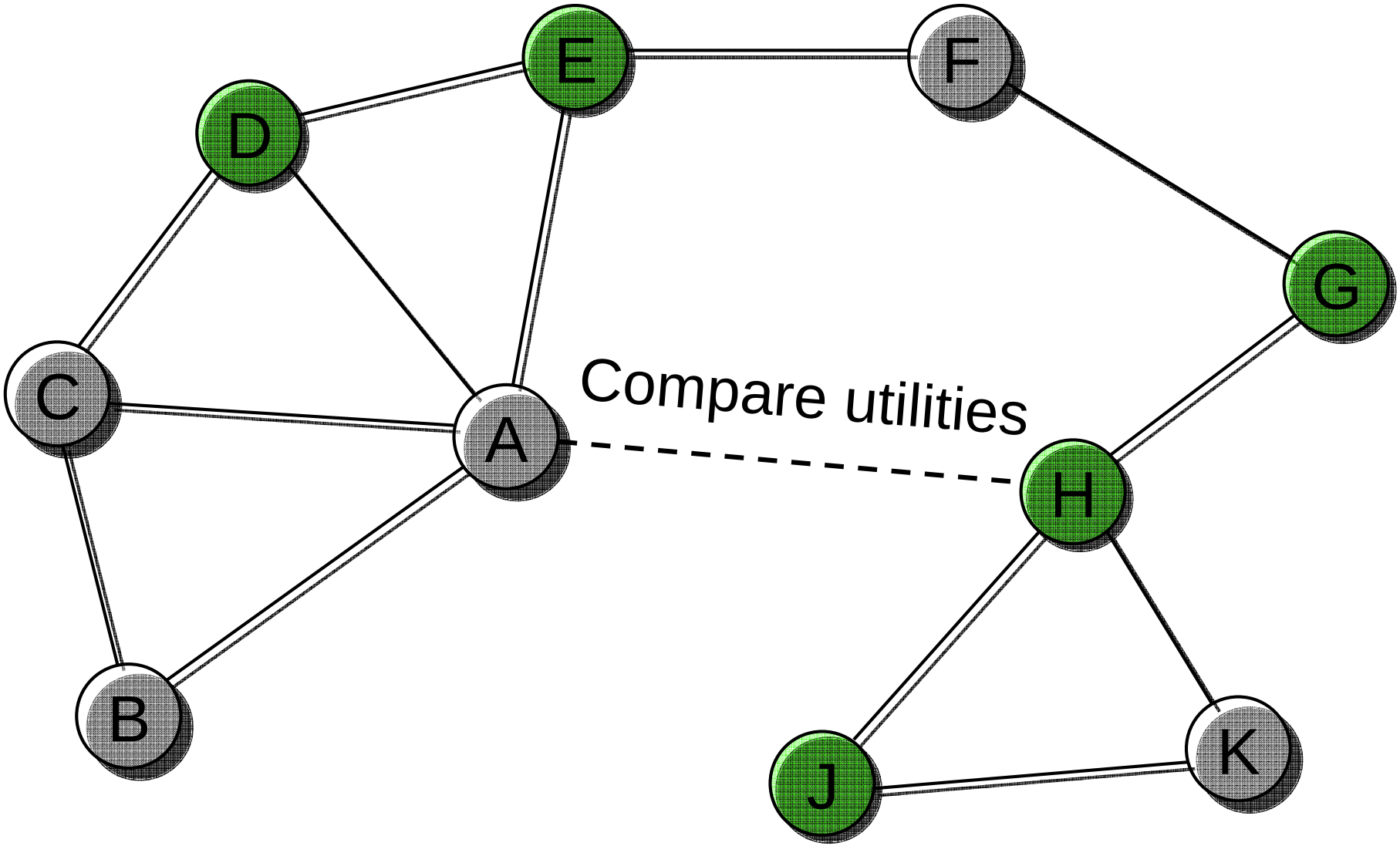

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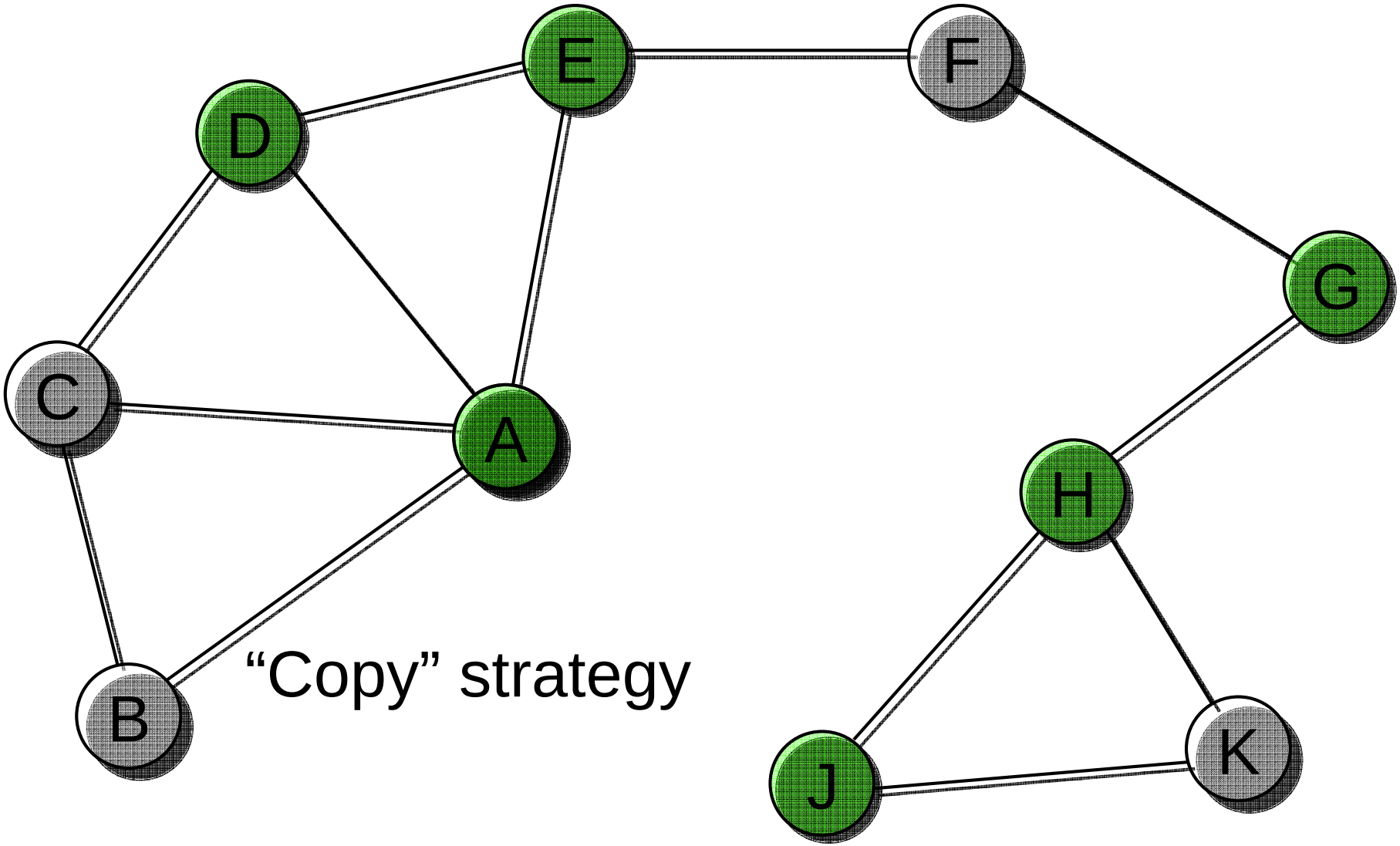
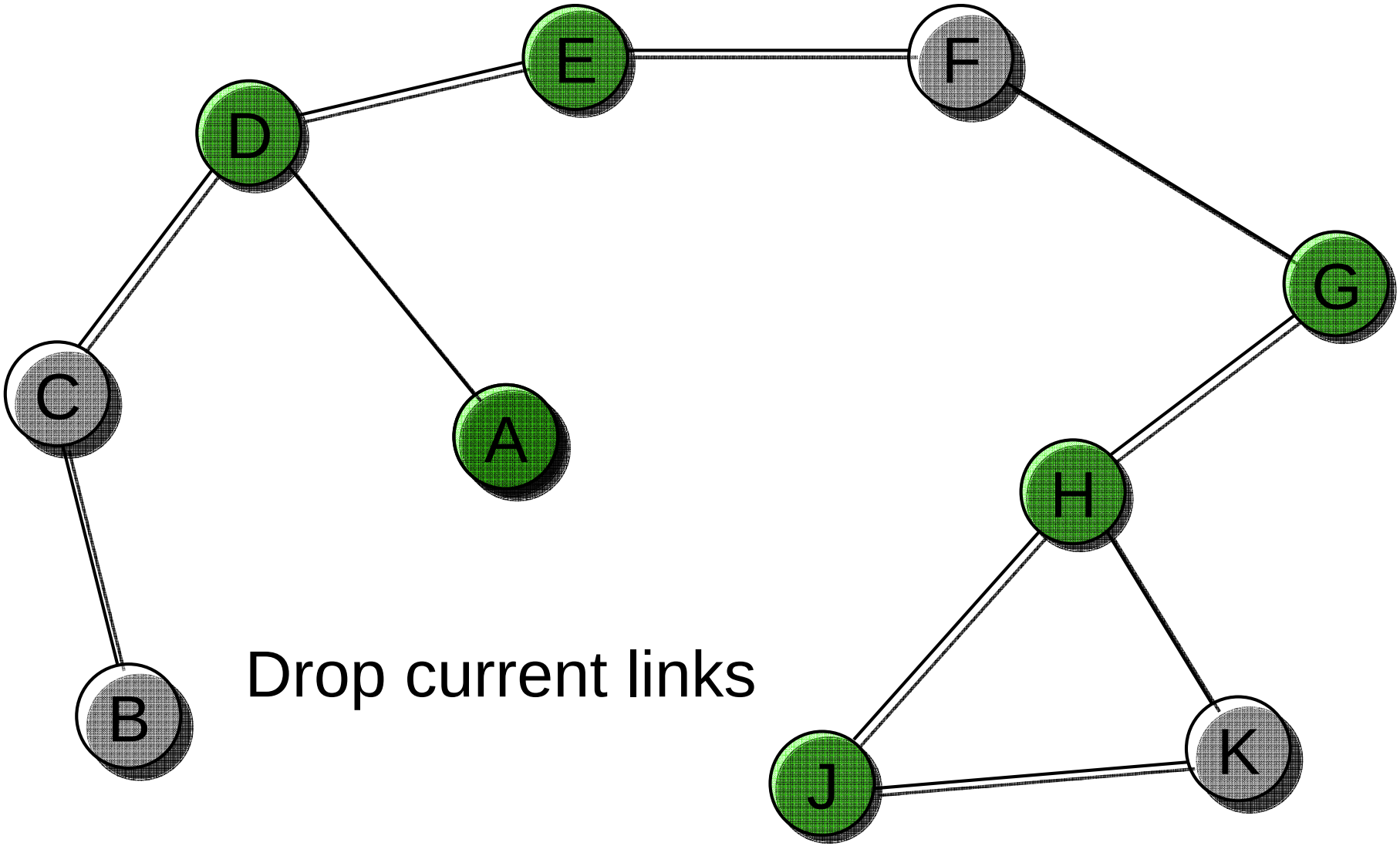
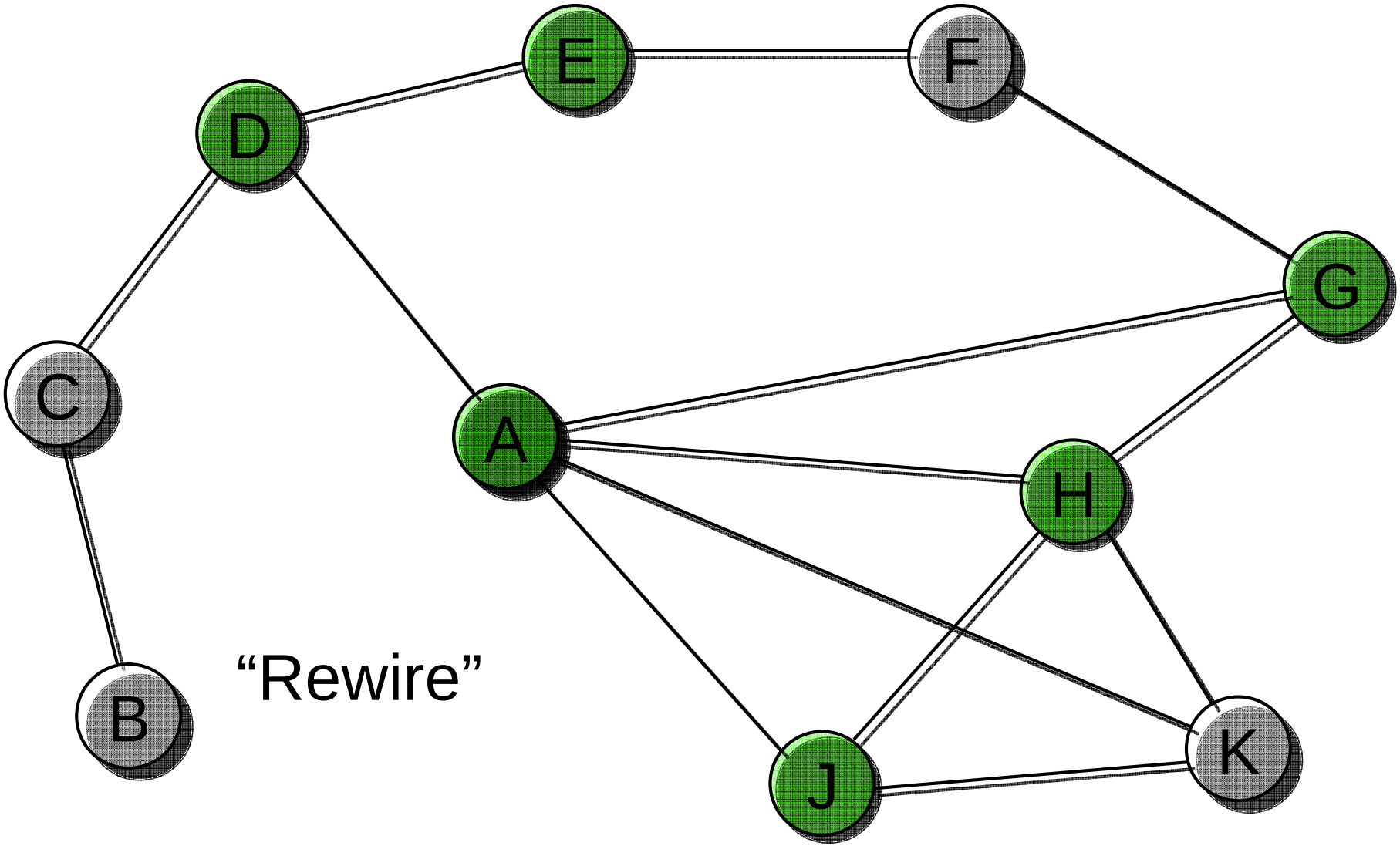


"Copy" strategy

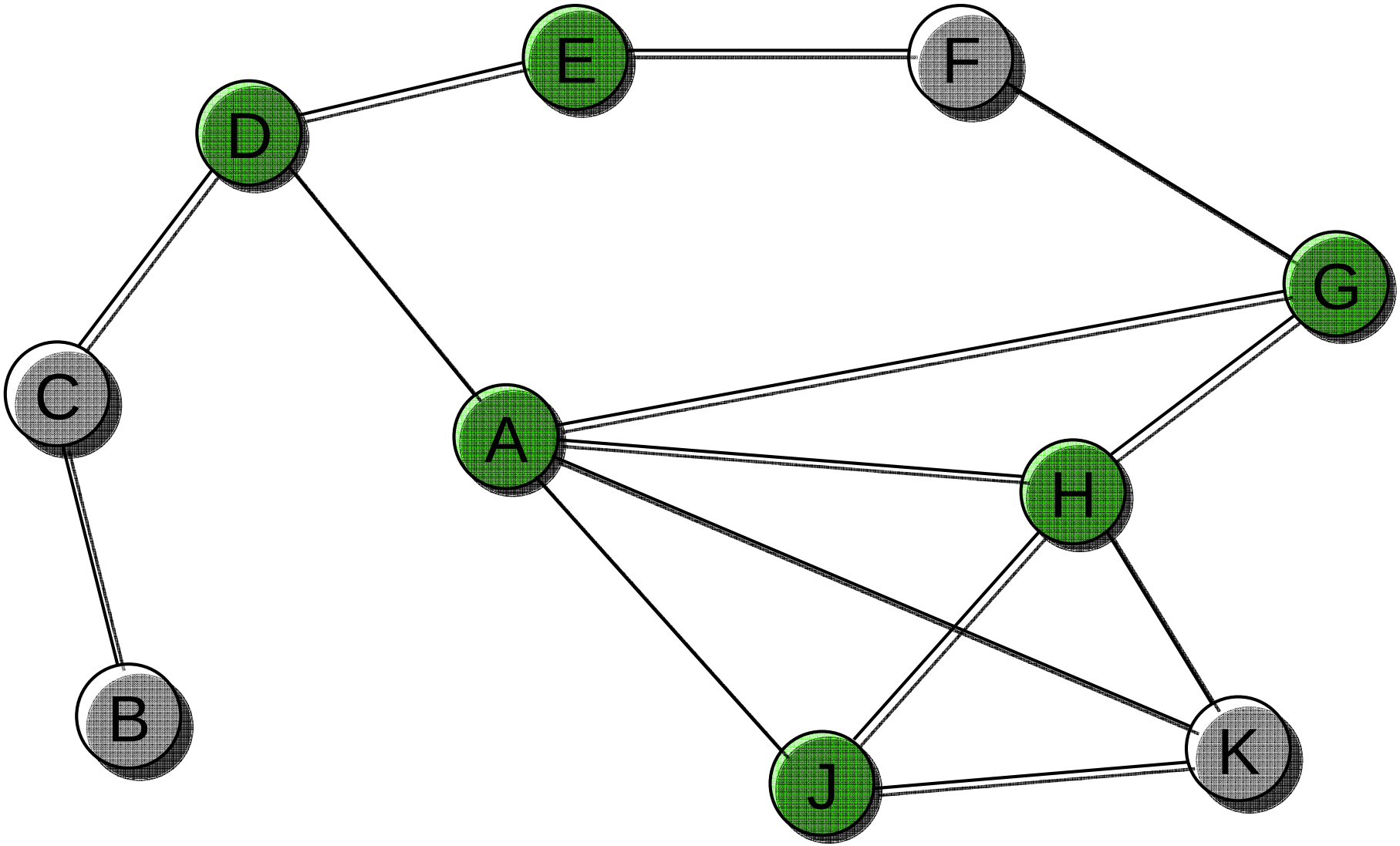
SLACER: Copy and Rewire



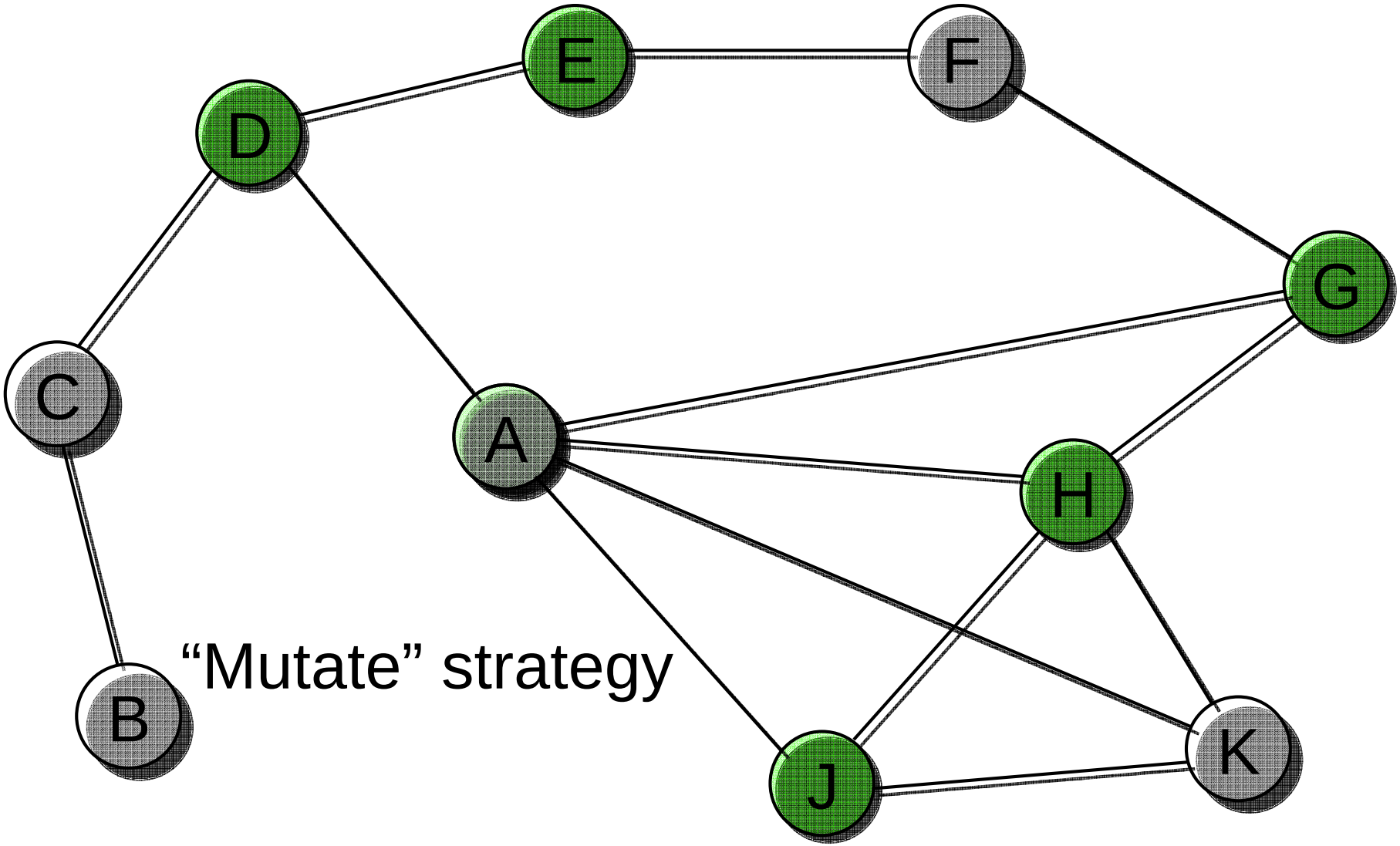
SLACER: Copy and Rewire



SLACER: Mutate

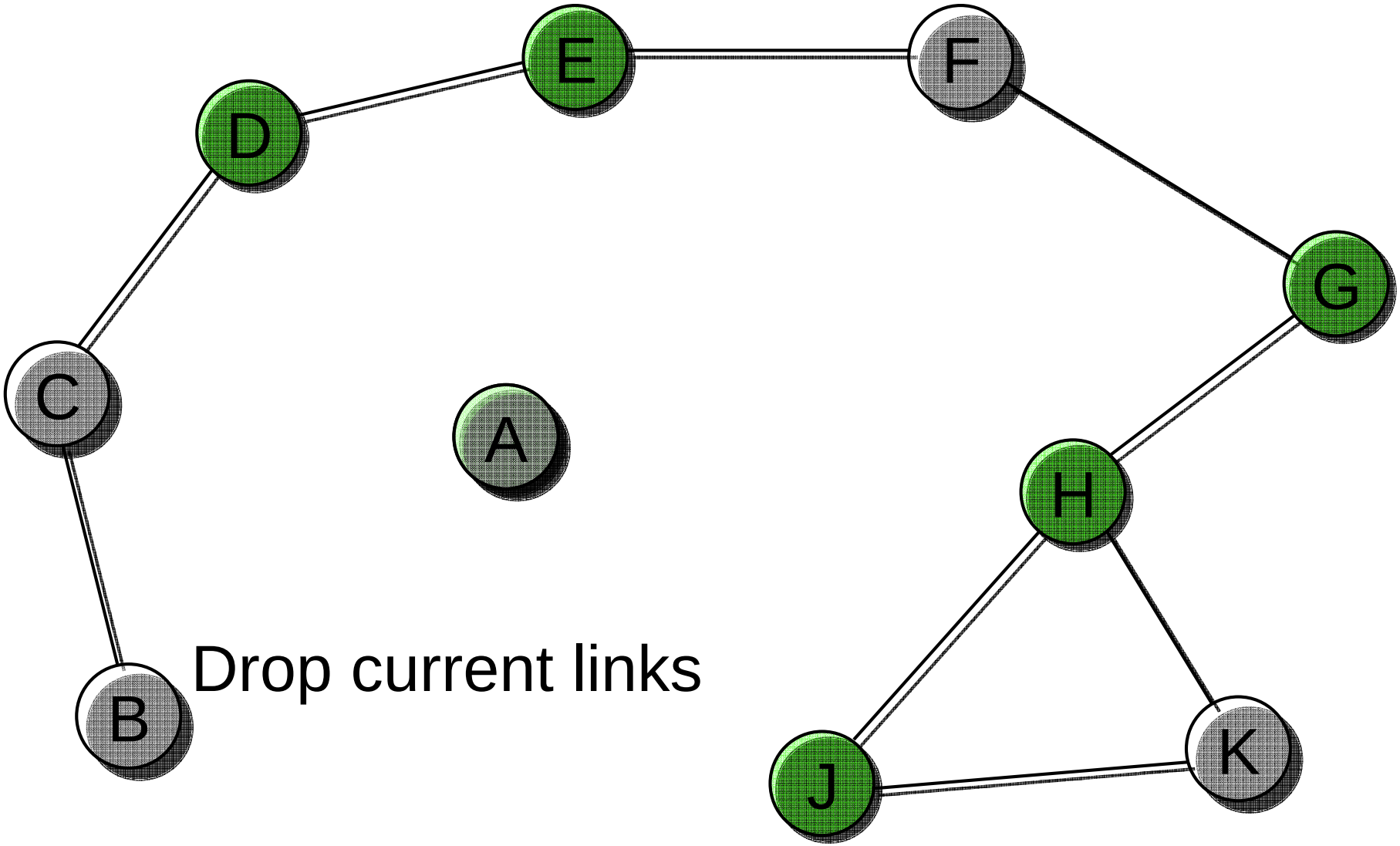


SLACER: Mutate



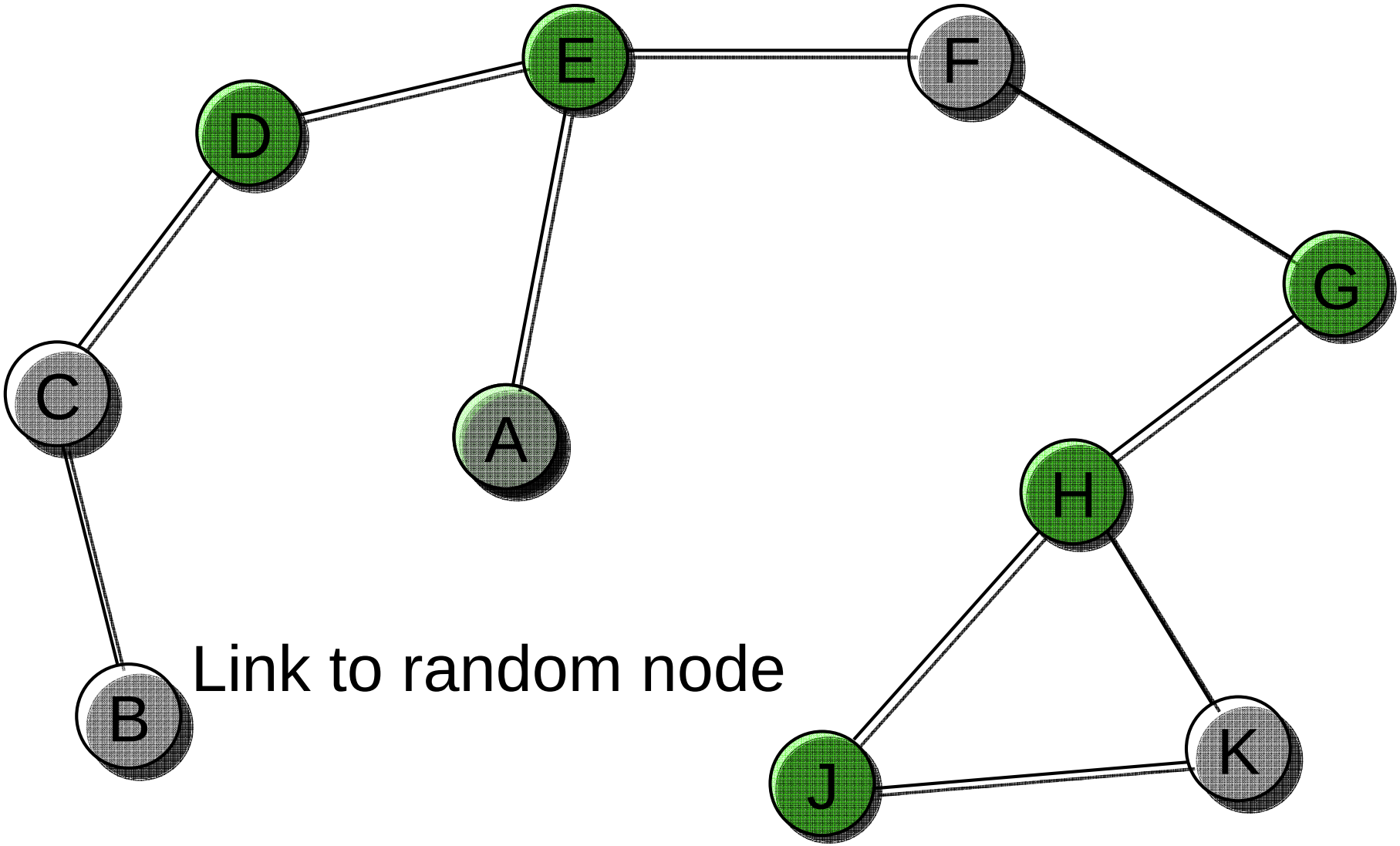
"Mutate" strategy

SLACER: Mutate



Drop current links

SLACER: Mutate

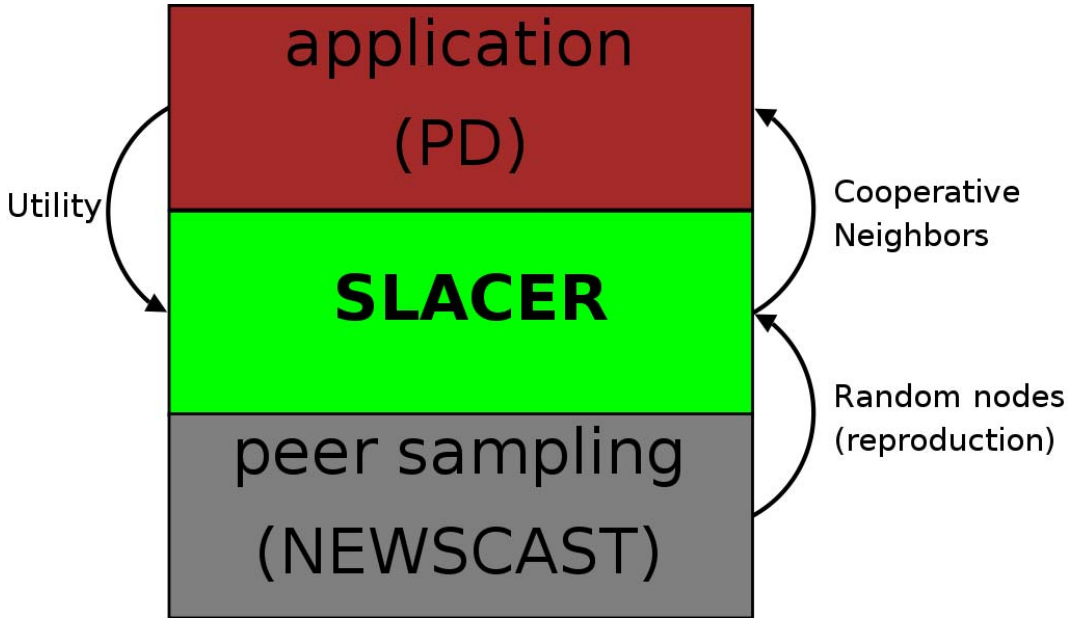


SLACER Simulation

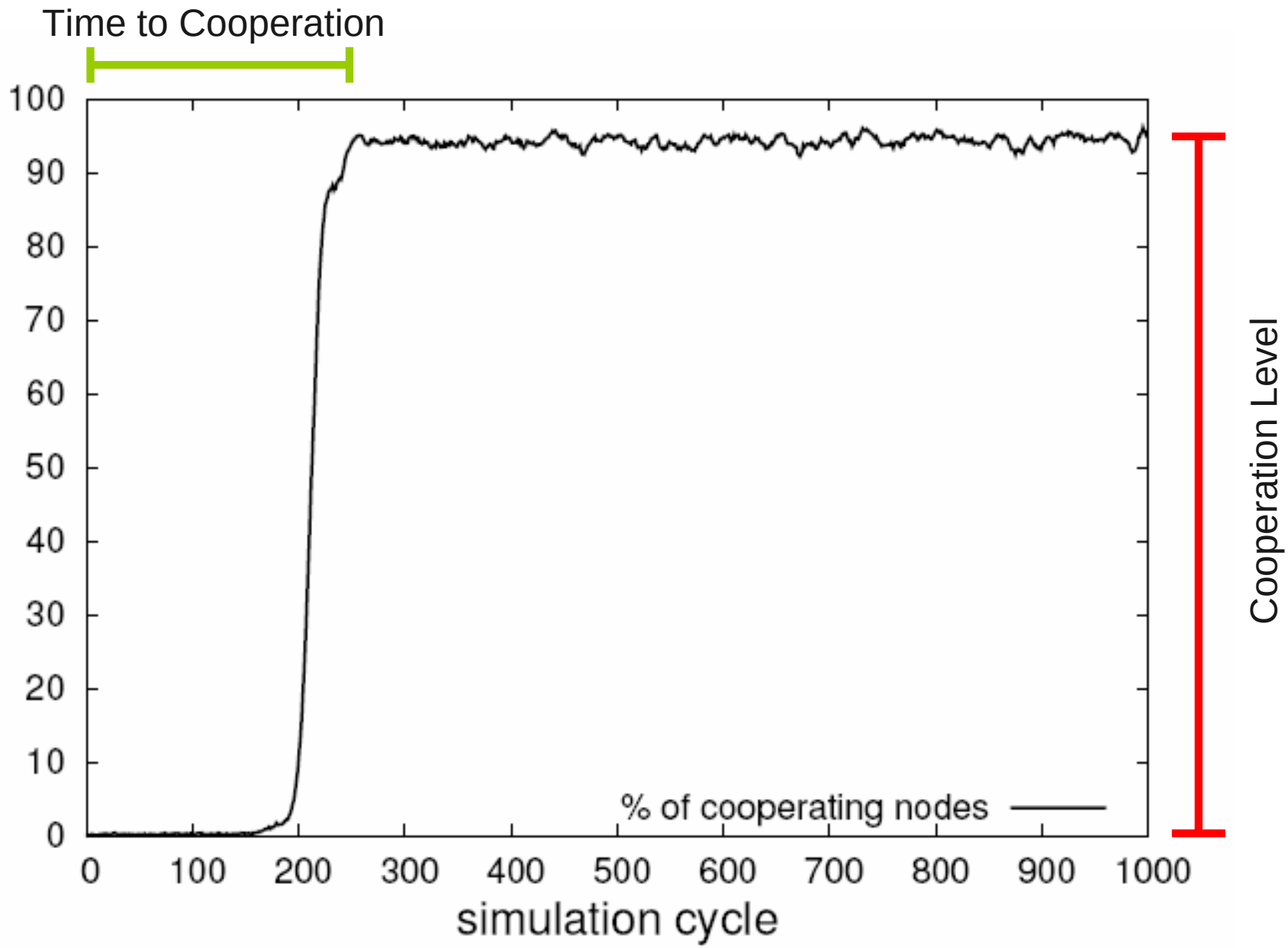
- SLACER has been implemented in Peersim
- Newscast used for random sampling
  - Utility comparison
- PD used as a test application
  - At each cycle each node plays a single round with a random neighbor
  - Only pure strategies (*always C* or *always D*)

SLACER Architecture

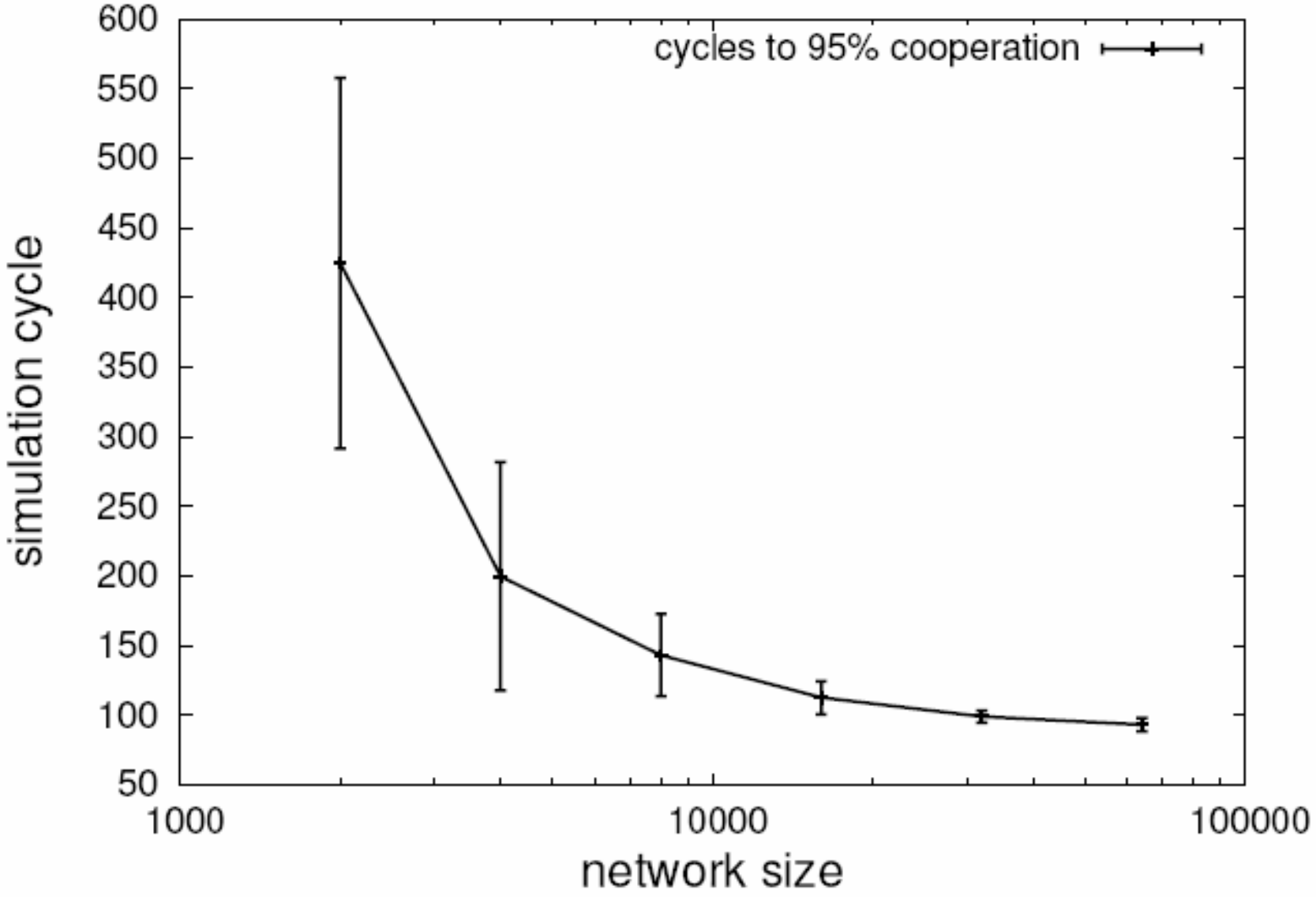
- 3 layers architecture
- Random sampling
  - Newscast
- Cooperation and topology
  - Slacer
- Application task
  - PD



SLACER Results: Cooperation Trend

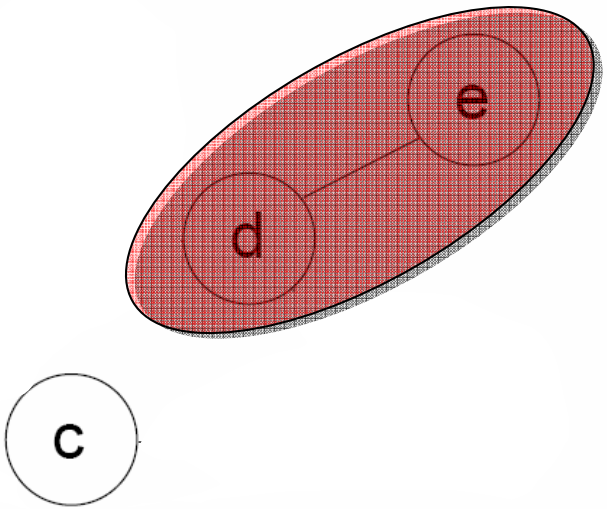


SLACER Results: Time to Cooperation



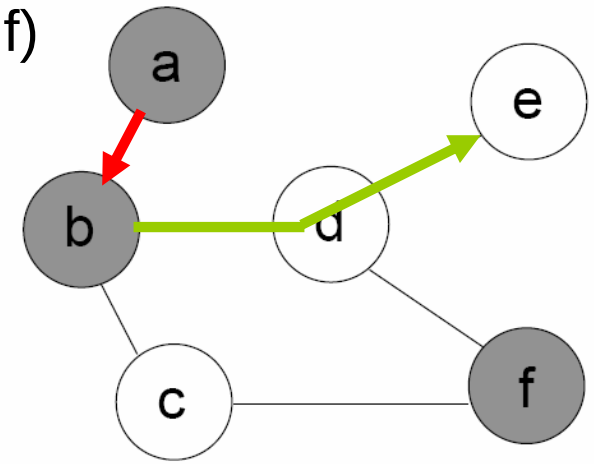
Largest Cooperative Component

- Largest Cooperative Component (LCC)
  - Subnetwork composed only by cooperative nodes
  - Size of the largest component taken into account

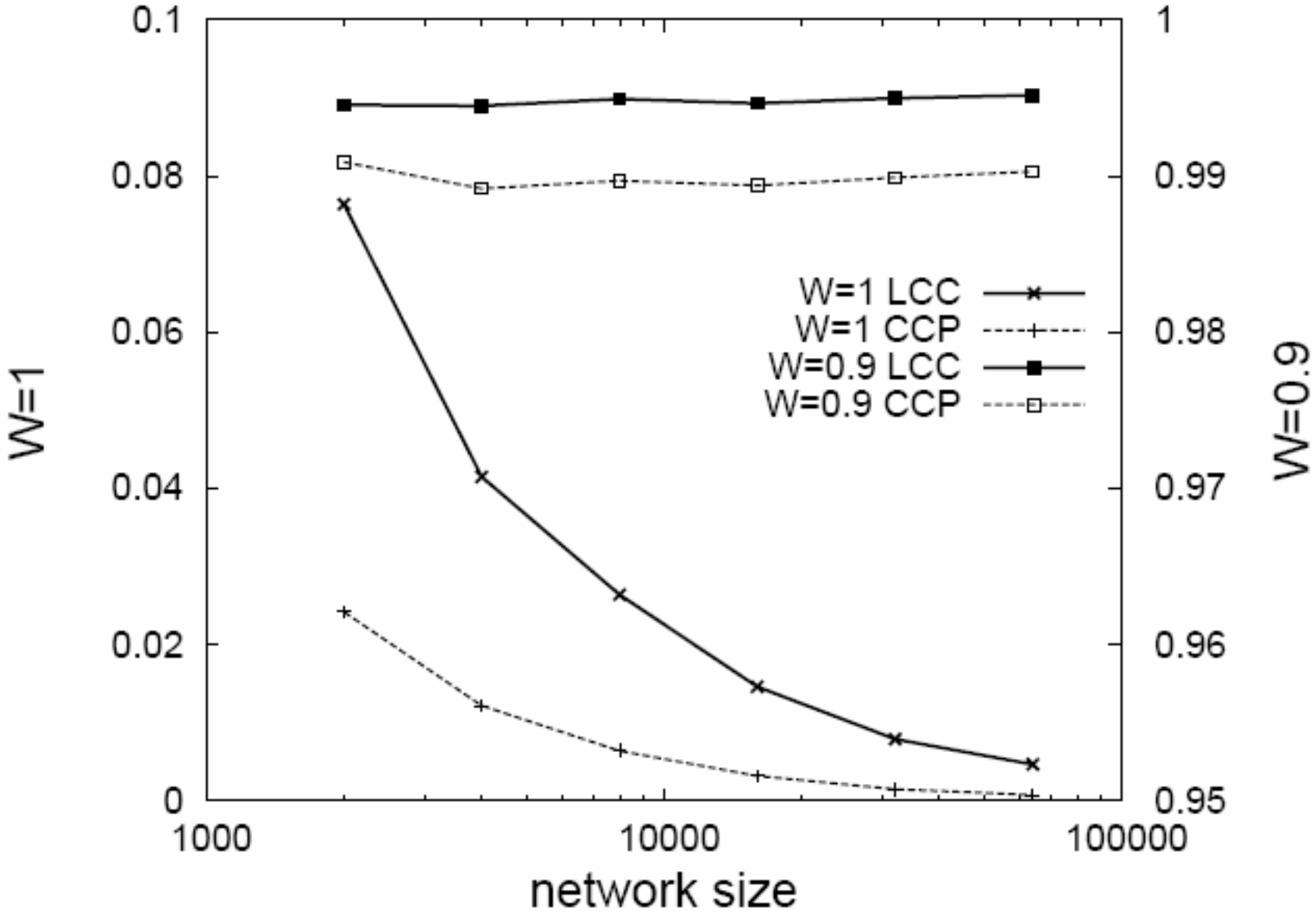


Cooperative Connected Paths

- Cooperative path:
  - Direct connection
  - Connection through a path composed by cooperative nodes
- Cooperative Connected Paths (CCP)
  - Proportion between
    - Pair of nodes connected through cooperative paths
    - Every possible pair of nodes
      - (a,b) (b,c) (b,d) (b,e) (b,f) (c,f) (d,e) (d,f) (e,f)
      - 9/15=0.6
- Cooperative Connected Path Length (CCPL)
  - Average path length evaluated only on cooperative paths



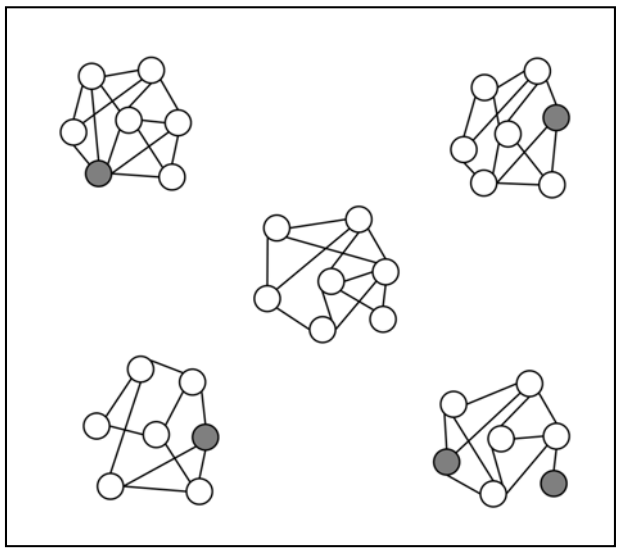
SLACER Results: LCC and CCP



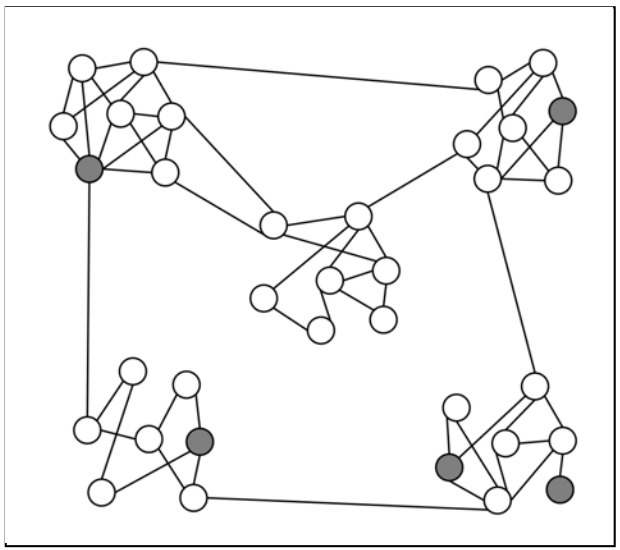
Cooperation vs. Randomness Tradeoff

- Drop probability value lead to different kind of topology
  - W=1 highly partitioned network
  - W=0.9 Small world-like network
- The lower the W the more random the network
  - More robust
  - Lower cooperation

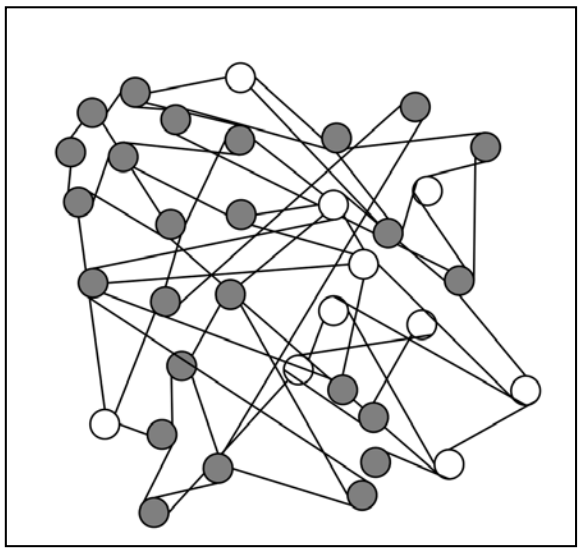
W=1 Disconnected



W=0.9 Small World



Low W Random



Conclusion

- Cooperation in P2P networks
- Slacer algorithm
  - Simple local rules
  - Pushes network to cooperation
  - Provides a small world-like topology
- Tuning *W* is possible to obtain different kinds of topology
  - Disconnected
  - Small World like
  - Random-like

Bibliography

- D. Hales and S. Arteconi. Slacer: A self-organizing protocol for coordination in peer-to-peer networks. *IEEE Intelligent Systems*, 21(2):29–35, Mar/Apr 2006.
- D. Hales and S.Arteconi. Friends for Free: Self-Organizing Artificial Social Networks for Trust and Cooperation. Technical Report UBLCS-2005-20. Available at: http://www.cs.unibo.it/pub/TR/UBLCS/2005/2005-20.pdf