Node interactions in Random Networks

Gerrit De Young
and
Alexandros Kyrtsos

Boston University

Boston, November 24, 2015

The question

- The economic crisis of 2008 was devastating:
  - Average wage loss of $5,800 per household
  - $2050 per household was spent on stimulus
  - $30,300 per household lost in real estate wealth
  - $66,200 per household lost in stock market

Source: Pew Charitable Trust

http://www.pewtrusts.org/en/research-and-analysis/reports/2010/04/28/the-impact-of-the-september-2008-economic-collapse

The question

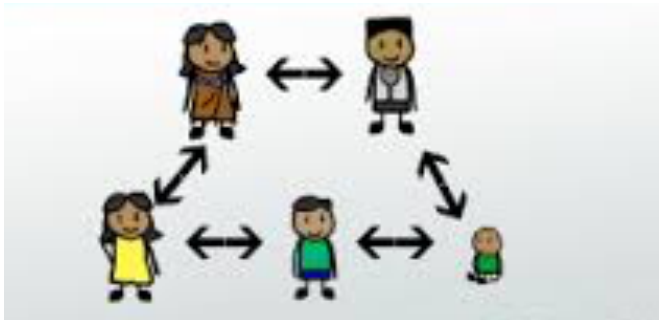
- The crisis was precipitated by a cascade of bad loans, leading to bank failures, leading to debt defaults, leading to more bank failures.
- Could the strength of an individual financial firm be predicted by its counterparties?

The Pattern

- If we consider the banks as nodes, and their lending relationships links, we can clearly see that the health of one node in the network is dependent on the health of the remainder.
- This holds true in a number of domains

Property Prices

Family Systems



Social Norms

- Christakis and Fowler found that prosocial behavior in a modified prisoner dilemma affected behavior multiple rounds after the initial behavior was introduced.

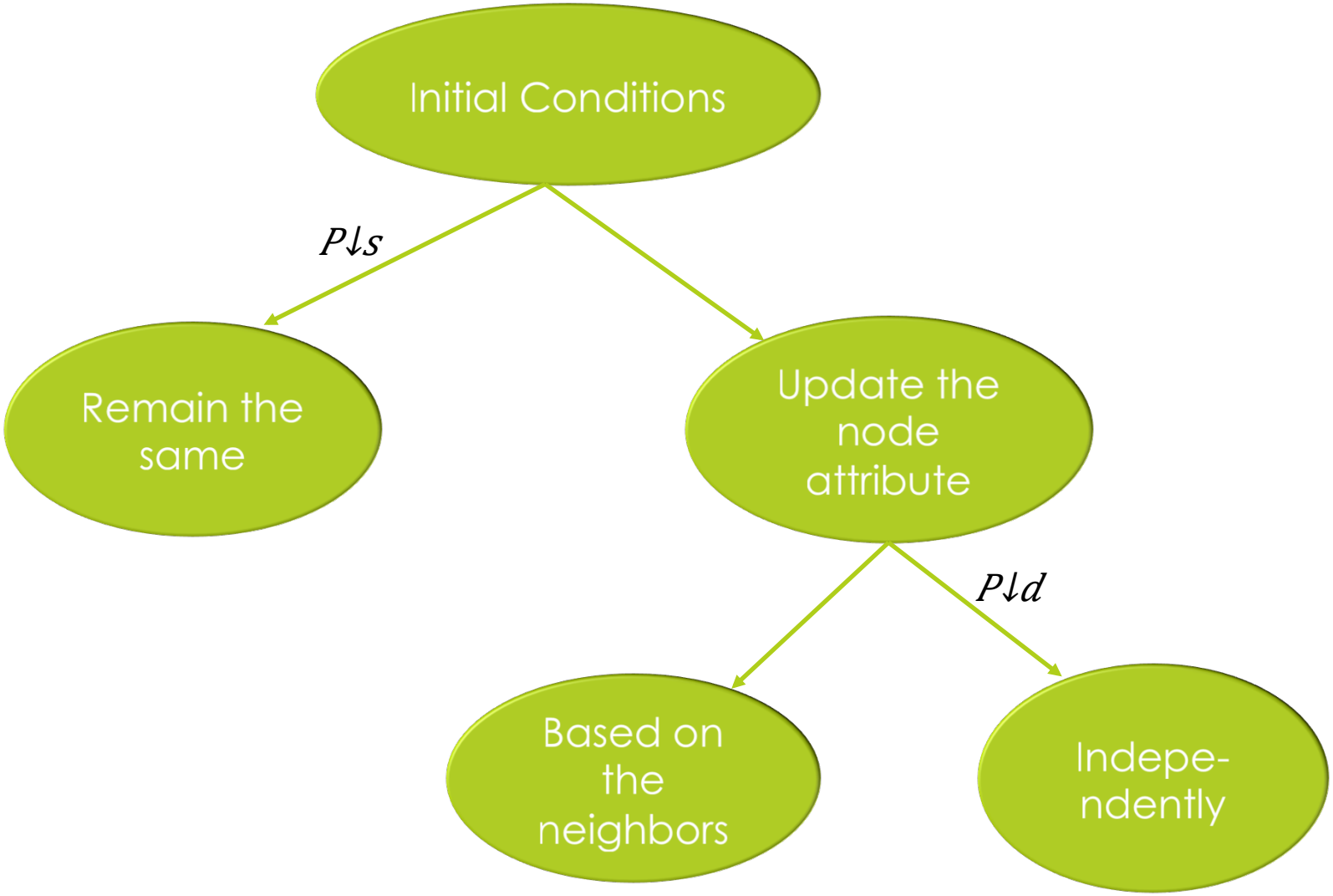
The goal

- To study the dynamics of a network attribute
- Study different interactions between nodes

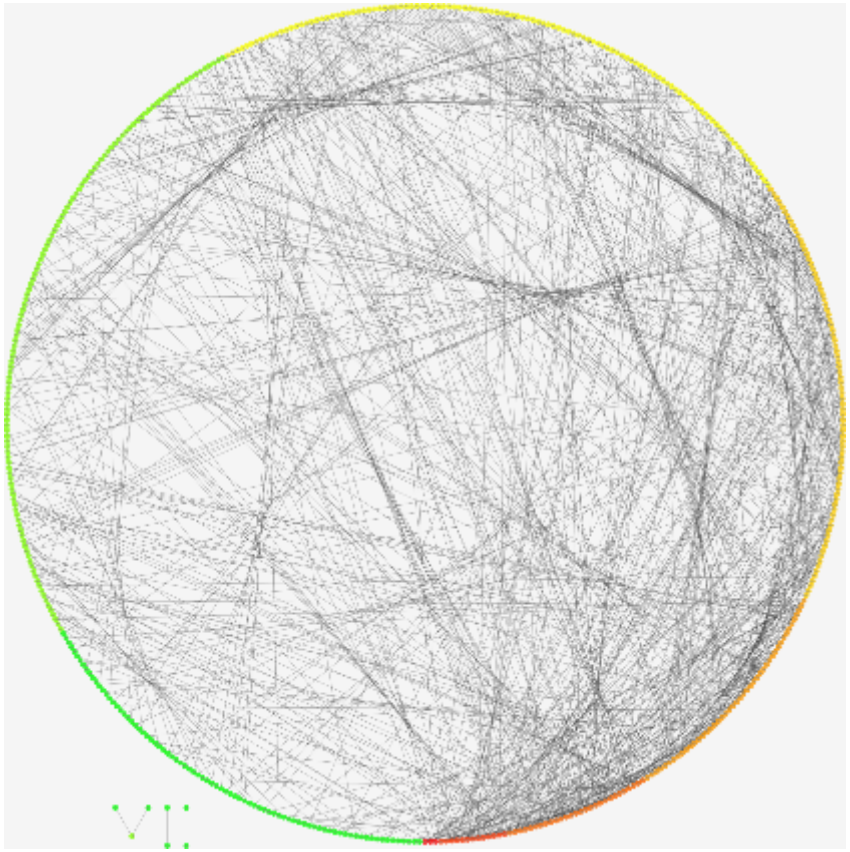
Method

- Create a set of nodes and assign edges based on the Erdös-Rényi formalism.
- Assign values of the attribute in the range [0,1].
- Define a set of rules to determine the interaction of the nodes at every time step.
- Update the attribute at the end of each step and repeat for the given number of steps.

Control flow

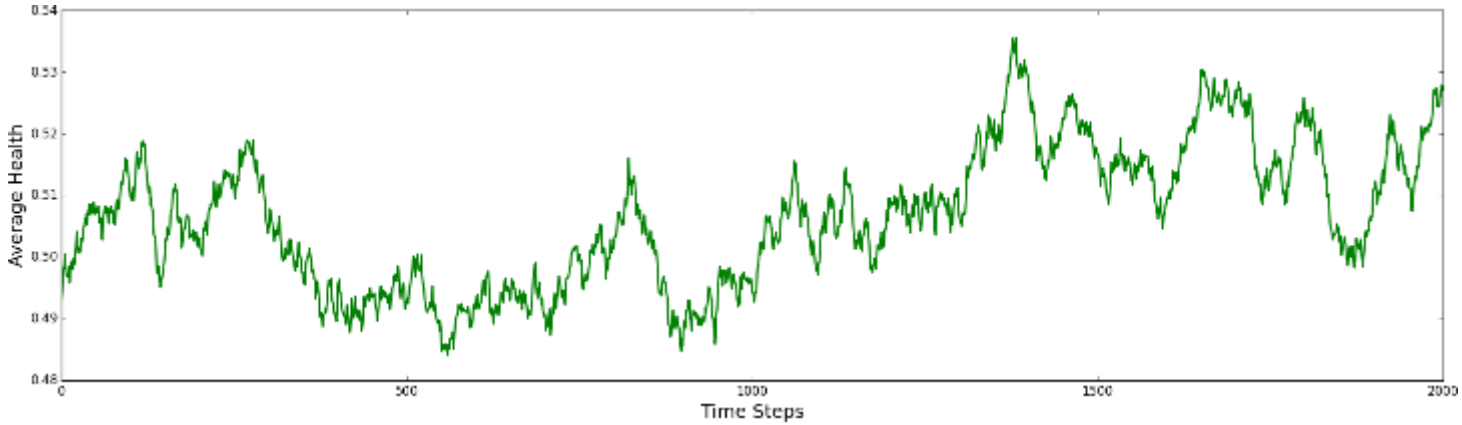


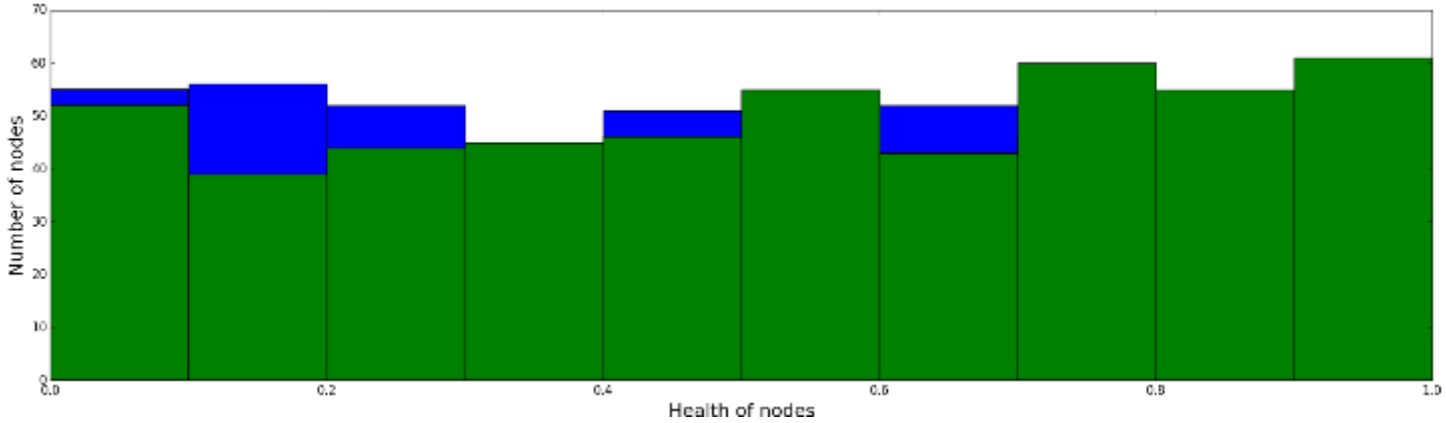
Results



Random network with k=3.0

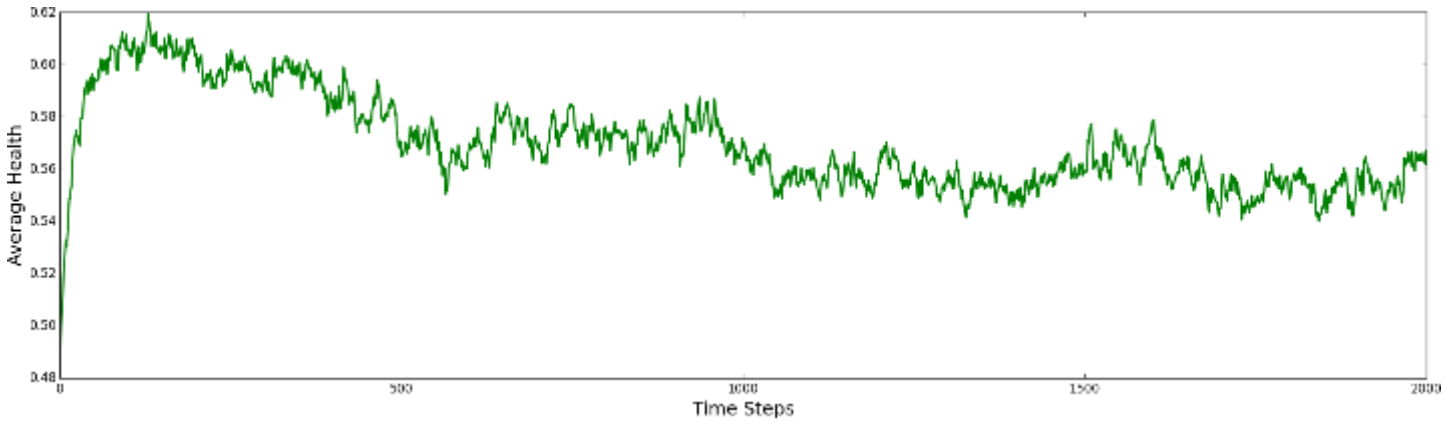
Results

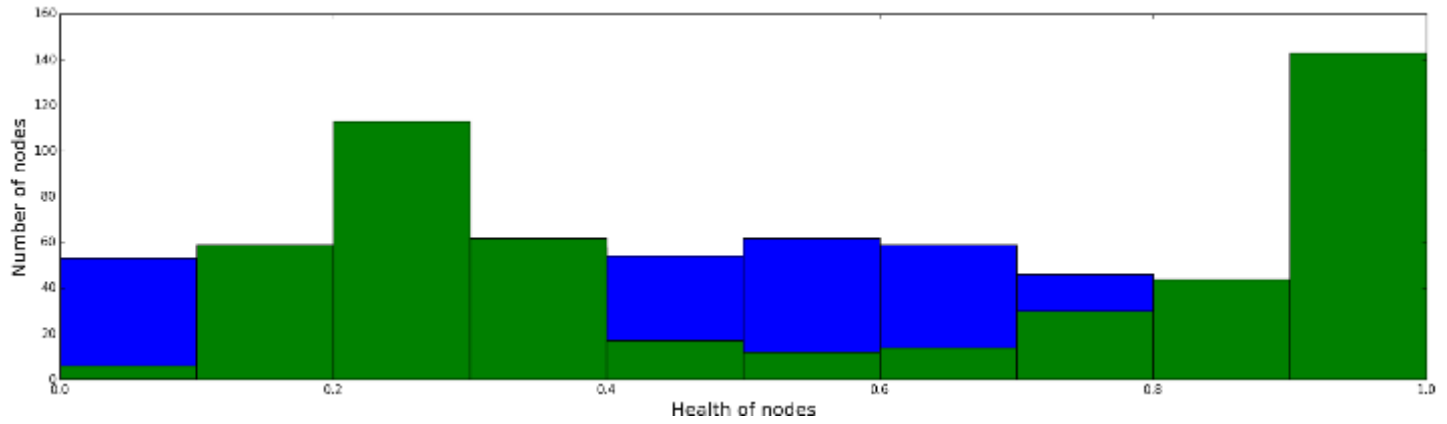




$P\downarrow s = 0, \quad P\downarrow d = 1, \; h\downarrow i = \text{uniform}$

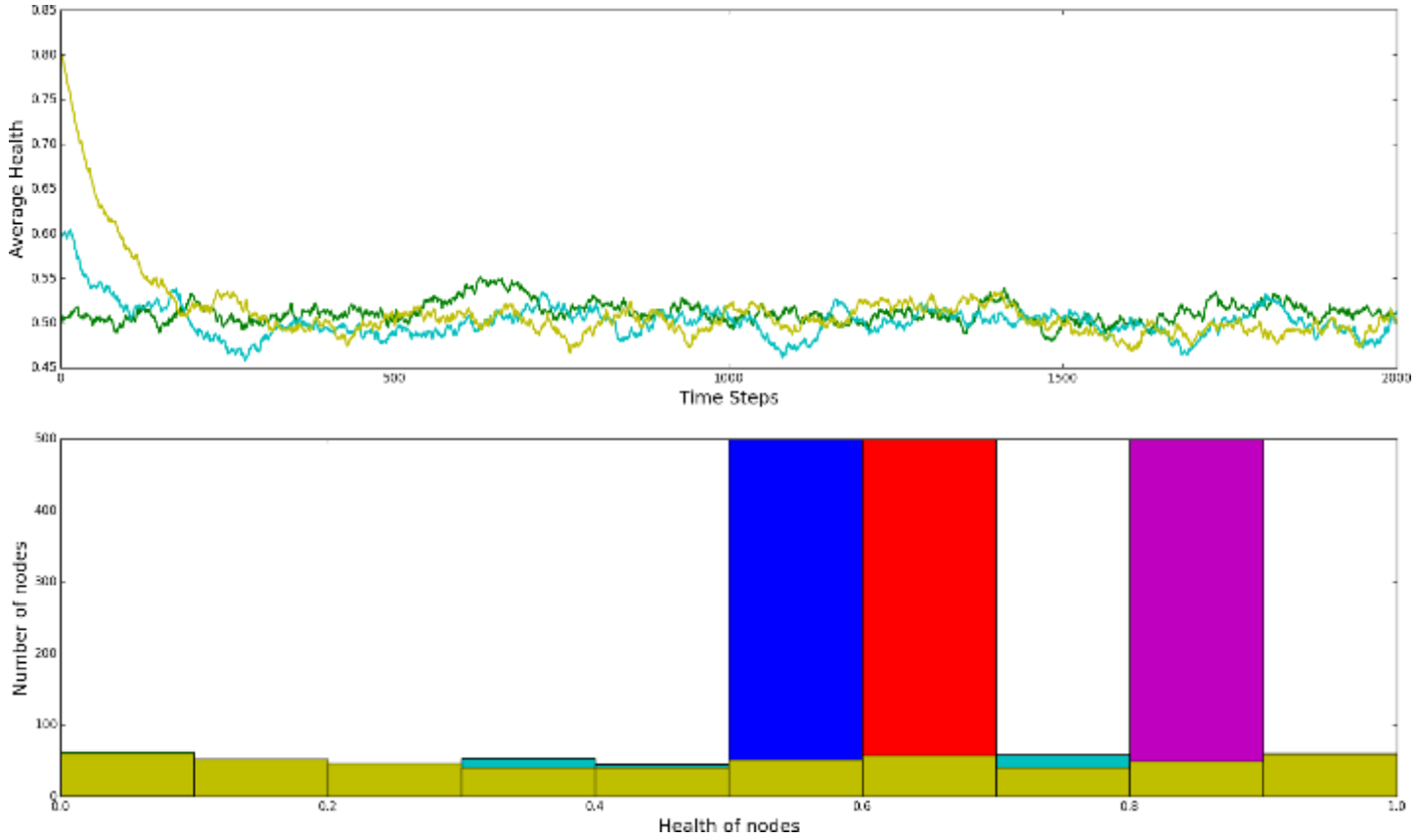
Results





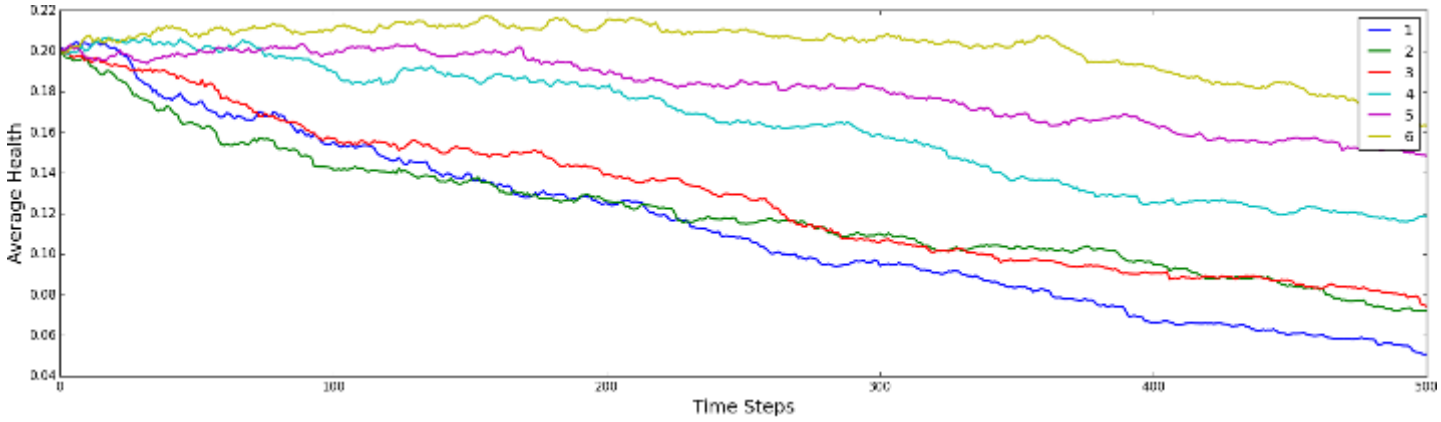
$P\downarrow s = 0, \quad P\downarrow d = 0.5, \; h\downarrow i = \text{uniform}$

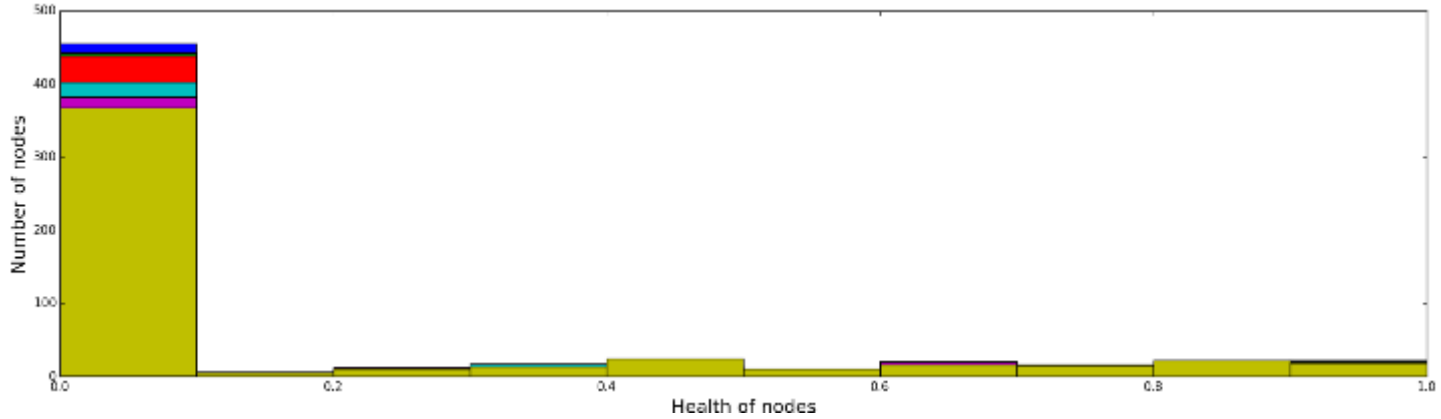
Results



$P\downarrow s = 0, \quad P\downarrow d = 1.0, \; h\downarrow i = 0.5, 0.6, 0.8$

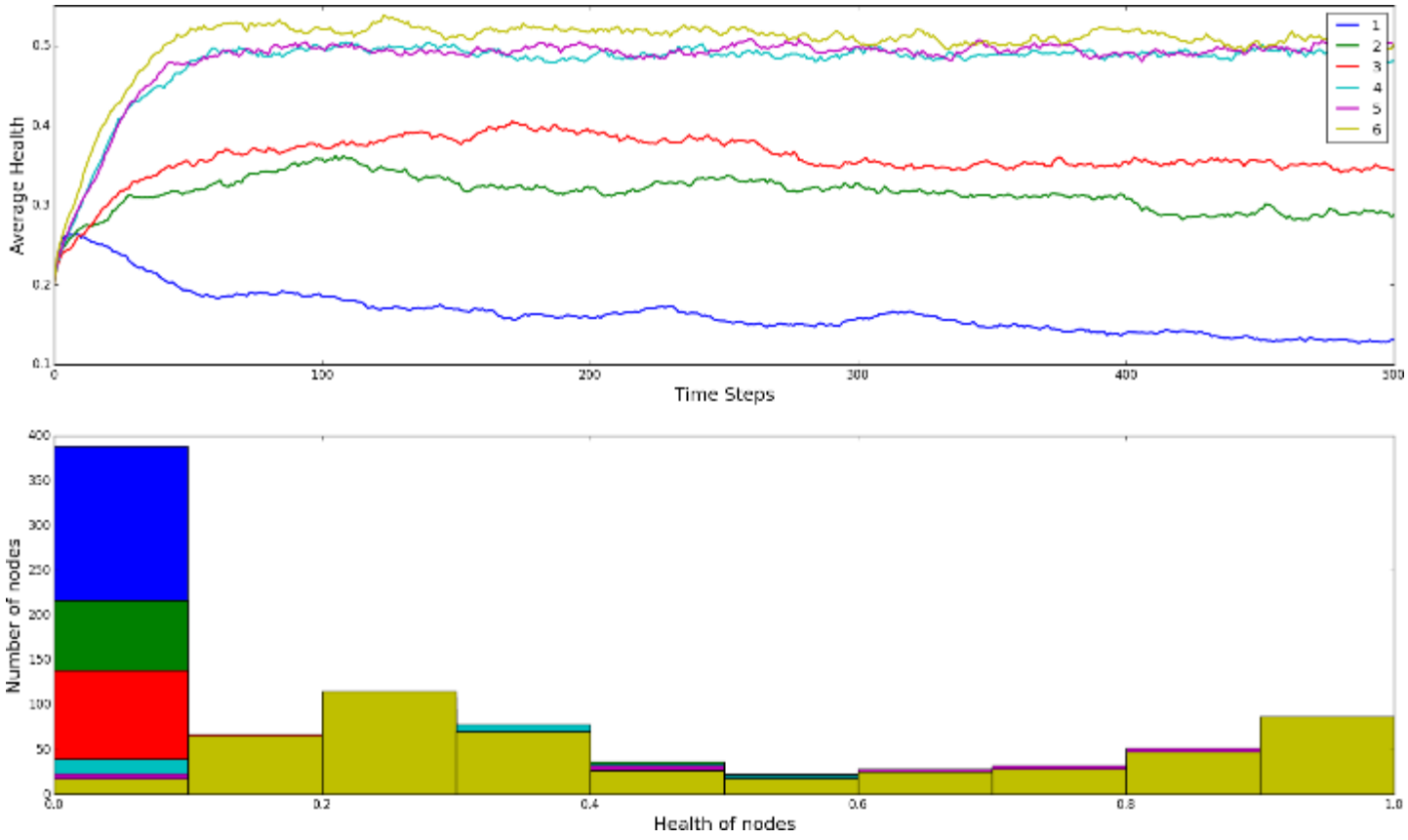
Results





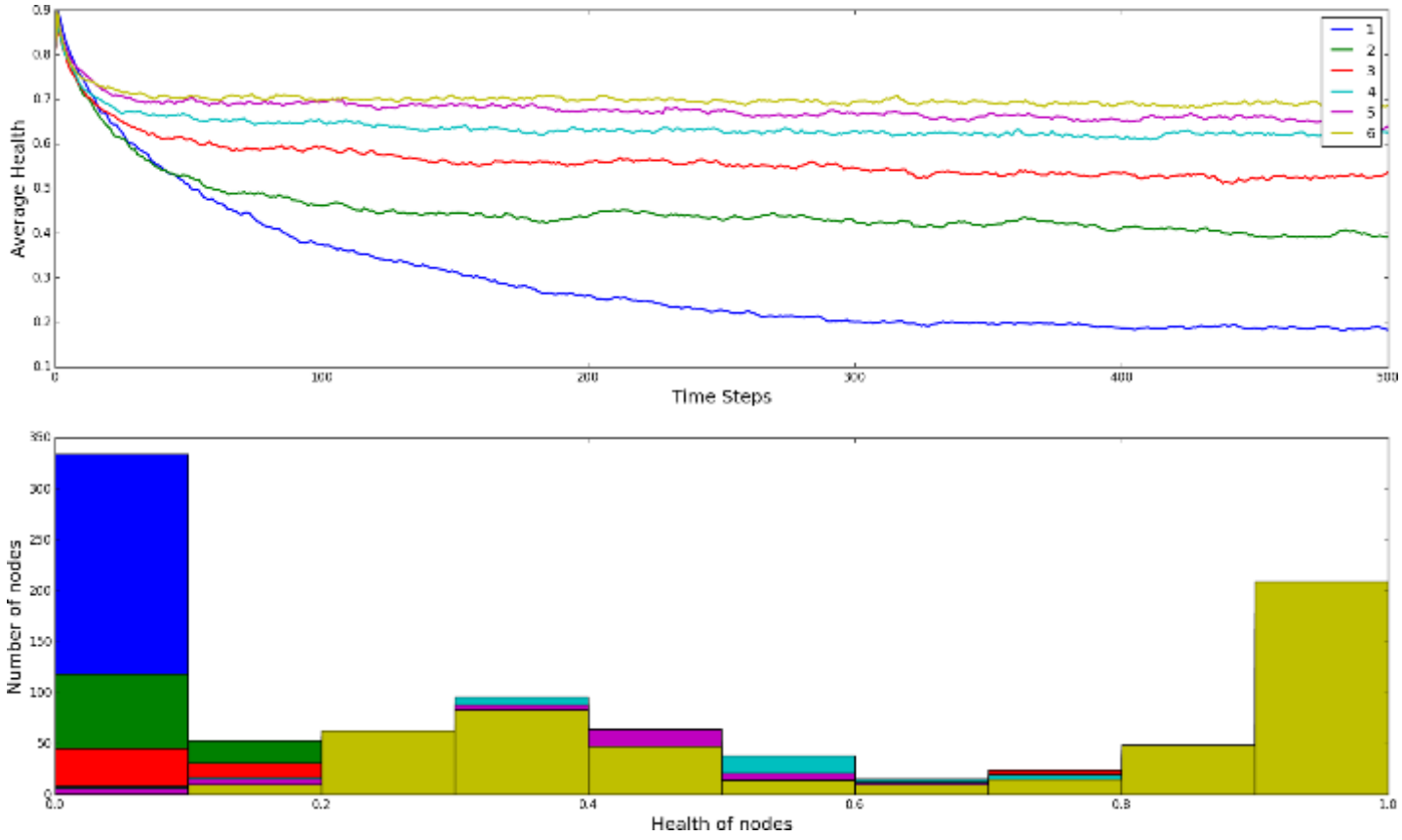
$P\downarrow s = 0.2, \quad P\downarrow d = 0.2, \; h\downarrow i = 0.2$

Results



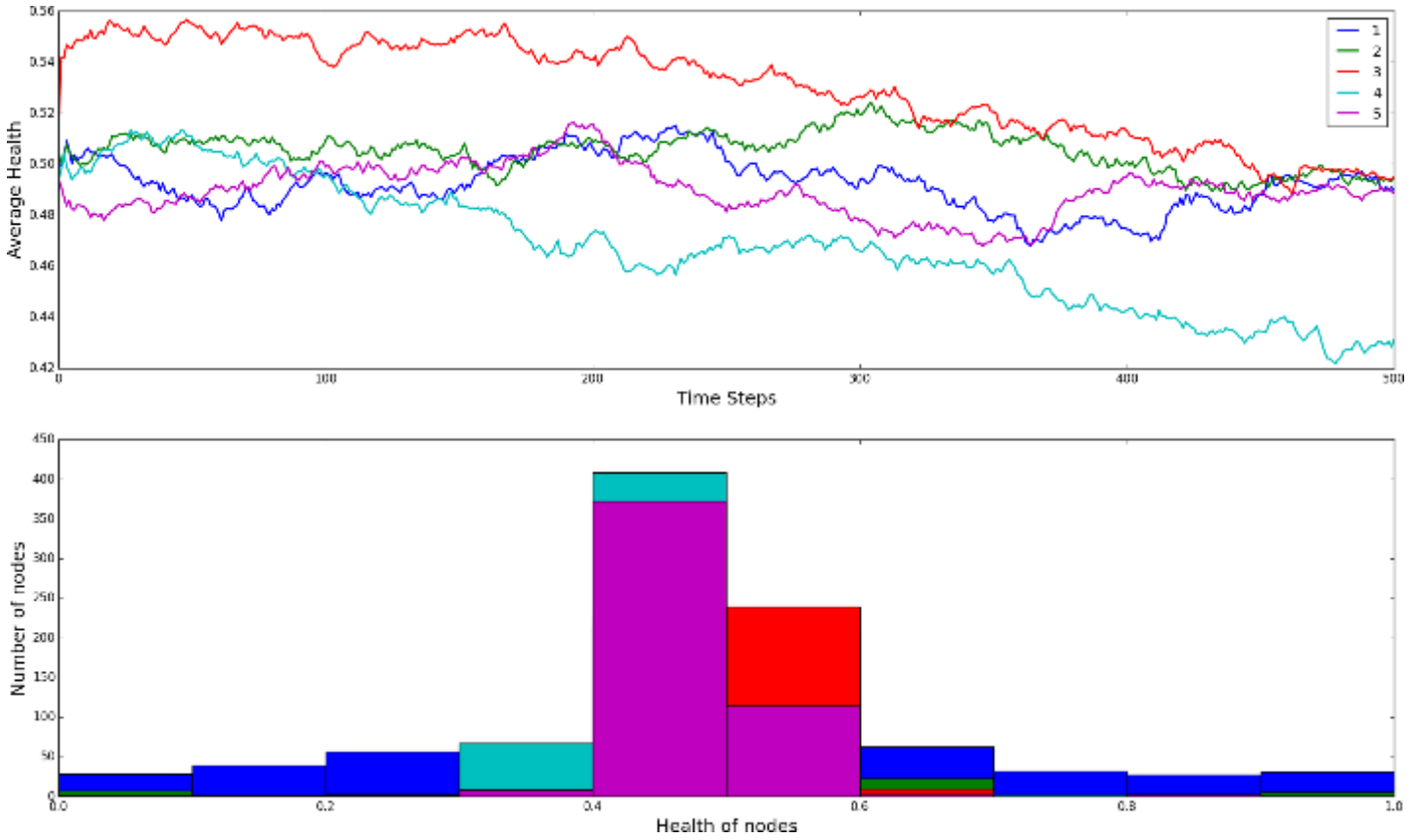
$P\downarrow s = 0.2, \quad P\downarrow d = 0.2, \; h\downarrow i = 0.2,$ allow dead nodes

Results



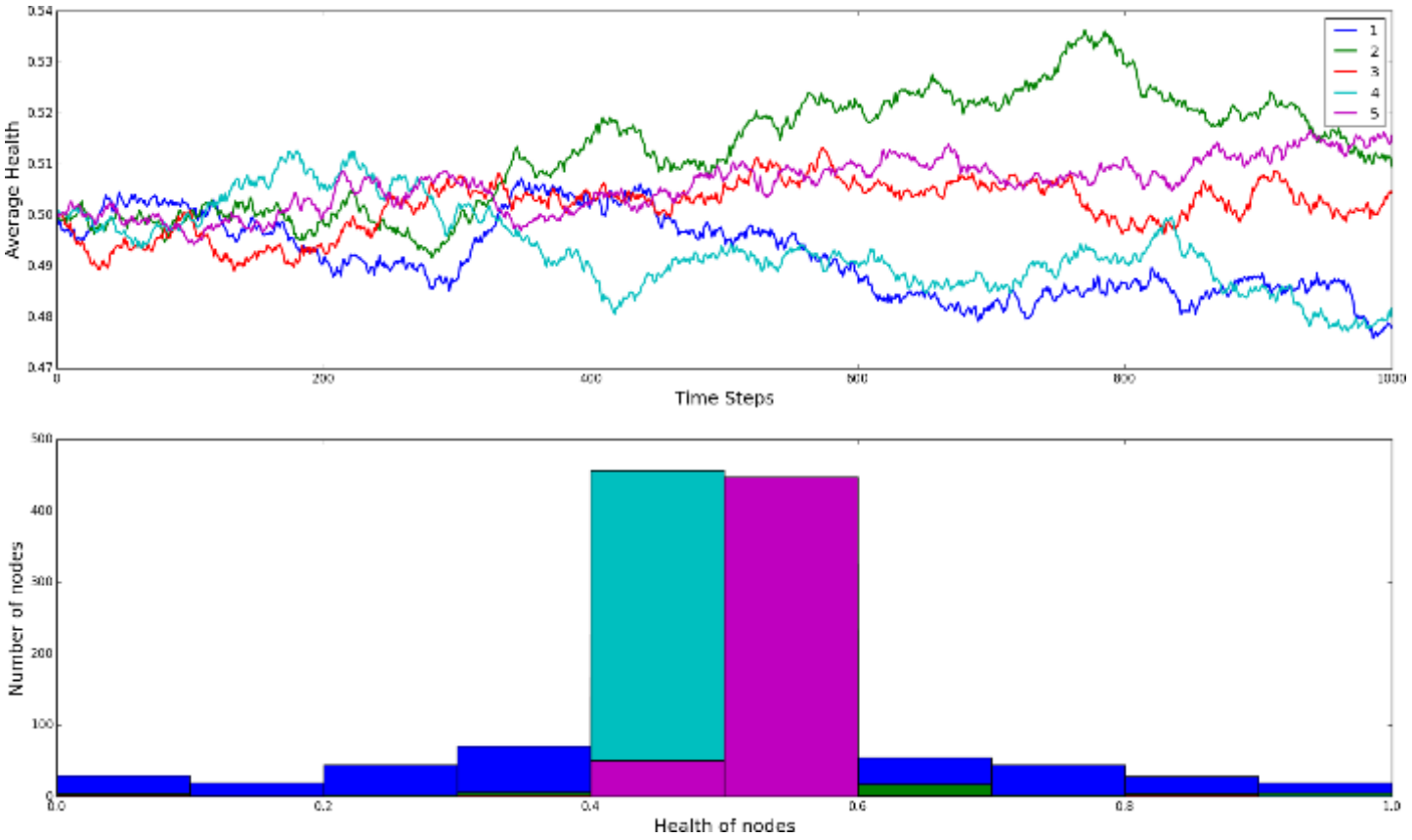
$P\downarrow s = 0.2, \quad P\downarrow d = 0.2, \; h\downarrow i = 0.8,$ allow dead nodes

Results



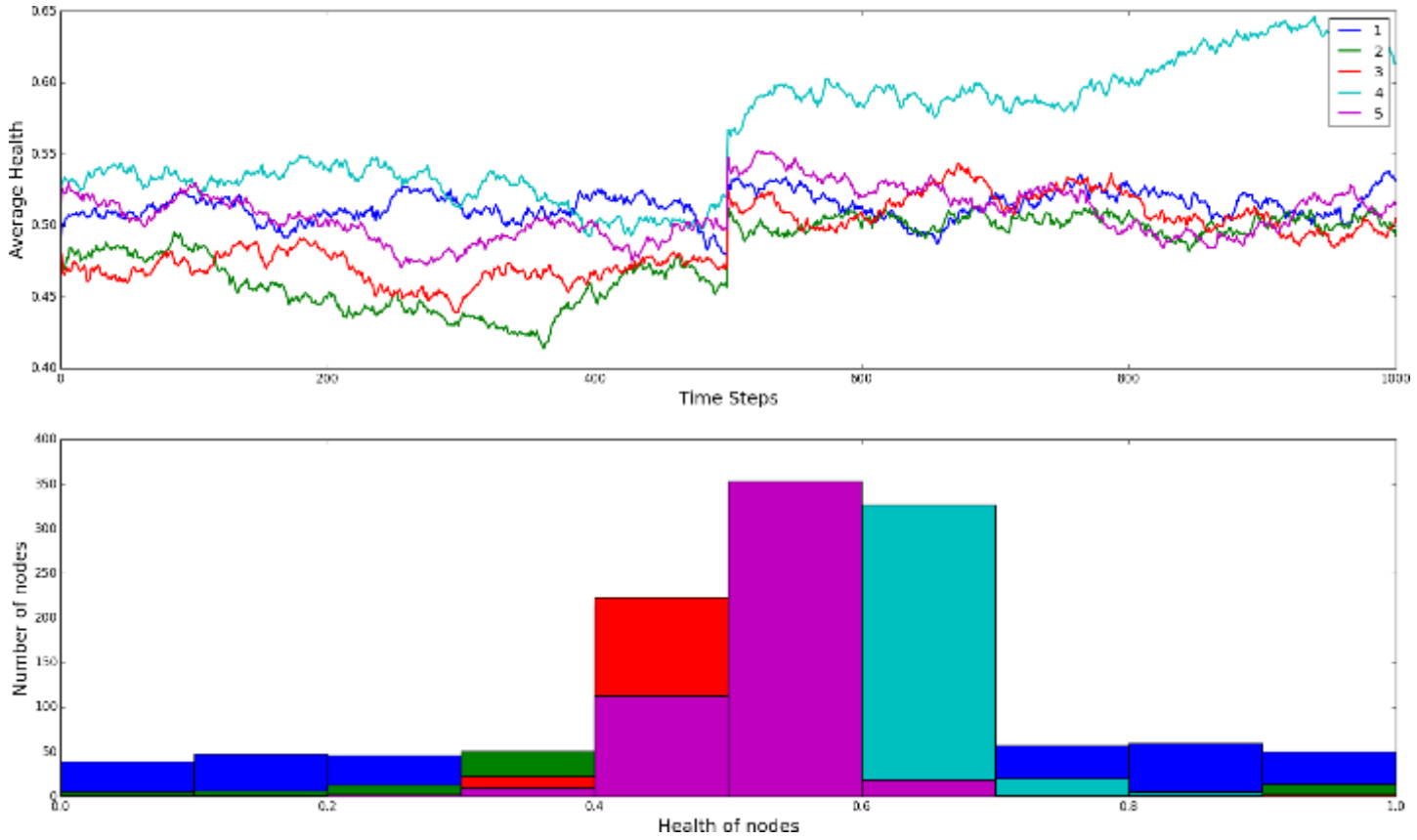
$P\downarrow s = 0.2, \quad P\downarrow d = 0.2, \; h\downarrow i =$ uniform, average of the neighbors

Results



$P\downarrow s = 0.2, \quad P\downarrow d = 0.2, \; h\downarrow i = 0.5,$ average of the neighbors

Results



$P\downarrow s = 0.2, \quad P\downarrow d = 0.2, \; h\downarrow i = \text{uniform}, \; \text{boost in } 25\%$

Future Directions

- Changes in initial distribution of node health: how does this affect the health of others in the network?
- Empirically determining how to quantify node health in various domains
- Empirically defining and determining effect of link weights
- Empirically determining probabilities of improvement or decline in health
- Test using scale free, rather than random, network