Modeling the Opinion Dynamics of a Social Network

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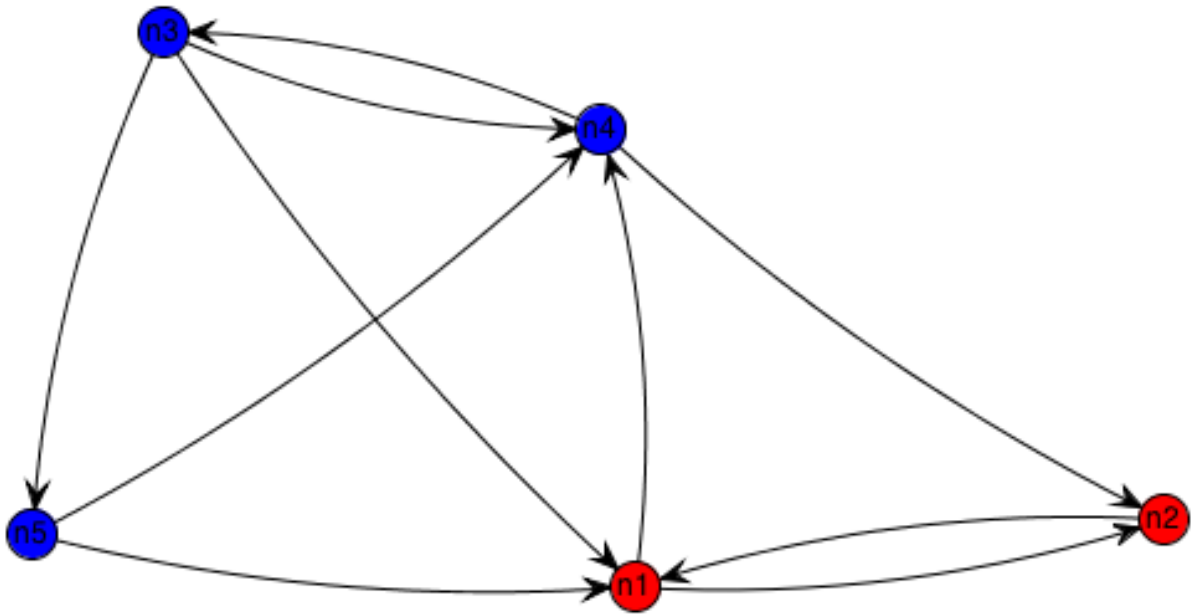
Social Networks

- Consist of people, their opinions, and friendships
- People change their opinions over time by interacting with others
- People change their friendships over time through decisions based on certain factors

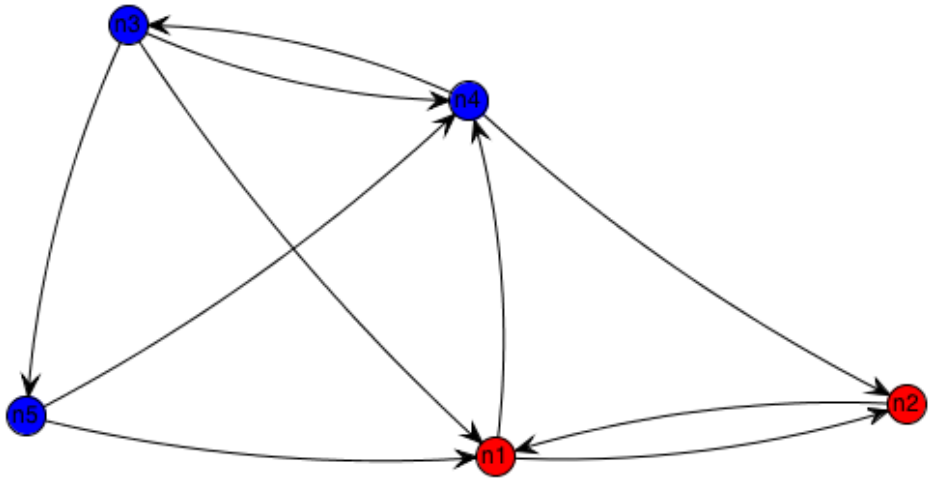


The Problem

- How can we accurately model the changes that occur in a social network?
- Targets:
  - The change in opinion over time
  - The change in connections over time
- In Previous Work:
  - The change in opinion over time is well understood
  - The change in connections over time is poorly understood
- We focus on the interplay between connection and opinion changes over time

Why is it Interesting?

- Model can predict the future opinion spread and connectivity of the network
- Can understand how different types of societies behave over time
  - Example: conservative vs. non-conservative societies
- Connects to problems in optimization:
  - How can we optimize the spread of an opinion throughout a network?

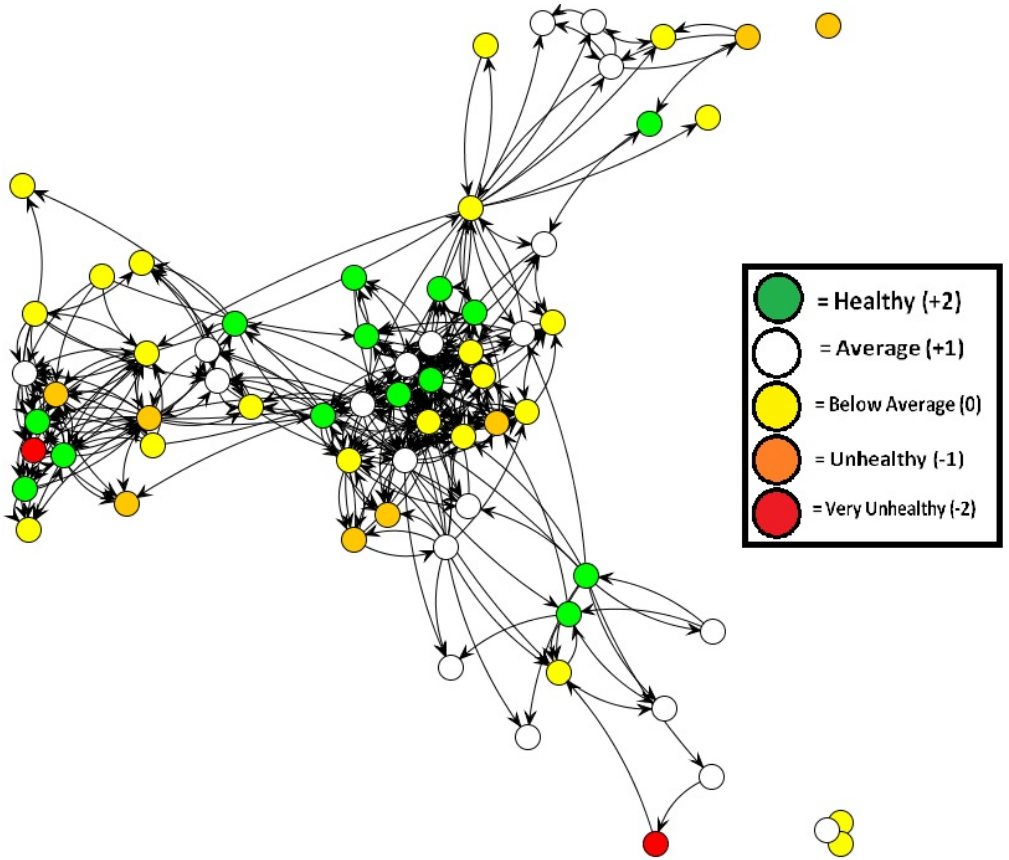


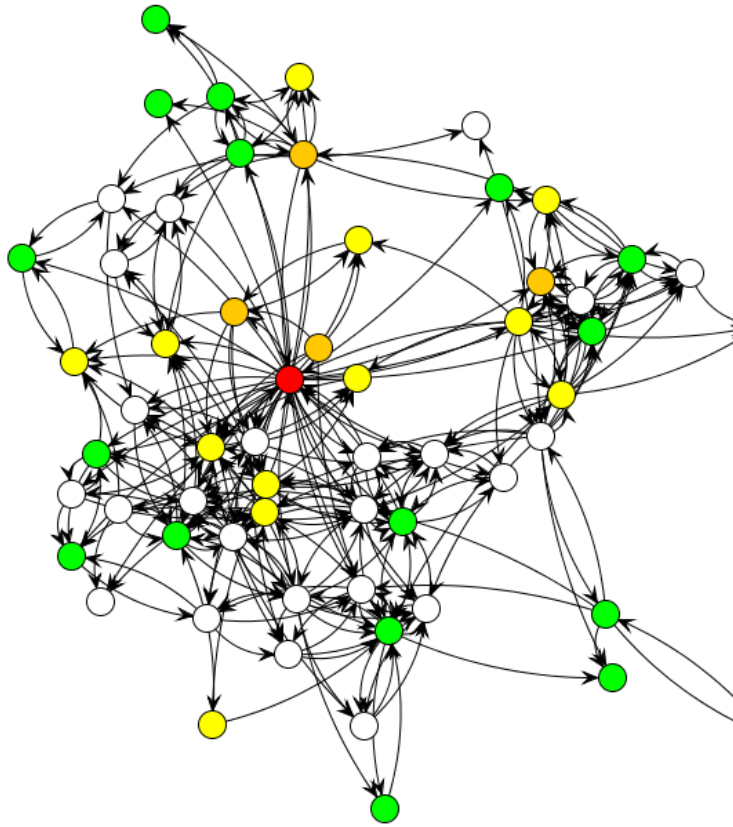
A Data Driven Modeling Approach

- A study of students in a Harvard Dormitory over several months
- Four main survey times
  - September 2008
  - October 2008
  - December 2008
  - March 2009
- Students record responses to questions asking for their:
  - Overall healthiness of their diet
  - Number of hours of weekly aerobic
  - Students they consider to be close friends
  - Students they socialize with at least twice per week
- We analyze the dynamics of each student's opinion and friendships over time in order to make a model

September 2008 vs. March 2009

- Individual opinion tends towards average of network
- Number of close friend connections changes over time: 323 to 285



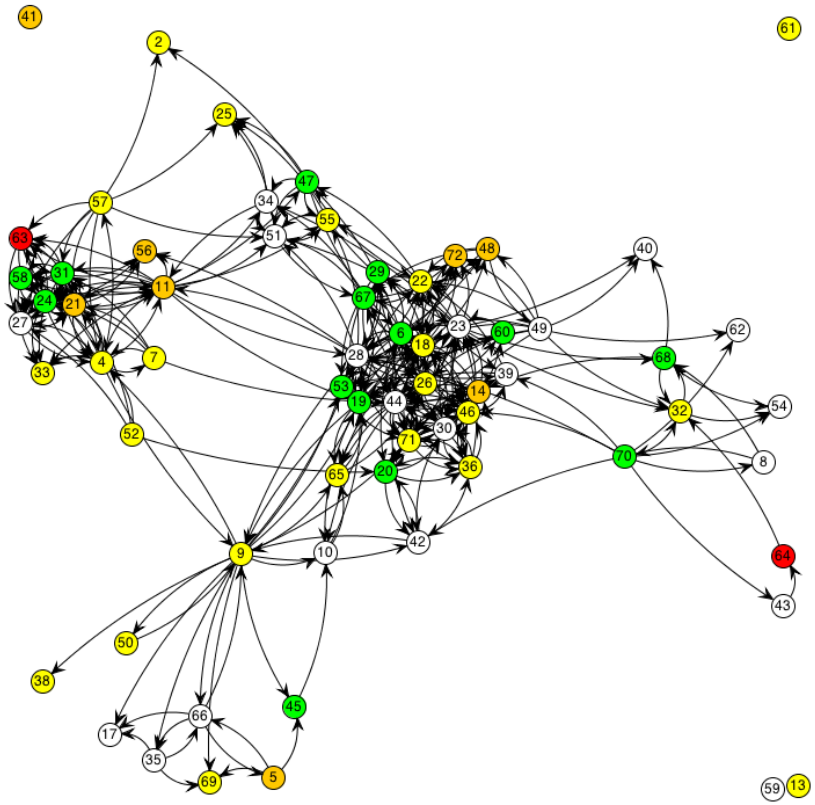


Data Observations

- People with many friends tend to change their friends more often than people with fewer friends.
- Difference in opinion influences connection forming, but not connection breaking.
- What we try to predict with the model:
  - Each individual's self perception of health tends towards the average health opinion of the network
  - Average health opinion of the network increases
  - Number of edges connecting those who socialize twice per week decreases

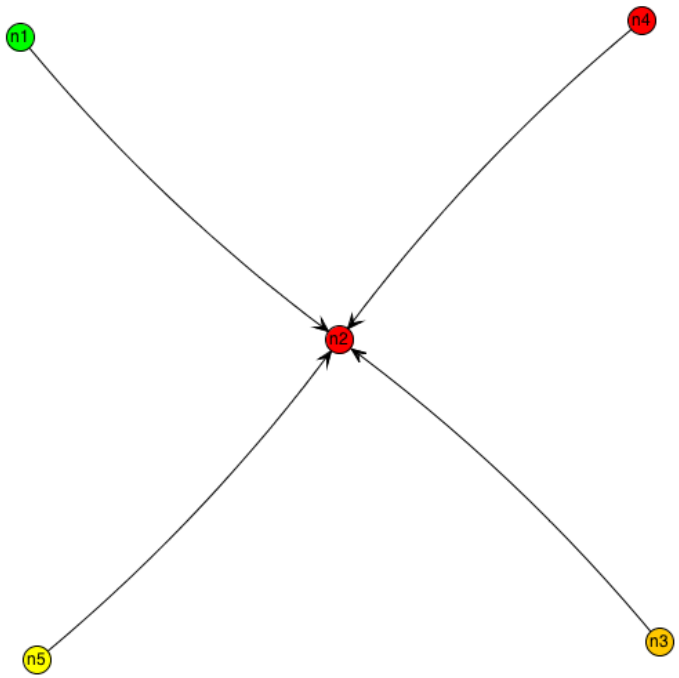
The Model

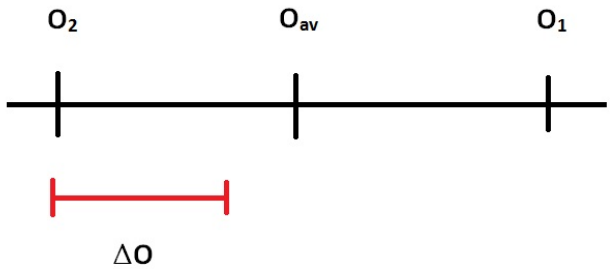
- Directed graph to fit the implications of the data
- Agent based
- Model different aspects of a society with parameters
  - C: how conservative people are
  - T: the tendency of people to increase their number of friends



Rule for Updating Opinions

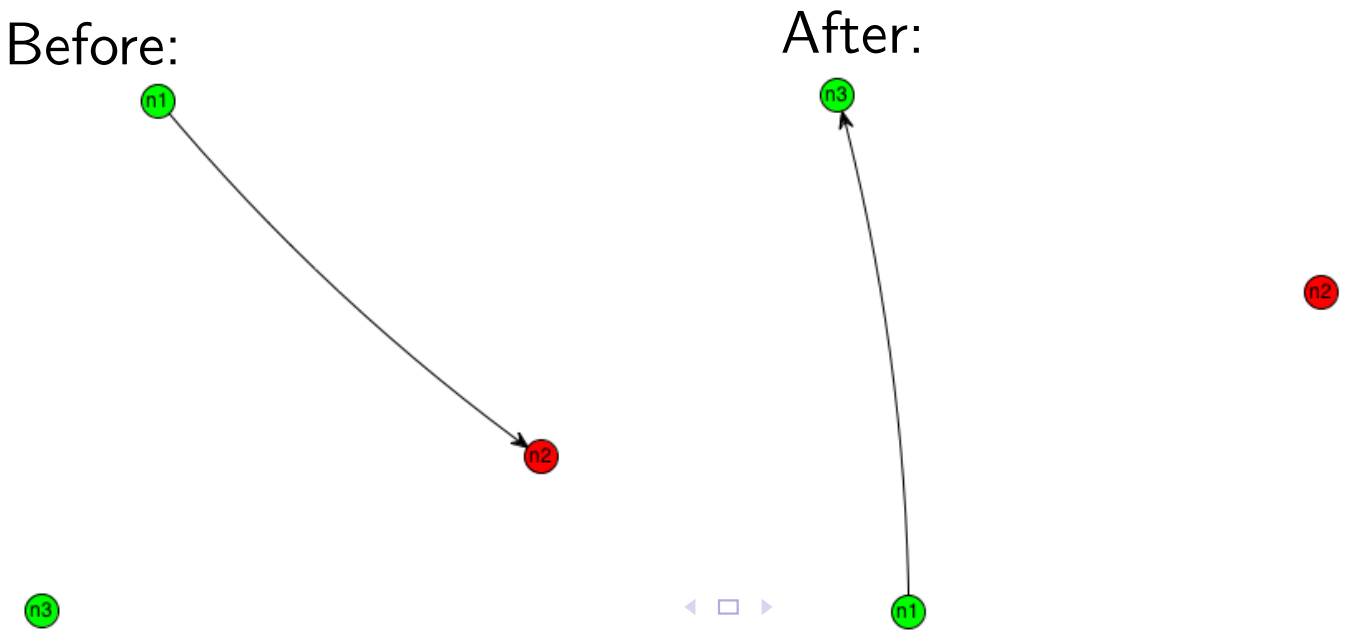
- Opinion updated in probabilistic interactions between connected nodes
- Let node n_1 influence node n_2
- n_2's opinion will move towards n_1's opinion if the threshold condition is satisfied
- Extent of opinion change is a function of C





Rule for Updating Connections

- Data suggests that connection forming depends on distance in opinion
- Connection updating done probabilistically
- Probability of changing a connection is a function of distance in opinion and T
  - High value of T: Easy to form connections, hard to break connections
  - Low value of T: Easy to break connections, hard to form connections



Bounds on the Number of Connections

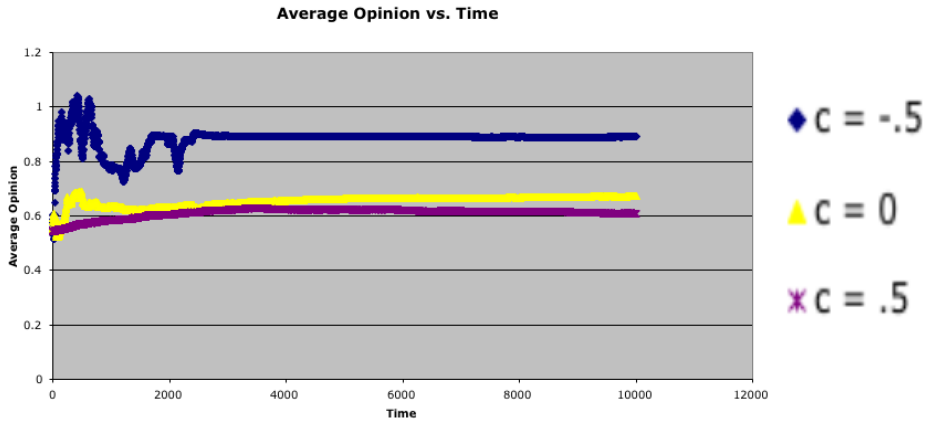
- Data suggests that less popular nodes tend to change their friends less often than popular nodes change their friends
- Place wide bounds on number of connections of popular nodes
- Place tight bounds on number of connections of unpopular nodes

Simulation Results

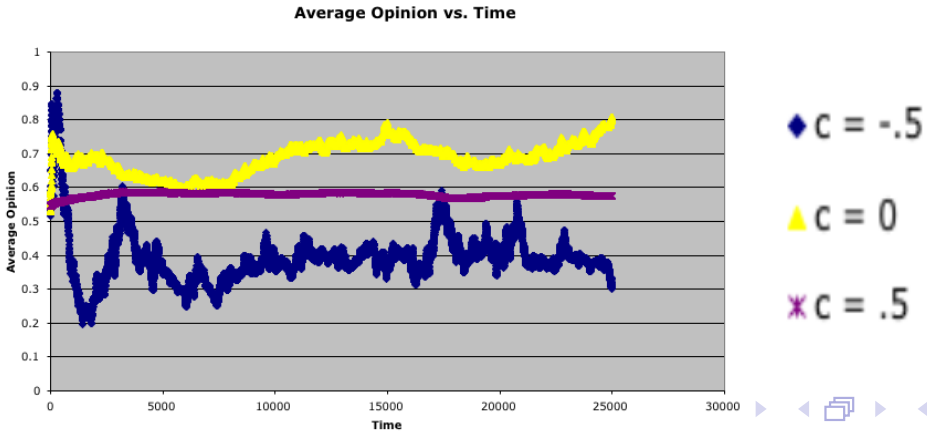
- Simulations use probabilistic interactions between nodes for opinion and connection changes
- In the simulations we used:
  - Opinion: The self perceived health of each agent
  - Graph Structure: Edges representing connections between close friends
  - Initial Conditions: The September 2008 network from the data
- Varied parameters to understand how the network behaves under different condtions
- Used bounds on number of connections for each node

Average Opinion vs. Time

- Varying C: How conservative people are
- When connections are not changing: Average opinion stabilizes

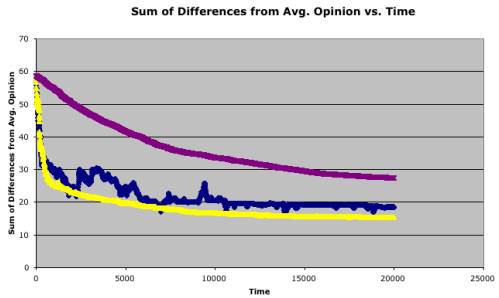


- When connections are changing: Average opinion does not stabilize



Rate of Convergence to Average Opinion of Network

- Average opinion changes, but individual opinions tend to converge within a certain bound of the average
- Use sum of differences from average opinion to examine convergence
- When connections are not changing:

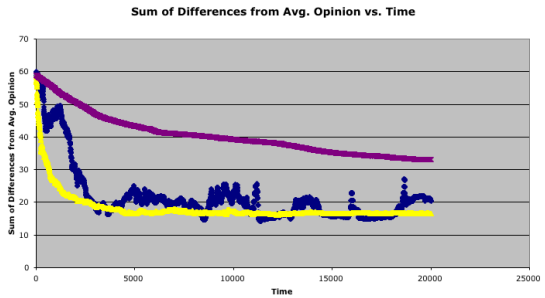


◆ c = -.5

▲ c = 0

✱ c = .5

- When connections are changing:



◆ c = -.5

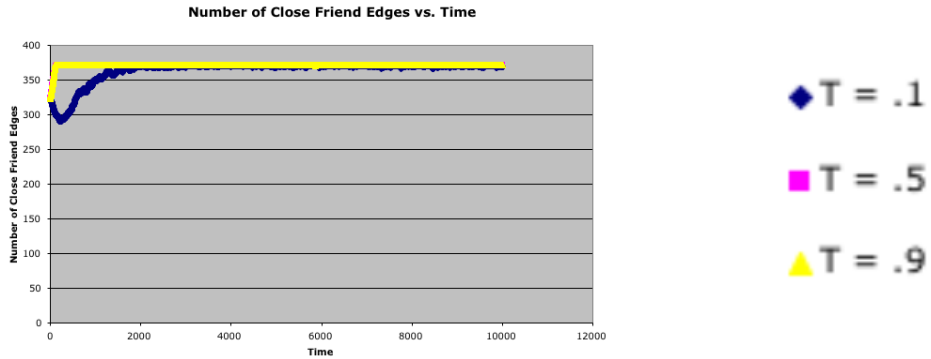
▲ c = 0

✱ c = .5

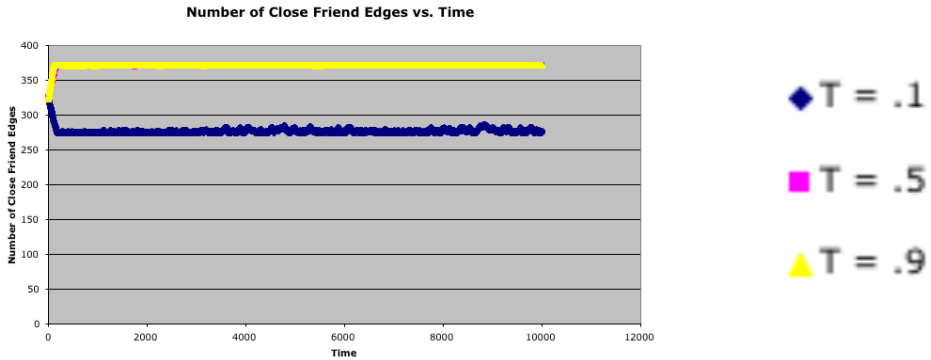
- The rate of convergence is not significantly associated with edge changing

Number of Close Friend Edges vs. Time

- Varying T: The tendency of people to increase in number of connections
- When a society converges to the average quickly: $C = -.5$



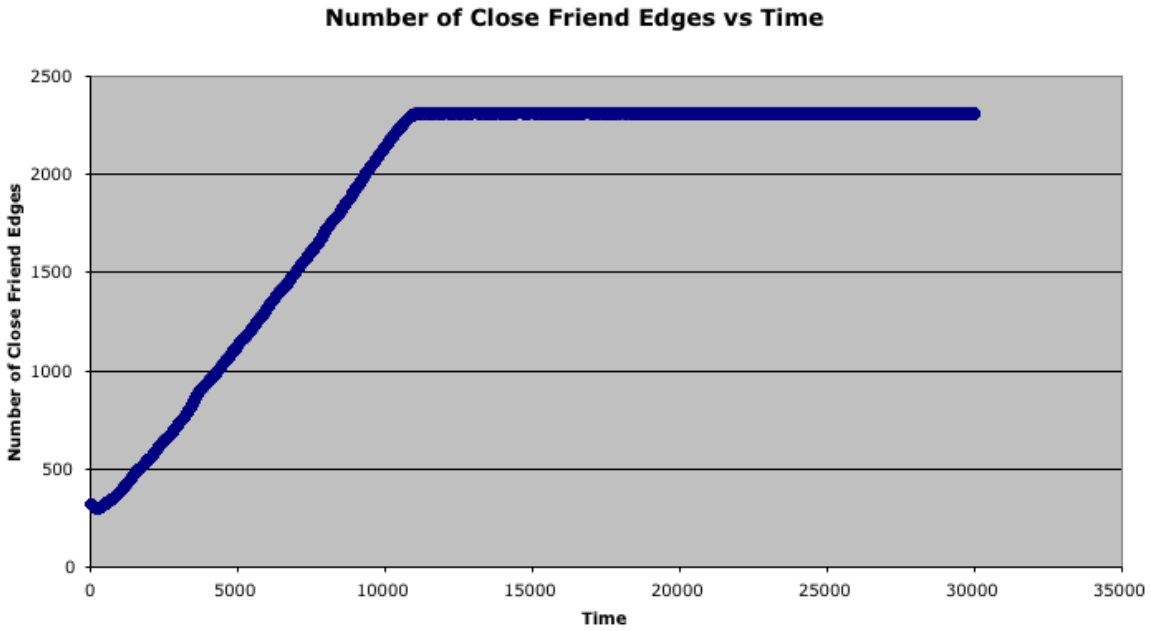
- When a society converges to the average slowly: $C = .5$



- The rate of convergence determines whether or not the edges increase or decrease for certain values of T

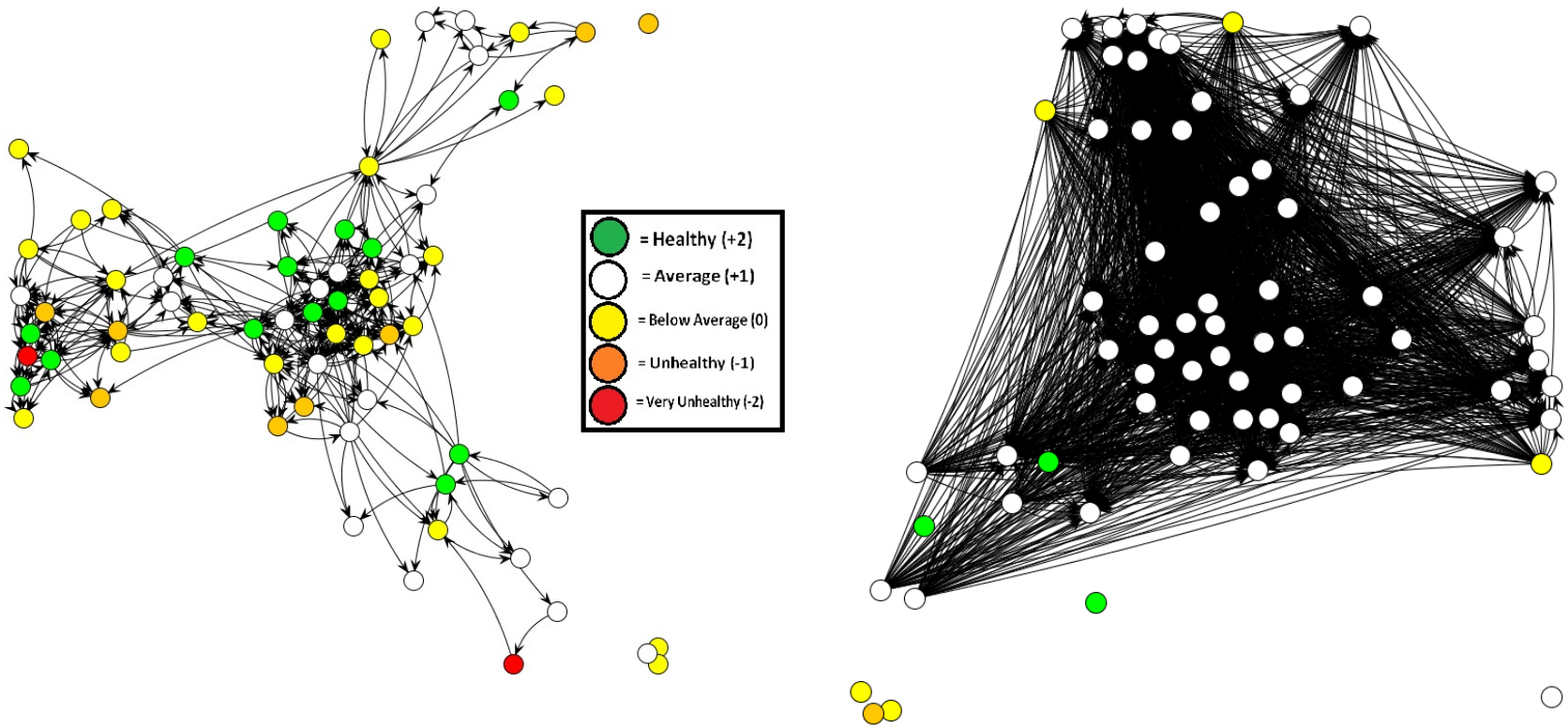
Number of Edges vs. Time With No Bounds On Degree

- Let $C = 0$ and $T = .1$:



- With no bounds on popularity, even a society that is highly intent on breaking connections will become almost completely connected over time

Number of Edges vs. Time With No Bounds On Degree



- If nodes are close in opinion, the probability of forming connections is much higher than the probability of breaking connections

Conclusions

- Observations regarding opinion spread:
  - Updating connections decreases the stability of the average opinion
  - Individual opinions approach the average opinion faster in less conservative societies
- The convergence of opinion is important in maximizing the connectivity of the network
- With certain parameters, the trends in number of edges and average opinion produced by the model reflect the changes shown in the data
- A closed network with unbounded connections tends to become highly interconnected

Future Research

- Update the model to better explain the observed data
- Develop an optimization based model for quickest opinion spread and use our understanding of the model to answer the question:
  - How can we optimize opinion propagation in a network?
- Develop a theoretical approach to understanding opinion spread in conjunction with the model
- Use different data to validate the predictive ability of the model

Acknowledgements

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