Seeding on Moving Ground: How Understanding Network Instability Can Improve Message Dissemination

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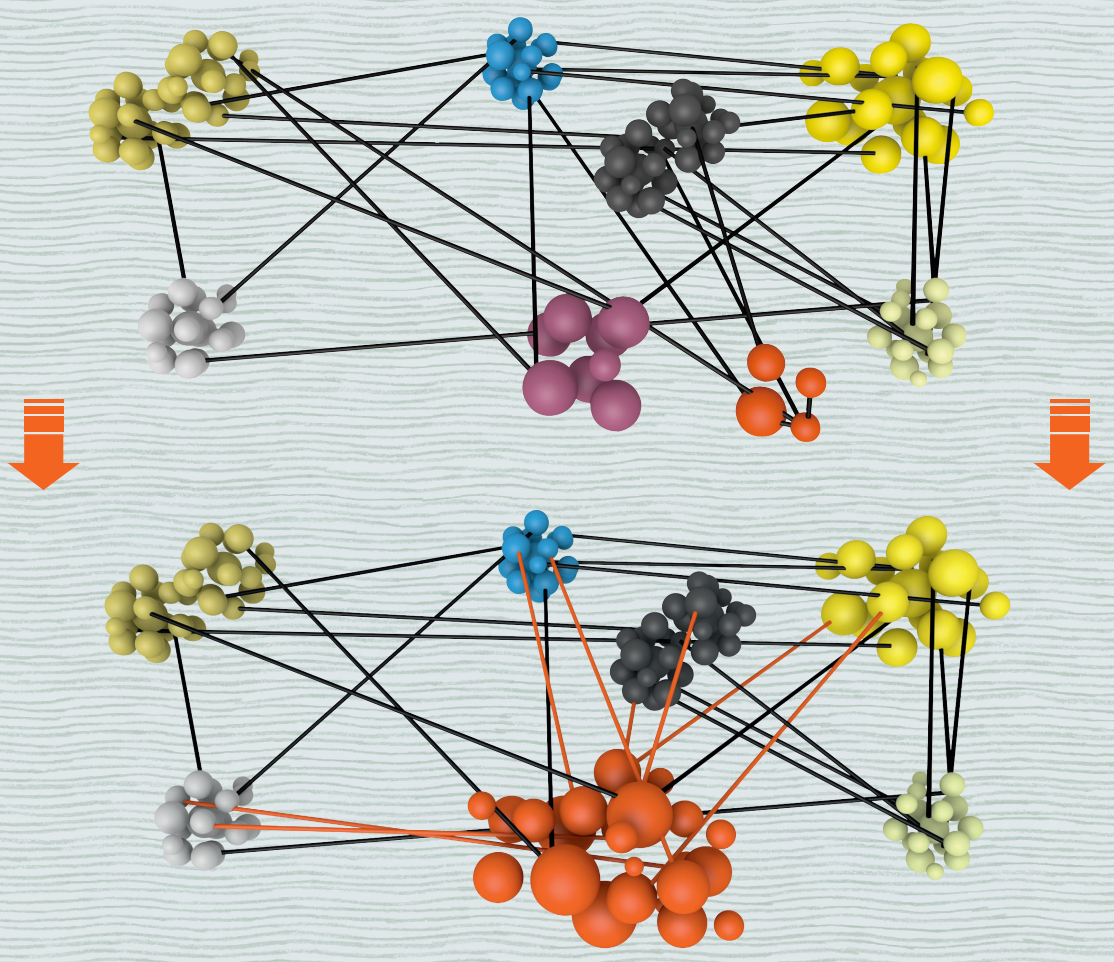
The practice of using social networks to spread information /// Companies increasingly leverage online social networks to spread their messages. A common practice is to seed information cascades by approaching a predefined set of influencers. In many cases these special individuals are identified by their position in the network – often some kind of centrality – and the structure of their network neighborhood. That information is usually extracted from past measurements, under implicit assumption that the network is stable and past observations are plausible proxies for the current structure. But, as we explain below, it is not as simple as it may appear.

Although networks are pivotal in the dissemination of content between individuals, our understanding of the relationship between the individuals and how content and structure change over time is still limited. It's virtually impossible to predict how specific changes in the network structure reflect on the network processes such as information cascades or changes in consumer behavior. We also lack understanding of how the information spreading through the network affects its structure. Some of the assumptions that underlie current search and recommender systems have not been tested sufficiently.

FIGURE 1:
Networks evolve through local bursts affecting structure and interests simultaneously



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In a burst of activity, network members change both the content they are interested in and the members they are connected to.
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Common assumptions about networks should be questioned ///

Steadiness and continuous evolution? Most analyses of the social structure of a network implicitly assume that the relationships in the network are relatively stable. This assumption follows directly from theories of network evolution that posit that networks grow monotonously, with links added sporadically around the network. One of the main forces that drive network evolution is assumed to be the network itself. For instance, people that have many common friends tend to develop ties with much higher probability than the ones that don't. We are used to viewing network growth as occurring at a regular, monotonous pace and do not expect networks to change radically over time. While monotonous-like patterns

of network evolution seem reasonable, there is little empirical evidence to support that assumption.

Stable clusters? Another trait that is assumed in a strong way, perhaps implicitly, is the stability of similarity between connected individuals, or homophily in academic terms. This similarity is one of several principles that are typically invoked to explain network evolution. It implies that people tend to connect to people who resemble them: the "birds of the feather flock together" principle. New links are likely to be formed when individuals share some common traits. As a result of this principle in action, a network typically contains clusters made up of similar people, and peer influence can drive connected people to become more similar.

How similar is similar? Another critical issue of many network studies is how they measure similarity. Most studies compile a very limited set of parameters such as age, gender, political affiliation, community membership, etc. into some similarity measure. These are easy to measure, but, even if taken together, these variables represent an unusually small number of aspects of human existence and a very superficial and mostly context-independent view of what makes people similar or different. We are not sure whether these are even the features that have the greatest impact in motivating people to connect to others. They are simply the information that is most easily collected. Nonetheless, we have been generalizing from such limited sets of traits to determine that two individuals are similar in a way that is meaning-

{*Box 1*}

CHECKING THE ASSUMPTIONS OF WIDELY USED SEARCH AND RECOMMENDER SYSTEMS

In our research we addressed some of these assumptions and methodological concerns. Specifically, we tracked how links are added and deleted in a specific network over time, and we measure similarity among network members on added and deleted links, using self-reported interests – a new more sensitive, comprehensive and context-dependent measure of similarity. We also explored the connection between changes in similarity and changes in network structure over time. The data we collected represents the evolution over one year of LiveJournal (LJ), a social network of nearly 10 million individuals. It is based on a popular online blog platform where members publish posts on a wide range of issues. Each LJ user maintains an individual set of "friendship" relationships and a list of bookmarked blogs. Friends have access to privately published content and receive an automatically generated personalized news feed.
Employing a sequence of snapshots over the period of about one year, we measured the similarity of interests among LJ members by using members' own profiles, which typically contain up to 20 areas of interests. We used members' friendship lists to track changes in the ties among network members. We also drilled down to a finer resolution by tracking the evolution of a sample of this network (83 snapshots of 359 random users along with their friends and friends of their friends) and monitoring their status twice per day.

ful for network evolution. Further, previous studies typically make no connection between two important parameters of network evolution: the interrelation of similarity effects and structural evolution.

New insights on social network traits ///

Networks grow in bursts /// The evolution of the LJ network challenges the common assumptions about network growth in two respects: The network grew in bursts rather than monotonously over time, and these bursts were highly localized; that is, links were added and deleted in nearby localities and are not randomly dispersed throughout the network.

Bursts favor local clusters /// These bursts produce neighborhoods that become more densely linked within themselves. Densification is accompanied by increasing isolation of the active area from the remainder of the network. In other words, bursts and localization of new link creation in social networks lead to formation of well-pronounced clusters within the network.

Changes in ties lead to simultaneous changes in interests /// Even more surprisingly, we found that the local bursts of changes in the ties between network members coincide with a local increase in similarity among members of the target network section. People report changes in their interests and almost simultaneously alter their network ties. Figure 1 illustrates the local changes: In a burst of activity, network members change both the content (color) they are interested in and the members they are connected to. The rest of the network remains relatively unaffected. Another way of saying this is that the network selection and influence processes occur almost simultaneously with an elevation of the cluster-building of similar individuals.

In our opinion, the simplest and most straightforward explanation for this pattern of close co-evolution is that it is driven by strong feedback between content and structure. The two seemingly unrelated network processes turned out to be strongly coupled, and this coupling can lead to complex, still unstudied processes that govern the evolution of online social networks.

How to improve social network analysis marketing /// Our findings suggest several easily implemented improvements in SNA marketing applications currently in use.

- ***Update knowledge on networks of interest more frequently*** /// Managers typically measure and analyze what they define as a network of interest at a single point in time and may use this information several months or years later to design seeding or recommendation systems. If the network keeps on changing in unpredictable ways and not all parts of the network are affected equally, the network analysis that marketers use for seeding has a shorter shelf life than marketers believe. Local bursts around the seed can change the structure of the network dramatically and therefore a marketer's influence and his chances of success. Network measurements should be carried out more frequently and closer to the actual implementation of a seeding campaign.

- ***Use a finer granulation for analysis*** /// Another popular application of network analysis in marketing is monitoring of network chatter to find evidence of negative feedback, complaints, etc.

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Typically, specific sections of a network are selected for monitoring, with the belief that it matters little when or where this sample is taken as long as it is statistically representative of the entire population. According to our study the interests and ties among networks may change significantly from the time of the initial analysis to the actual marketing implementation in some parts of the network, while other parts of the network are unaffected. To detect these abrupt, dramatic local changes marketers should not only conduct network analysis more frequently but also use a finer resolution. If they are able to identify local bursts of change and to identify which communities in the market have been affected by such local changes, they are able to adapt their strategies accordingly. Therefore, measurements should not only be conducted more frequently but also in a more fine-grained manner that uses more comprehensive and relevant measures of connectedness.

> ***Use the right measures for similarity*** /// Common similarity measures, like age, gender, political affiliation and community membership, might be too superficial to actually predict connectedness. Using any available self-reported interests can deliver a new more sensitive, comprehensive and context-dependent measure of similarity and may represent a better basis for identifying the best influencers in a network.

Overall, our findings point to an opportunity to greatly improve prediction and recommendation algorithms. Armed with an understanding that changes in network structure and content can be relatively sudden and are limited to local areas of the network, we can develop methods to identify the areas affected by the change. There, methods simultaneously accounting for the network structure and content can be used to quantify the change and understand its practical implications.

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ORIGINAL ARTICLE

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