Last updated - 03/14/2018
Guide to the Repository
Alexander Trevelyan

Dear Reader,

Thank you for navigating to the repository for my publication in *Physical Review E* as a Rapid Communication about the Degree Product Rule Process, a competitive network growth scheme developed in the Corwin Lab at University of Oregon. This letter will guide you through the project from start to finish. I am especially proud of this publication, as it began with my discovery of the burgeoning field of competitive network growth via the excellent review paper written by D'Souza and Nagler, *Anomalous critical and supercritical phenomena in explosive percolation* (Nature Physics, 2015), from which I developed my idea of exploring a localized growth process and proceeded to code the simulations and run the analysis that produced our paper. From understanding the literature, to spawning the idea, producing the code, analyzing the data, and writing the paper, I spearheaded each part of the project and incorporated the invaluable ideas and observations of my advisor, Eric Corwin, and our lab postdoc Georgios Tsekenis along the way.

The unabated advance in computing power over the preceding few decades has afforded us the ability to perform detailed statistical experiments that once seemed intractable. When Erdos and Renyi developed the classical model for random network growth, it was made tractable by condensing random growth into closed-form mathematical expressions from which stable distributions could be analyzed. Recently, the concept of interacting with a growing network continuously over time has disrupted our ability to arrive at closed-form solutions, and network growth simulations are now required in order to extract the critical behavior of these competitive growth processes. The Achlioptas Process developed by Achlioptas, D'Souza, and Spencer (*Explosive percolation in random networks*, Science, 2009) is the seminal example of such a competitive growth process, where edges compete for addition to the network at each timestep based on the size of clusters that they would join together.

The Achlioptas process delays the onset of criticality, a potentially desirable characteristic for guiding network growth. However, it does so at the cost of an “explosion” of connectivity once the critical point is reached, even producing a first-order (discontinuous) phase transition in the limit where the number of competing edges grows with system size. To address this drawback, we developed the Degree Product Rule (DPR) Process, which uses the product of node degrees as the competitive criteria when growing the network. The DPR Process still delays the onset of criticality, however it significantly softens the explosive nature of the phase transition, and only appears to reach first-order in the limit of global competition. Furthermore, it requires knowledge of only the nearest set of neighbors to evaluate the competitive criteria, which reduces the flow of information from global to local near the critical point as compared to the Achlioptas Process. This makes it far easier to implement in a growing network, and far less computationally intensive.

The code provided in this repository can be used to generate network growth realizations using the Achlioptas and the DPR processes. The critical properties can be extracted by following the evolution of the largest cluster in the network at each step, which serves as the order parameter of the percolation phase transition. Distributions of the size and location of the largest jump in the order parameter allow determination of the transition critical exponents and location of the critical point. Cluster size and degree distributions can be generated at specified points in order to follow the evolution of clusters which are smaller than the largest cluster at any given point.

The text of our publication is provided with details of the full analysis. Please do not hesitate to correspond with us if you have any questions. Thank you for reading!

Alex

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