

# Recommender Systems

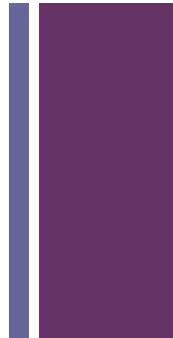
## Trust-based Recommendation

Professor Robin Burke  
Spring 2019

Thanks to Jennifer Golbeck for some materials



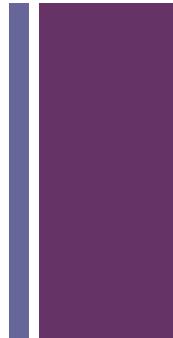
# Outline



- Recommendation in networks
- Trust-based recommendation
- Random walks in bipartite networks
- Maybe start on Learning to Rank
  - Not really covered in the book
  - Note readings posted on Canvas
    - Rendel, et al. “BPR: Bayesian Personalized Ranking from Implicit Feedback”, UAI 2009
    - Shi, et al. “CLiMF: Learning to Maximize Reciprocal Rank with Collaborative Less-is-More Filtering”, RecSys 2012



# Just for fun



- A real “click farm”
- [https://dms.licdn.com/playback/C4E05AQFuYGo\\_Gxvx8w/092ed4917560458f8ca6700ebf8c4d39/feedshare-mp4\\_3300-captions-thumbnails/1507940147251-drlcss?e=1554850800&v=beta&t=rocKfGSZM5xRbdhjS05pC4Y4hUCRrw97FrQ2Mza3zjA](https://dms.licdn.com/playback/C4E05AQFuYGo_Gxvx8w/092ed4917560458f8ca6700ebf8c4d39/feedshare-mp4_3300-captions-thumbnails/1507940147251-drlcss?e=1554850800&v=beta&t=rocKfGSZM5xRbdhjS05pC4Y4hUCRrw97FrQ2Mza3zjA)



# Trust-based Recommendations

- Trust-based recommendation
  - In addition to regular user/item data
  - You have trust links between users
    - Could be friends or other links
    - May also have “distrust” links
- Should really be called “explicit trust relation”-based recommendation
  - Because trust is a complex concept



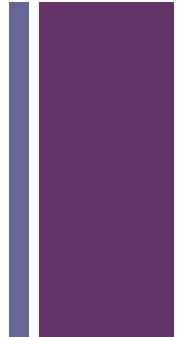
# Trust



- Trust is a social concept
  - Inherently about relationships
  - We have trust relationships to people we know
    - But also to strangers (police, nuclear power plant operators)
- Trust is asymmetric
  - A child trusts his or her parents, but not quite so much the other way around
- This is a context-dependent concept
  - I might trust my child to drive to the store, but not when the roads are very icy
- Trust in our sense is about relying on others' judgement
- Fundamental to collaborative filtering!
  - You are trusting peers to deliver good recommendations
  - You are trusting the system to aggregate in an effective way



# Questions

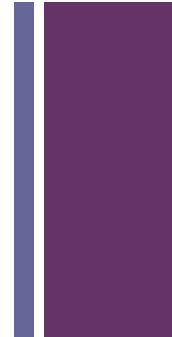


- Are explicitly trusted peers better than peers chosen by kNN?
- Answer
  - Yes, often
- Can we use a measure of trust instead of a peer similarity calculation
- Answer
  - Yes, often



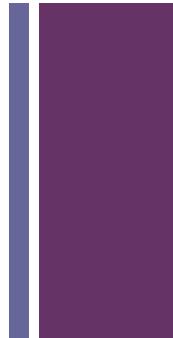
# Trust Sparsity

- Friend groups are pretty small
  - And often homogeneous
- Problems
  - Not enough trusted peers
  - Direct peers likely to have similar profiles to you
  - Not enough options for recommendation





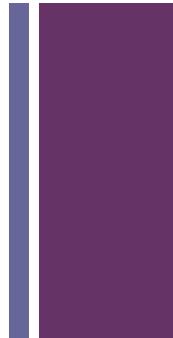
# Trust Transitivity



- So trust-based recommendation becomes a problem of trust transitivity
  - Given a source node, and a target node (sink)
  - What degree of trust can be inferred for the target?
- If we can calculate trust for many users
  - We don't need the user to provide many trust values



# Direct trust

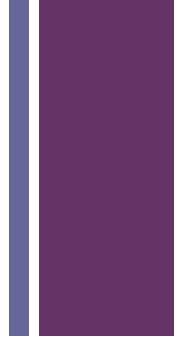


- **We assume that we can evaluate the relationship between two users who are directly connected**
- **This could be explicit**
  - "Friend" connection or not
- **It could be implicit**
  - How often you "like" their posts, how often you are tagged in photos together, etc.
- **Assume there is some set of indicators  $i(x)$** 
  - Weights associated with each

$$\text{trust}(\text{ego user}, \text{friend}_x) = \frac{\sum_{i \in I} i(x) * w_i}{\sum_{i \in I} w_i}$$



# Normalizing trust

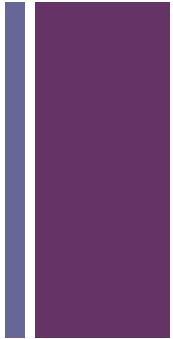


- Need to look at all of a user's connections
  - Normalize the indicator inputs by the maximum over all friends
- Otherwise highly-active users will look very different from less-active users
  - $i(x)$  becomes

$$\frac{i(x)}{\max_{z \in \text{friends}(u)} i(z)}$$



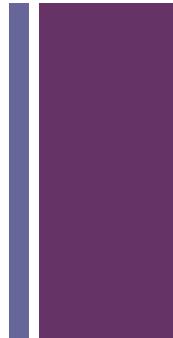
# Indirect trust



- Have to assume that trust is (to some extent) transitive
  - A trusts B
  - B trusts C
  - A trusts C
    - But how much?
- Different algorithms
  - TidalTrust
  - MoleTrust
  - Others



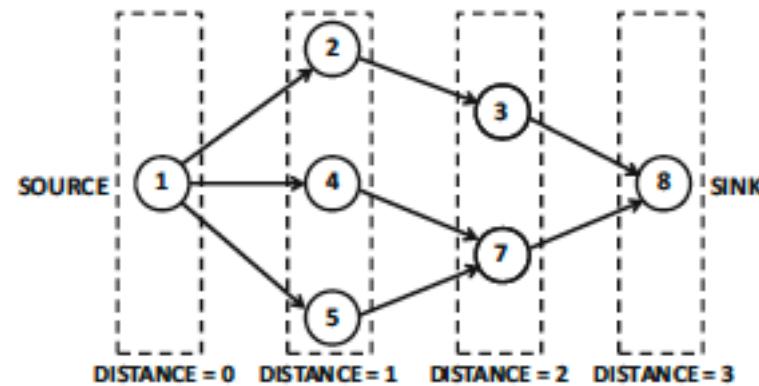
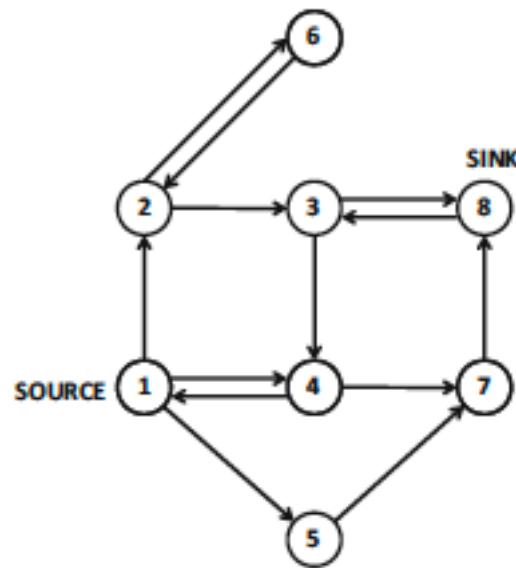
# TidalTrust



- *Uses network built by direct trust algorithm*
- *Uses shortest paths to the sink*
- *Forward step*
  - *Find the minimum weight edge on each path*
  - *Find the maximum of these minima  $\beta$*
- *Backward step*
  - *Retain only the edges with trust  $\geq \beta$*
  - *Recursively compute weighted sums of trust values*



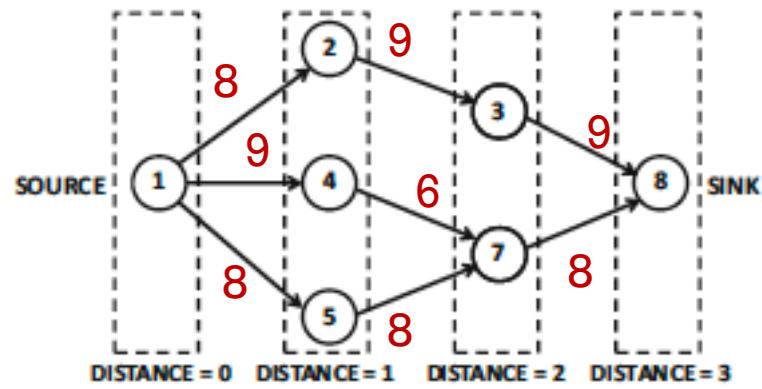
# TidalTrust





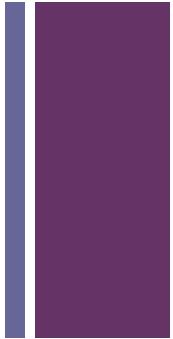
# TidalTrust

- Forward step
  - 3 paths
    - Mins = 6, 8, 8
  - $\beta = 8$
- Backward step
  - Remove edge 4-7 so this path no longer exists
    - Two paths
  - $T(3,8) = 9, T(7,8) = 8$
  - $T(2,8) = 9, T(5,8) = 8$
  - $T(1,8) = (9 * 8 + 8 * 8) / 16 = 8.5$





# MoleTrust

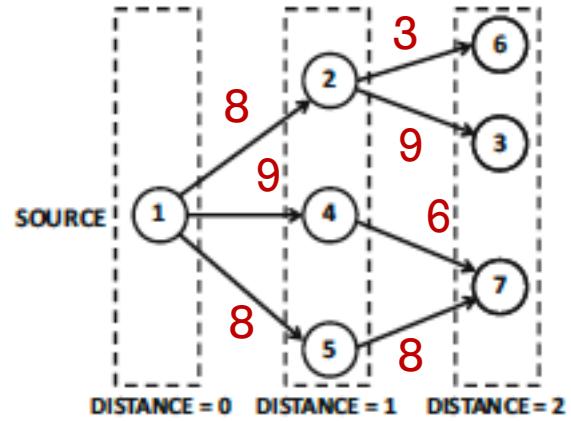


- Computes for all possible sinks from a given user
  - Given a maximum distance  $\delta$
- Assumes a user-specific threshold  $\alpha$
- Find all shortest paths to nodes of maximum distance  $\delta$
- For each path, compute trust forward
  - Using a similar weighted average



# MoleTrust

- $\delta = 2$
- $\alpha = 5$
- Remove edge 2-6
- $T(1,7) = (9*6)+(8*8)/15 = 7.8$
- $T(1,3) = 8$
- Slightly different from TidalTrust values
  - Can be computed for all nodes at once





# Trust-aware recommendation

- Substitute for kNN-based neighborhoods
  - If you have explicit trust information
- Trust transitivity required in realistic contexts
- Note: The term “trust” is sometimes used in other ways in the research literature



Both MoleTrust and TidalTrust depend on the idea of multiple trust paths and rely on the least-trusted path to prevent undue influence of any single individual. An attacker who manages to get someone in the network to trust them highly can:

- A. Not do that much harm because of the way the algorithms are designed.
- B. Get other nodes to become highly trusted as long as no one else is connected to these nodes
- C. Get any node in the network to become highly trusted

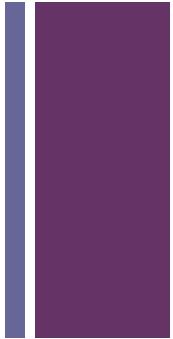


# Others methods

- Factorization / spectral decomposition of trust graph
- Graph regularization
- Network embedding
- Etc. etc.
- Basic idea is the same
  - Create some representation of the network
  - Enables users to be compared based on social distance



# Trust-aware recommendation



- Explicit user trust in particular
  - Can be a pretty strong signal
  - 1 trusted peer  $\approx$  10-15 ratings
- But
  - Users typically provide few such links
  - Hard to gather good information on trust relationships
    - (like context)
  - Some users may be gullible
- Trust transitivity required to incorporate into collaborative recommendation
- More typical in practice
  - Recommendations explicitly from connections
    - “Joe liked this musical artist.”