The Effect of Gossip on Social Networks

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***Abstract*—In this project we look at the effects of gossip spread on social network structure. We define gossip as information passed between two individuals A and B about an individual C who is not present, which has the potential to affect the strengths of all three relationships A-B, B-C, and A-C. This work is novel in two respects: first, there is no theoretical work on how network structure changes when information passing through a network has the potential to affect edges not in the direct path, and second while past studies have looked at how network structure affects gossip spread, there is no work done on how gossip spread affects network structure.**

***Index Terms*—Gossip, Social Networks, Network Dynamics**

I. Introduction

Gossip is ubiquitous in human groups and has even been argued to be fundamental to human society [1]. Although gossip usually has negative connotations generally no one wants to be thought of as a *gossip*, and gossiping has traditionally been viewed as an indirect form of aggressiveness it seems to have a variety of benefits, including serving to help individuals learn the cultural rules of their group [2]. [1] even proposed that gossip is analogous to grooming in primates; essentially a tool to create and maintain relationships between individuals, with little importance given to the actual information being passed.

Unlike rumors, gossip involves a single target individual, the *victim* [3]. Gossip can essentially be defined as information passed from one individual (*originator*) to another (the *gossiper*) about an absent third individual (*victim*), and therefore any analysis of gossip must occur at the level of the triad or higher [4].

Some work done on how social structure influences the flow of gossip and which network types best promote gossip [3]. We propose to do the flip side of this and see how gossip affects network structure.

Although some work done on how information passing through networks influences strength of edges it passes over (e.g. reinforcement, hebbian learning, neurons), nothing has been done on how information passed along one edge affects the strengths of other edges in the network.

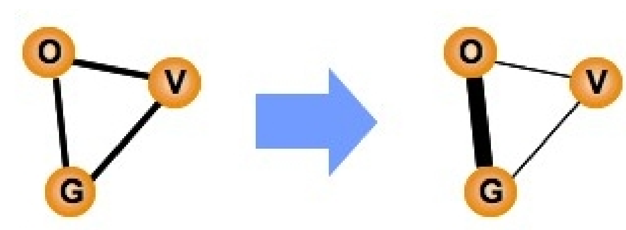

Fig. 1. Schematic for the effect of gossip on strengths of relationships of individuals in the triad. Individuals are represented as nodes and the strength of their relationship is represented by the thickness of the line between them. An originator (O) spreads gossip about a victim (V) to a mutual friend, the gossiper (G). The result is a stronger relationship between the originator and gossiper, and a weaker relationship between the victim and each the originator and the gossiper.

II. Methods

We conducted simulations on a simple network model (built in NetLogo) to understand how the spread of gossip influences social network structure.

A. Model

To simulate a single gossip event on a network we first choose a victim of gossip as a random node in the network. We choose of the victim's link-neighbors, as the originator of the gossip (Fig.2a). In the first wave of a gossip event, the gossip is spread to all the mutual neighbors, now gossipers, of the victim and originator (Fig.2b). Each of these new gossipers then spreads the gossip to their mutual friends with the victim, in subsequent waves (Fig.2c). This process continues until no new individuals become gossipers.

We assume that the effect of spreading gossip is a stronger relationship between all gossipers, and a weakened relationship between the victim and all gossipers. Links were allowed to take values between 0.005 and 1, and those links that dropped below 0.005 were severed.

To test if any results we saw were due to just strengthening and weakening connections between triads of nodes, we also ran simulations on a null-gossip network, where a single gossip event only occurred within a single triad of individuals. In other words, gossip was only allowed to spread from the originator to one other individual.

Each simulation was run for 10,000 gossip events.

B. Networks

We conducted simulations on several network types to see if the effect of gossip varied with network structure. We used random, small-world, and spatially-clustered networks. We did not consider scale-free networks since these inherently have a branching form with no triads (ref), making them incompatible with our model of gossip.

For comparison we generated small (N=50) and large (N=200) networks that were sparsely (L=6) and densely (L=12), connected. All edges were initially set to have a strength of 0.5.

C. Heterogeneity

Also tried non-random victim choice – picked node with the most connections (since gossip hypothesized to level social playing field. Tried non-random choice of originator weakest connection with victim, since expect that wouldnt pass gossip about close friends, benefit most by weakening already weak connection.

D. Statistics

Looked at average node degree, average path length, clustering coefficient, degree distributions.

III. Analysis

Four different functions have been used to change weight of the links:

- **normalized**: For increasing, $w_{n+1} \leftarrow w_n + \alpha(1-w_n)$ and for decreasing, $w_{n+1} \leftarrow \beta w_n$ in which $\alpha < 1$ and $\beta < 1$. This method has hysteresis, i.e. an increase followed by a decrease does not necessarily lead to the initial value of strength.
- **quadratic**: For increasing, $w_{n+1} \leftarrow \sqrt{w_n}$ and for decreasing, $w_{n+1} \leftarrow w_n^2$. Other powers can be used for extensions.
- **simple**: For increasing, $w_{n+1} \leftarrow w_n + \alpha$ and for decreasing, $w_{n+1} \leftarrow w_n - \beta$ in which $\alpha > 0$ and $\beta > 0$.

For the simplest case, we assume that we have only three connected nodes. Without loss of generality, we assume that A gossips to B about C (see Fig.3).

In this case, c is replaced with $c^{\frac{1}{2}}$, a is replaced with a^2 and b is replaced with b^2. After n steps of the same action, the new values are

$$a^{2n}, b^{2n}, c^{\frac{1}{2n}} \tag{1}$$

if the victim is chosen at random for each step, after n steps the new values are (assuming that n is large enough)

$$a^{2(\frac{2n}{3})\times\frac{1}{2}(\frac{n}{3})} = a^{\frac{2n^2}{9}}, b^{\frac{2n^2}{9}}, c^{\frac{2n^2}{9}} \tag{2}$$

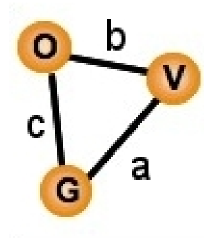

Fig. 3. A gossips to B about C

which means that when the victims are chosen at random, with further steps, the strengths of the connections weaken (until all of them tend to zero).

We can also consider a case in which the probability of choosing a victim is related to the strengths of the links in triads. For instance, when originators have more tendency to strengthen their strong connections, they might gossip with a close friend about a common friend. For this case, we can write the probabilities $P(N)$ of gossips about node N as below

$$P(A) = \frac{a}{a+b+c}$$
$$P(B) = \frac{b}{a+b+c}$$
$$P(C) = \frac{c}{a+b+c}$$

We have basins of attraction in this state space. It means that when one link is stronger than the others, it has higher chance to become stronger during iterations. This has a positive feedback effect that leads to a very strong connection and two connections that are very weak. There is still a probability that a connection that is not the strongest, become strongest over time. This change is more probable when the strengths are close to each other. Without loss of generality, we assume that $a_0 > b_0 > c_0$ in a triad. In this case, the probability that connection between nodes A and C becomes stronger in one iteration is $\frac{b_0}{a_0+b_0+c_0}$. This makes the new values of connections as follows

$$a_1 = a_0^2$$
$$b_1 = b_0^{\frac{1}{2}}$$
$$c_1 = c_0^2$$

Hence, for the next step, the probability of strengthening connection AC is

$$\frac{b_1}{a_1+b_1+c_1} = \frac{b_0^{\frac{1}{2}}}{a_0^2+b_0^{\frac{1}{2}}+c_0^2} \tag{3}$$

and so the probability of choosing connection AC for n consecutive steps is

$$\prod_{i=0}^{n-1} \frac{b_i}{a_i+b_i+c_i} = \prod_{i=0}^{n-1} \frac{b_0^{\frac{1}{2i}}}{a_0^{2i}+b_0^{\frac{1}{2i}}+c_0^{2i}} \tag{4}$$

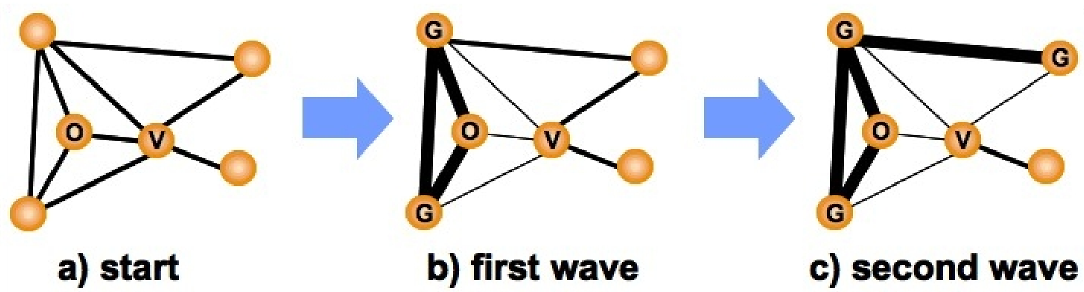

Fig. 2. Schematic for how gossip spreads in a social network. a) We randomly chose a node to be the victim (V) and one of its neighbors to be the originator of the gossip (O). b) the originator spreads the gossip to all mutual friends with the victim, strengthening connections between all gossipers and weakening all connections between the victim and gossipers. c) This process continues until no more individuals can become gossipers.

IV. Results

Many more details here figures? Tables?

at the very least discuss these: 1. null-gossip 2. spreading-gossip 2a. random networks 2b. spatially clustered and small-world 3. heterogeneity 3a. non-random victim choice 3b. non-random originator choice

some comment on convergence!

Gossip breaks up triads when it doesnt spread or random network is used BUT strengthens triads when gossip spreads in spatially clustered network

A priori expect that by breaking links (note: no way to form new links) that network will become more fragmented

V. Discussion and Future Directions

Simple:

- drop connections if they fall below a certain threshold
- in model2: have 'impact' of gossip change as you go down with each step away from original gossiper
- in model2: if A gossips to five secondary individuals (B1,B2,...) about C, does A-C increase 5x over?
- on-random node choice: pick nodes with respect to their overall connectedness (either picking strongly or weakly connected individuals more)
- on-random edge choice: stronger (or weaker) edges are more likely to have gossip passed along them

Alternative gossip rules are as follows:

- try positive (instead of negative) gossip: pick V-shaped connection (see figure), add B-C connection
- possibly strengthen A-B since gossip increases trust. Alternatively assume that if B shares with A positive gossip about C, A diverts time from her relationship with B and starts hanging out with C, so weaken A-B instead.
- start from a sparse random network and see if we get a complete network?
- NOTE: is this a reasonable model for positive gossip? if nodes are only increased in strength, network will never converge...
- how do networks resulting from positive vs negative gossip differ?
- (a priori expect that positive gossip will result in the network becoming more connected)
- combined gossip types: pass both positive and negative gossip through network, vary

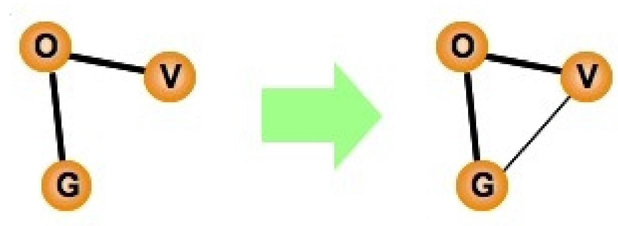

Fig. 4. Schematic for positive gossip (as opposed to negative gossip as depicted in Fig.1).

- if A gossips to B about C: B weakens A-B and strengths B-C
- let all links (friendships) grow over time according to some function. gossip events change link location on curve (negative moves down, positive moves up).

Adding heterogeneity:

- individual variation: tendency to gossip, gossip target, impact of gossip
- individual behavior: individuals can choose to pass on the gossip, ignore it, or reject the gossiper and sever the connection
- How do individual properties (e.g. range of social circle, poverty, wealth, the information itself, or geographic location) speed up or slow down the spread of gossip?
- Can individuals influence their location in a network (e.g. increase centrality) by changing their gossiping frequency?

VI. Acknowledgments

We would like to appreciate Santa Fe Institute for giving the opportunity to work on this project. We would also like to appreciate Dr. Tom Carter for all his helpful comments.

References

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