

On the possibility of turning an arbitrary graph into a complex network, using rewiring mechanisms

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Abstract—The abstract goes here.

Index Terms—Computer Society, IEEE, IEEEtran, journal, LATEX, paper, template.



1 INTRODUCTION

2 RELATED WORK

3 METHODS

3.1 General operation

- Use frequency of dynamic links during the exploration phase (f_e).
- Visit frequency to candidate nodes during the exploration phase (f_n).

3.2 Initial conditions

3.2.1 Initial topology

The initial topology is given by a 2D grid, where each node has a Von Neumann neighborhood consisting of the top, bottom, left and right neighbors, except for the nodes lying on the corners and borders of the 2D grid, which have 2 or 3 neighbors, respectively. Links belonging to this initial topology are fixed along the rewiring mechanism.

In addition to fixed links, each node has a determinate number of dynamic links. Initially, these dynamic links are only connected to their owning nodes, and can be understood as loose ends. The loose end of each dynamic link is rewired along the rewiring mechanism, while the end connected to its owning node remains fixed.

It is important to mention that we proposed a 2D grid as initial topology because the rewiring mechanism is designed to work on real telecommunication networks, where the length of physical links is a restriction that must be taken into account. Since the 2D grid has a natural embedding on the euclidean space it is easy to compute

3.2.2 Compass routing

The rewiring mechanism requires a routing algorithm to explore the network and exchange messages between nodes. Since The compass routing algorithm was designed to work on planar graph

we want to travel from an initial vertex s to a destination vertex t , and that all the information available to us at any point in time is: the coordinates of our destination, our current position, and the directions of the edges incident with the vertex at which we are located. Starting at s , we will in a recursive way choose to traverse the edge of the geometric graph incident to our current position and with the closest slope to that of the line segment connecting the vertex of our current position to t . Ties are broken randomly.

To choose the next step of a packet, the routing is performed as follows: we draw a main straight line between the current node in charge and the final destination. Also, we draw a secondary line between the node in charge and each of its immediate neighbors. Each secondary line crosses the main line with a different angle. The neighbor corresponding to the smallest angle will be designated as the next node in the route of the tracer

Each node is identified by a coordinate in the initial 2D grid as is shown in Fig. ?? . The Compass routing algorithm was designed to on planar graphs

3.2.3 Coordinator election

As is explained in the following section, the coordinator node have two tasks: 1) to count the number of cycles of the rewiring mechanism, and 2) to coordinate the start and end of each cycle phase.

3.3 Rewiring mechanism

The rewiring mechanism is a distributed process that is executed in a determined number of cycles. The coordinator node starts each cycle spreading notification messages through a PI algorithm. Each cycle consists of the following four phases:

3.3.1 Exploration

Each node starts its exploration phase when it receives a notification from the coordinator node. During this phase, each node sequentially sends twenty tracer packets to arbitrary destination nodes. Packets are routed applying compass routing. Destination nodes respond to a tracer packet with an acknowledgment packet containing the path followed by

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the tracer packet. When a node receives an acknowledgment packet, it updates its vectors f_e and f_n . A node finishes its exploration phase when it has received acknowledgments packets for its twenty tracer packets.

3.3.2 Exploration synchronization

This phase starts when the coordinator node has finished its exploration phase. Then it starts a PIF algorithm to spread messages asking if the rest of nodes have finished its exploration phase. When the coordinator node receives an acknowledgment from all the nodes in the network, it starts a PI algorithm to spread messages notifying that nodes must start its rewiring phase.

3.3.3 Rewiring

Each node starts its rewiring phase when it receives a notification from the coordinator. Then, the notified node uses the information in its vectors f_e and f_n to take a rewiring decision according to one of the following rules:

- **Rule 1.** A node rewires its least used dynamic link (according with f_e) to the most visited node (according to f_n).
- **Rule 2.** A node rewires its least used dynamic link (according with f_e) to the first node at distance 2 from it, which is the first node in f_n .

3.3.4 Rewiring synchronization

Analogous to the *Exploration Synchronization phase*, this phase starts when the coordinator node has finished its rewiring phase. Then it starts a PIF algorithm to spread messages asking if the rest of nodes have finished its rewiring phase. When the coordinator node receives an acknowledgment from all the nodes in network, it checks if all cycles have been completed. If so, the rewiring mechanism finishes. Otherwise, the coordinator node updates the cycle counter and starts a PI algorithm to spread messages notifying that the cycle has finished and nodes must start the *Exploration phase* of a new cycle.

4 RESULTS

4.0.1 Initial parameters

- Initial graph: 2D-grid of size 50×50 .
- 30 cycles
- 20 tracer packets.
- Length of dynamic links.
- Number of dynamic links.

4.1 Topological properties of the resulting graphs

4.1.1 Average clustering coefficient

4.1.2 Centrality distributions

- Degree centrality
- Betweenness centrality
- Closeness centrality

4.1.3 Distance metrics

- Average path length
- Diameter

4.1.4 Community metrics

- Modularity
- Number of communities

4.2 Robustness against failures

- Average clustering coefficient
- Number of connected components
- Proportion of the largest connected component
- Diameter of the largest connected component
- Average path length of the largest connected component

4.3 Robustness against attacks

- Average clustering coefficient
- Number of connected components
- Proportion of the largest connected component
- Diameter of the largest connected component
- Average path length of the largest connected component

5 DISCUSSION

6 FUTURE WORK

- Impact of the initial graph
- Impact of the number of the routing algorithm
- Impact of the number of exploration packets
- Determine the number of exploration packets
- Epidemic spreading

APPENDIX A

PROOF OF THE FIRST ZONKLAR EQUATION

Appendix one text goes here.

APPENDIX B

Appendix two text goes here.

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The authors would like to thank...

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Michael Shell Biography text here.

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Jane Doe Biography text here.