Information Contagion:
An Empirical Study of the Spread of News on Digg and Twitter Social Networks

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Online social networks have become important channels for the spread of timely and relevant information
Information flow on networks

Network 1

Network 2

http://www.flickr.com/photos/27318782@N03/4639307471/

http://www.flickr.com/photos/27318782@N03/4639307923
Dynamics of Social Information

How does information spread on online social networks?

• How far and how fast does information flow on networks?
• What factors influence its spread?
• How does the network structure affect dynamics of information flow?
• What does this tell us about the quality of information?

Study these questions through a comparative empirical analysis of two social news networks

• Using URLs as markers for tracking the flow of information
Social news: Digg

Users submit and vote for (digg) news stories

Users join networks to see
- Stories friends submit
- Stories friends vote for

Digg features stories with most votes on its front page
Social news: Twitter + Tweetmeme

Users tweet and retweet* URLs to news stories

*‘Retweet’ = tweet someone else’s post
“RT @x failed bomb plot http://bit.ly/xmas09”

Users join networks to see
- Tweets by users they follow
- Retweets by users they follow

Tweetmeme aggregates all tweets and features most retweeted URLs on its front page

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Social news: Data sets

Digg
- Stories
  - 3,553 stories, promoted in June, 2009
    - Time submitted, promoted
  - Votes for each story
    - Time of the vote
    - Name of voter
- Active users
  - 139,409 who voted for at least one story
  - 71,834 of them following at least one user
  - 258,220 links
  - fan network

Twitter
- Stories
  - 398 most retweeted stories 6/11/09—7/3/09
    - extracted from Tweetmeme
  - Retweets of each story
    - <1000 most recent retweets
    - Time of retweet & user name
- Active users
  - 137,582 who retweeted at least one story
  - Following/follower relations through Twitter API
  - 6,200,051 links
  - follower network
Questions

Usability of Social News
• Do people use Digg and Twitter the same way?
• What effect do differences in the user interface have?

Dynamics of Social News
• How far does information spread on networks?
• How fast does information spread on networks?
• What is the role of network structure?
Basic terms

Submitter

- user who submitted link to a story
- user who first tweeted link to a story

Vote

- digg
- retweet

Fan of user A

- user watching A’s activity on Digg
- user following A on Twitter
User activity: distribution of fans

- Typical number of followers on Twitter ~10, but can be millions
- No typical number of fans on Digg – “long tail”
User activity: distribution of voting

- “Long tail” distribution of user activity
- Difference in slope related to effort of activity [cf Wilkinson 2008]
Dynamics of stories

1: U.S. Government Asks Twitter to Stay Up for #IranElection
2: Western Corporations Helped Censor Iranian Internet
3: Iranian clerics defy ayatollah, join protests

1: US gov asks twitter to stay up
2: Iran Has Built a Censorship Monster with help of west tech
3: Clerics join Iran’s anti-government protests - CNN.com
Dynamics of stories

• Two distinct phases for Digg stories: upcoming and promoted
• Number of votes on both sites saturates after one day
• Saturated value reflects story popularity
Popularity of stories

• Aggregate over all stories to factor out influence of submitter and story quality
• "Inequality of popularity" – some stories much more popular than others
cf social influence study of [Salganik, Dodds & Watts, 2006]
Information flow on networks

Information spreads on a network as fans (followers) vote for (retweet) stories their friends submit or vote for.

... fan votes – i.e., votes from fans
Dynamics of information spread on networks

Digg

Twitter

- Evolution of fan votes qualitatively similar to that of all votes
How far does information spread on networks?

- “Inequality of popularity” no longer observed (social influence accounted for?)
- News spreads farther on Twitter social networks
- On Digg, all stories receive fan votes
How far does information spread among submitter’s fans?

- Most stories on Twitter are never retweeted by submitter’s followers
How fast does information spread on networks?

- Two distinct phases on Digg: stories spread faster through the network before promotion than afterwards
- Twitter stories spread at a uniform rate, but with greater variability
How fast does information spread on networks?

Probability next vote is from a fan

- Two phases on Digg: stories spread faster before promotion than after
- Twitter stories spread slower than Digg stories before promotion, but faster than promoted stories
Network structure

Network sample size

- Digg: 279,725 users
- Twitter: 6,200,051 users

Network density

- Fraction of reciprocal links (i.e., mutual fans)
  - Digg: $f_m = 3.20 \times 10^{-6}$
  - Twitter: $f_m = 2.07 \times 10^{-7}$
- Modified clustering coefficient (fraction of cycles, e.g., $A \rightarrow B \rightarrow C \rightarrow A$)
  - Digg: $f_c = 7.60 \times 10^{-12}$
  - Twitter: $f_c = 1.92 \times 10^{-14}$

Digg network is denser, more inter-connected than Twitter’s
Summary of results

Network structure and information flow

- Digg’s network is denser than Twitter’s
  - News spreads faster initially through Digg’s network than Twitter’s
  - But, it does not spread as far as on Twitter
  - Fans who vote for a story on Digg are also submitter’s fans
- Twitter’s network is sparse
  - Fans unconnected to submitter help spread the story

User interface and information flow

- Before promotion, Digg stories spread mainly through the network
  - Similar to story spread on Twitter
- After promotion, stories spread mainly outside the network
  - Promotion increases story visibility outside the network
  - No equivalent mechanism on Twitter
Related work

- Information flow on social networks
  - Email chains [Wu, Huberman, et al, 2004]
    - Email forwarding chains terminate after a few steps
    - Information flow is slowed by decay in similarity among individuals in a social network
  - Product recommendations [Leskovec, Adamic & Huberman, 2006]
    - Word-of-mouth recommendation chains terminate after 1 or 2 steps
    We find significantly large information spreading chains

- Information diffusion through blogosphere
  - Spread of topics through blogosphere [Gruhl & Liben-Nowell 2004]
  - Information cascades through blog posts [Leskovec et al, 2007]
    - Power law distribution of cascade sizes
    We find a normal distribution of cascade sizes (number of fan votes)
  - Networks derived from observed interactions, rather than declared links (as on Digg, Twitter)
Conclusion

Comparative empirical analysis of online social networks and social news on Digg and Twitter

• Similarities
  • Networks are used on both sites to spread news
  • Information flow on Digg before promotion is similar to information flow on Twitter

• Differences in dynamics can be explained by user interface and network density
  • Digg’s user interface gives high visibility to promoted stories
    • Promotion slows information spread
  • Digg’s network is denser than Twitter’s
    • Affects how fast and how far news spreads

• Dynamics of information flow as a gauge of information quality
  • Social dynamics of Digg [Hogg & Lerman, poster][Lerman & Hogg, WWW 2010]