



# **SocialLink: Utilizing Social Network and Transaction Links for Effective Trust Management in P2P File Sharing Systems**

Kang Chen<sup>1</sup>, Guoxin Liu<sup>2</sup>, **Haiying Shen<sup>2</sup>** and Fang Qi<sup>2</sup>

<sup>1</sup>Dept. Of ECE Southern Illinois Univ.  
(The work was done when at Clemson)

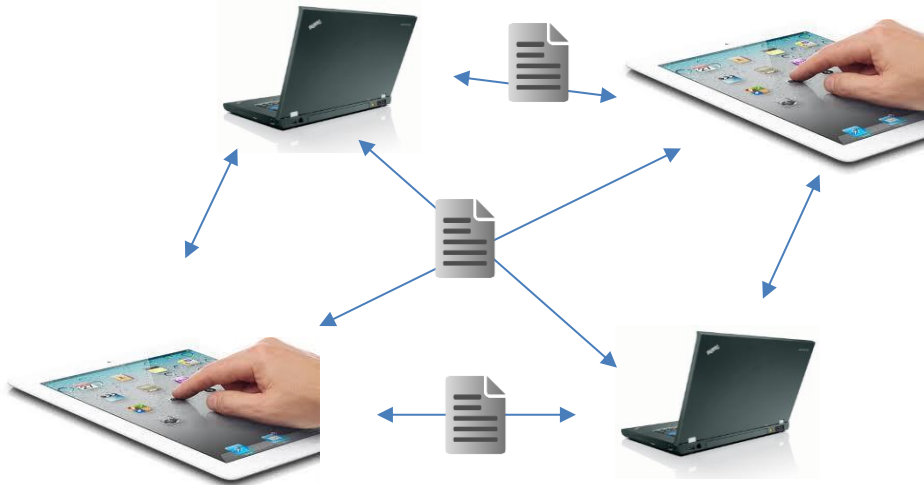
<sup>2</sup>Dept. of ECE, Clemson Univ.

# Outline

- Introduction
- Related Work
- System Design
- Performance Evaluation
- Conclusion

# Introduction

- P2P file sharing systems
  - Better exploit available file & bandwidth resources
  - But are prone to have free-riders and malware distribution
  - In one test
    - 85% of Gnutella users are selfish
    - 44% of files downloaded through Kazaa contained malicious code



# Introduction

- Reputation systems are invented
  - Record behaviors for reputation evaluation
  - Judge good or bad based on a threshold
  - Are good but still suffer from attacks
    - Free-riding: maintain reputation slightly above the threshold
    - White-washing: creating new accounts
    - Collusion: maliciously manipulate the reputation systems



I am good!



I am good too!



I am better!

# Introduction

- Emerging social networks can help
  - Friendship fosters collaboration
  - Friendship discourages malicious behaviors
  - Online social networks reflect friendships in the offline world



# Introduction

- Social networks have limitations
  - Not originally designed for file sharing
  - Friendship is arbitrary in certain social networks
  - Limited coverage, which means limited file resources
- Solution
  - Combine a social network and reputation system
  - Social network helps identify reliable servers
  - Reputation system extends the coverage of social networks

# Related Work

- Reputation management system [WWW'06, TKDE'08'10, TPDS'07'10]
  - Evaluate peer reputations based on feedbacks
  - Can be both centralized or distributed
  - Vulnerable to aforementioned attacks
- Social network based P2P file sharing [PerCom'08, CoRR'11, ICNP'12, IPDPS'09]
  - Construct a social network based overlay for file sharing
  - Rely on social relationships to deduce trust
  - Suffer from limited coverage of social networks

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# System Design

- Main components
  - Social Network Construction
    - Online connections: reliable file sharing experiences
    - Offline connections: offline acquaintances
  - Weighted Transaction Network
    - Built based upon file sharing transactions
    - Extend server selection to non-friends
  - Server Selection and File Sharing
    - Exploits both social network and weighted transaction network

# System Design

- Social network construction
  - Offline acquaintances are added directly as friends
  - Online friends
    - Each node sets a threshold for trust
    - Only two nodes reach the threshold of each other
  - Bi-directional
  - User behavior: be cautious on adding/deleting a friend

# System Design

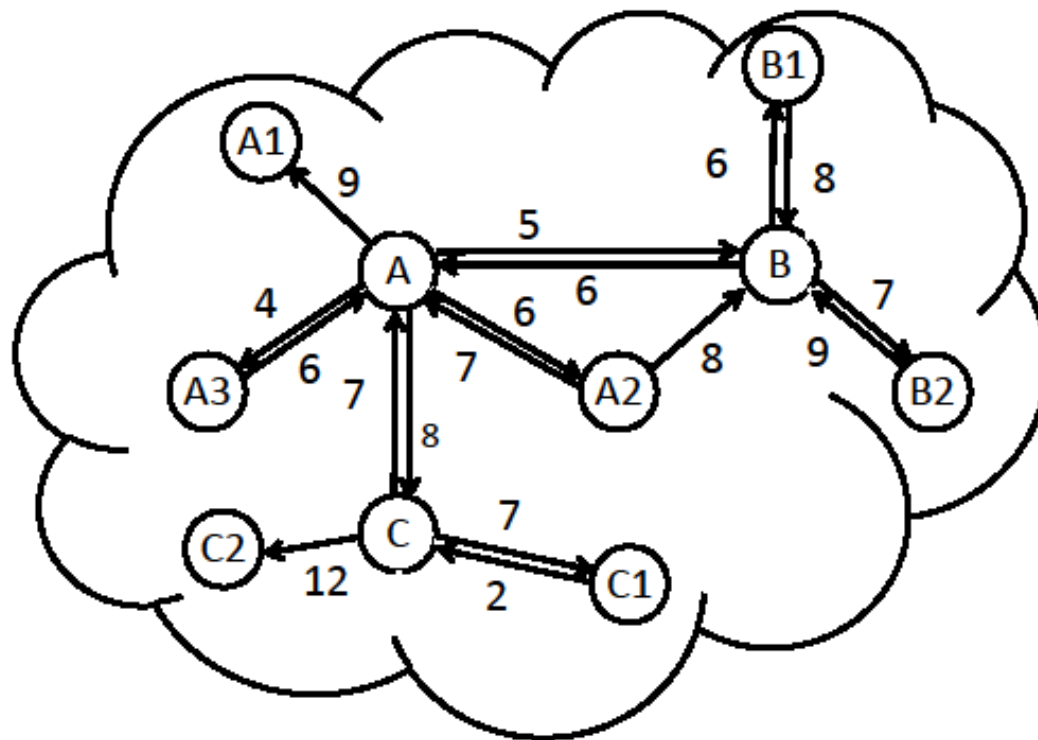
- Social network based file sharing
  - Query the P2P service center for server candidates
  - Check whether there are friends in the server list
  - If yes, select the friend as the server directly
  - If multiple, select the one with the highest trust
  - If none, rely on weighted transaction network

# System Design

- Weighted transaction network
  - Create links to connect non-friends for trust evaluation
  - Each link has a direction
    - Two nodes may not have the same trust to each other
  - Each link has a weight (file size)
    - Accumulated based on previous file sharing transactions
    - Denotes the client's trust of obtaining a file from the source
    - Ensures fair file sharing

# System Design

- Weighted transaction network



# System Design

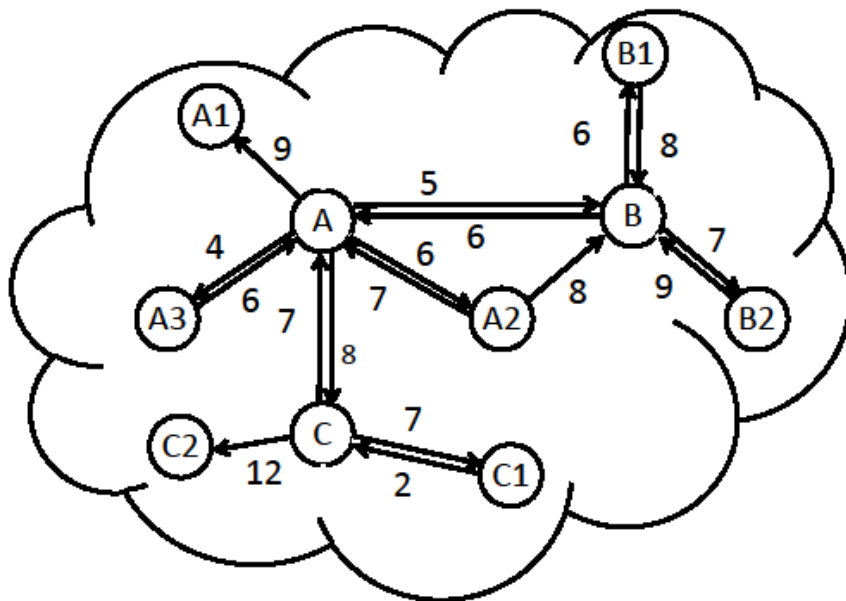
- Weighted transaction network
  - Trust of a path: smallest link weight
    - The weakest link limits the overall trust on the path
  - Trust-flow
    - The largest path weight of all paths from the server to the client
    - Denotes the file size the client can reliably download from the server, i.e., its trust to the server
  - Upload-flow
    - The largest path weight of all paths from the client to the server
    - Reflects the past transaction from the client to the server
    - For fair trading consideration

# System Design

- Weighted transaction network based file sharing
  - Query the P2P service center for server candidates
  - For each server, calculate the trust-flow and upload-flow
  - Filter servers
    - Trust-flow < size of the requested file: not trustable enough
    - |Trust-flow – upload-flow| > Thr: not fair sharing
  - Select the server with the largest trust-flow after above steps

# System Design

- Weighted transaction network based file sharing



- C1 asks a file owned by B2 with size 4
- Trust-flow from B2 to C1 is 6 through B2→B→A→C→C1
- Upload-flow from C1 to B2 is 2 through C1→C→A→B→B2
- Since  $|\text{trust-flow} - \text{upload-flow}| = 4$  (suppose the threshold here is 8) and  $\text{trust-flow} > 4$ , the transaction is approved and B2 will be selected



# System Design

- Weighted transaction network update
  - Updated after a file sharing transaction between non-friends
    - If there is no link, create a new link
  - Positive feedback
    - The weights of all links on the trust path from the server to the client is added by the size of the shared file
  - Negative feedback
    - The weights of all links on the trust path from the server to the client is reduced by the size of the shared file
  - Neutral or no feedback
    - Nothing changes

# System Design

- Summary
  - Social network
    - Represents trust among friends
    - Considers both online and offline relationships
    - Used directly when available
  - Weighted transaction network
    - Represents the trust among non-friends
    - Updated based on transactions
    - Complements the social network by expanding server candidates to non-friends

# Attack Resistance

- Free-riding:
  - When a node is reluctant to contribute to others, other non-friends are not willing to provide files to it too
- Whitewashing:
  - A link is created only after a successful transaction
  - without links, whitewashers will not be selected by non-friends as servers and cannot download files from others
- Collusion
  - Though colluding nodes have high-weight links connecting each other, the weights of their links to outside nodes are very low or even 0

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# Performance Evaluation

- Simulation
  - 10% bad nodes, 20% neutral nodes, and 70% good nodes
  - One round: each node randomly generates a file request
- Social network
  - LiveJournal[1] trace with 5,000 nodes
- Comparison methods
  - **SocialTrust** [2]: first rely on social network, and then use reputation system to facilitate the server selection process
  - **Social**: relies only on social relationships within 2 hops for file sharing

[1] L. Backstrom, D. Huttenlocher, J. Kleinberg and X. Lan, "Group formation in large social networks: membership, growth, and evolution," in Proc. of KDD, 2006.

[2] K. Chen, H. Shen, K. Saprana, and G. Liu, "A social network integrated reputation system for cooperative P2P file sharing," IEEE TPDS, 2015

# Detecting Suspicious Transactions

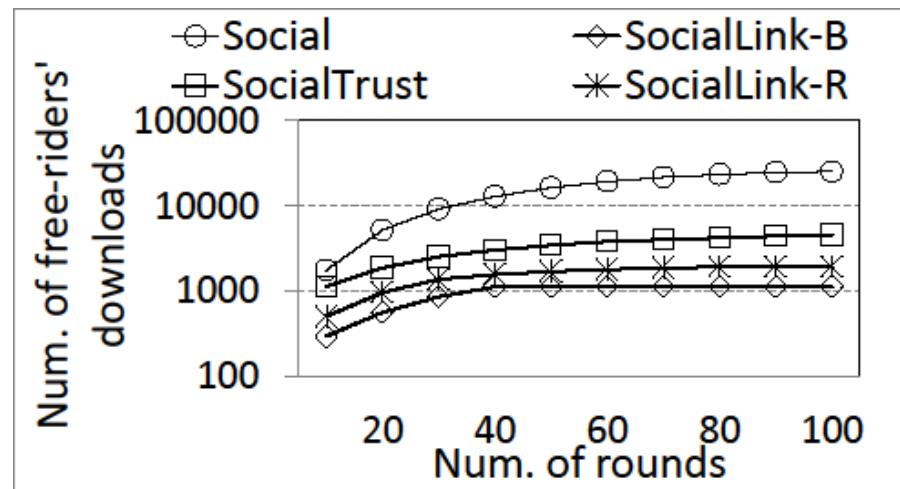
# rounds	10	20	30	40	50	60
# suspicious trans.	2694	826	187	60	15	10
# false negative	2454	712	115	32	4	1
% of false negative	91.1	86.3	61.3	53.2	26.7	10
# malicious trans.	212	208	182	153	87	24
# false positive	9.1	5.0	3.9	3.1	1.8	0.5

TABLE I: Percentage of falsely marked transactions by *SocialLink-B*.

SocialLink-B: A version of SocialLink in which the central trust center can block suspicious transactions

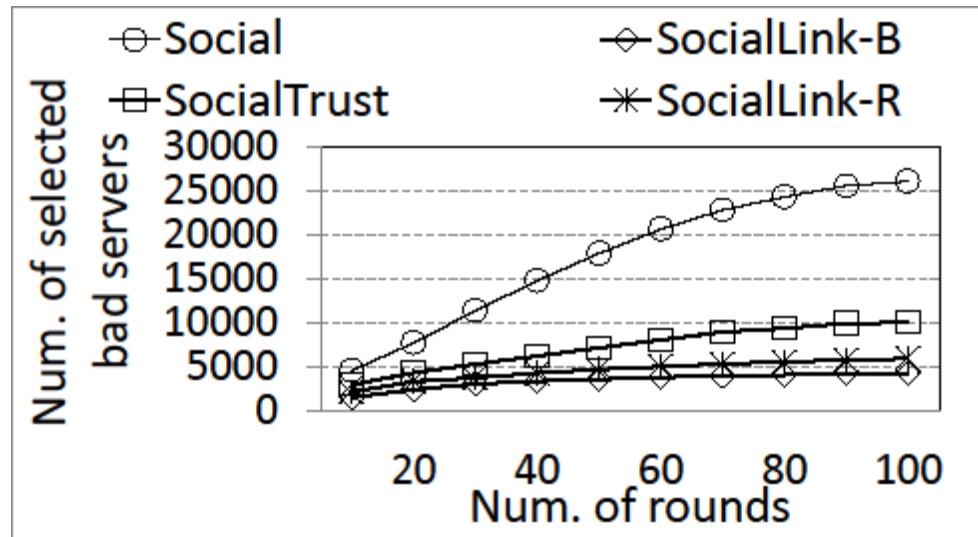
- # false negative decreases fast to a very small number
- # of malicious transactions decreases quickly due to timely block from SocialLink-B

# Preventing Free-riding



- 20% of 5,000 nodes are free-riders in the system that have 50% probability to reject file requests
- SocialLink-R: A version of SocialLink in which the central trust center always selects the server with the highest reputation
- SocialLink leads to the least free-riders' downloads due to the fairness consideration in server selection

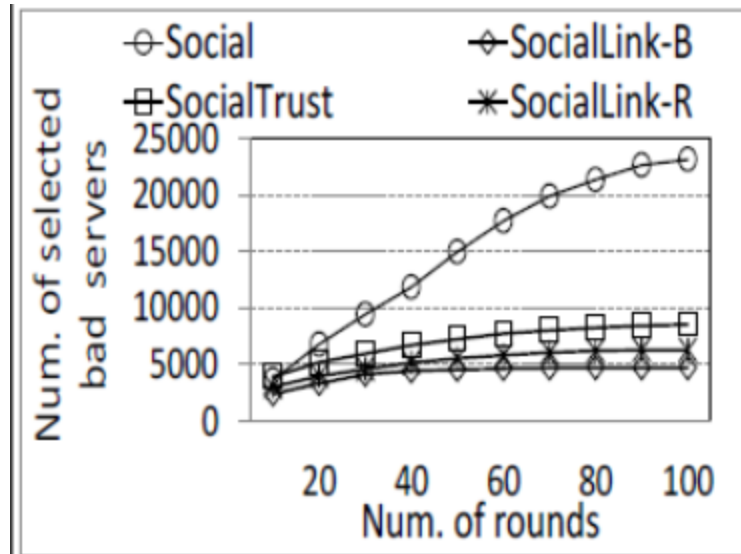
# Resisting White-washing



- 50% of malicious nodes whitewash
- SocialLink leads to the least number of selected bad servers since white-washers have no links to non-friends and can hardly be selected as servers



# Resisting Collusion



- Each bad node conducts 100 transactions with randomly selected colluders
- SocialLink generates the smallest number of transactions with bad nodes as servers

# Conclusions

- SocialLink
  - A reputation system for P2P file sharing
  - Combines both social network and transaction link
  - The social network exploits the trust from social relationships
  - The weighted transaction network exploits the trust accumulated from file sharing among non-friends
- Future work
  - Improve the weighted transaction network through in-depth modeling and analysis



*Thank you!*  
*Questions & Comments?*

**Haiying Shen**

**shenh@clemson.edu**

**Pervasive Communication Lab**

**Clemson University**