Detecting Conversing Groups of Chatters: A Model, Algorithm and Tests

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Motivation and Problem

- Internet chatrooms are open for exploitation by malicious users
  - Chatrooms are open forums which offer anonymity.
  - The real identity of participants are decoupled from their chatroom nicknames.
  - Multiple threads of communication can co-exist concurrently.
- Our goal is
  - to provide automated tools to study chatrooms
  - to discover <u>*who is chatting with whom?*</u>
    - Human monitoring is possible but not scalable.

Motivation and Problem (cont.)

- Not a trivial task even for a well trained human eye

[20:19:40] <id1> what u been up to or down to?
[20:19:42] <id2> Hi!! Anyone from Boston around?
[20:20:00] <id3> amenazas d eataque
[20:20:04] <id3> sorry
[20:20:29] <id4> laying around sick all weekend...
[20:20:30] <id1> can anyone in here speak english??
[20:20:37] <id4> what about you ?
[20:20:40] <id1> whats wrong?
[20:20:46] <id5> not me
[20:20:48] <id4> sinus infection
[20:20:57] <id1> i had that last week
[20:20:58] <id6> Hmm, those seem rather infectious down there
[20:21:07] <id1> its this stupid weather
[20:21:32] <id4> yeah...darn weather
[20:21:43] <id1> i wont get good and over them until we get a good rain or a really hard freeze

Outline

- Related work
- Contributions
- The Model
- Algorithms
  - Cluster
  - Connect
  - Color & Merge
- Results
- Conclusion

IRC - Internet Relay Chat

- RFC 2810 … 2813
- Interactive and public forum of communication for participants with diverse objectives.
- IRC is a multi-user, multi-channel and multi-server chat system which runs on a Network.
- It is a protocol for text based conferencing:
  - Provides people all over the world to talk to one another in real time.
  - Conversation or chat takes place either in private or on a public channel.

Related Work

- Multi-users in open forums
  - H.-C. Chen, M. Goldberg, M. Magdon-Ismail, “Identifying multi-users in open forums.” ISI 04.
- An automated surveillance system
  - S. A.Camtepe, M. S. Krishnamorthy, B. Yener, “A tool for Internet chatroom surveillance”, ISI 04.
- PieSpy
  - P. Mutton and J. Golbeck, “Visualization of Semantic Metadata and Ontologies”, IV03.
  - P. Mutton, “PieSpy Social Network Bot”, http://www.jibble.org/piespy/.
- Chat Circle
  - F. B. Viegas and J. S. Donath, "Chat Circles“, CHI 1999.
- Social Network Analysis (SNA)
  - V. Krebs, “An Introduction to Social Network Analysis”, http://www.orgnet.com/sna.html.

Contributions

- A model which does not use semantic information,
  - chatters are nodes in a graph,
  - collection of chatters is a hyperedge,
- Two efficient algorithms
  - Uses statistical information on the posts to create candidate hyperedges,
  - “Cleans” the hyperedges using:
    - Transitivity,
    - Graph coloring,
- Algorithms are rigorously tested using simulation on the model.

The Model - Assumptions

- We model a single chatroom which corresponds to a topic.

- Members form small groups and talk on one or more subtopics:
  - Subtopics are created at the beginning and never halts.

- A user participates in one subtopic only. A user:
  - arrives,
  - selects a subtopic to talk on,
  - stays in the same subtopic during his/her lifetime.

- At any time, only one user is selected to post in a subtopic
- Message interarrival times are random according to a given distribution.

The Model – Assumptions (cont.)

- User's arrival and departure times are selected uniformly at random. To make a user to post enough messages for analysis:
  - Simulation time is divided into **"n" regions**
  - Arrival times are selected uniformly at random from the first region,
  - Departure times are selected uniformly at random from the last region.

- At any time, messages coming from all subtopics are uniformly at random shuffled and output.

The Model - Parameters

- Simulation time and number of regions
- Number of users
- Number of subtopics
- Probability distribution and parameters (mean, variance, …) for:
  - User to subtopic assignment
  - Message interarrival time
- Step size K (will be defined in the next slide)

The Model - Algorithm

- Single event queue
  - Message post events (post, user, subtopic, time)
  - User join events (join, user, subtopic, time)
  - User leave events (leave, user, subtopic, time)

- K-step posting probability for each subtopic
  - A list of size **K** named as “Probability History List”
  - A user who post recently is pushed to front
  - A user at the front has smallest probability of post next
  - A user at the end and users not in the list have the highest probability of post next

The Model - Algorithm (cont.)

- Load parameters
- For each user
  - select an arrival time, generate an arrival event for the user
  - select a departure time, generate a departure event for the user
  - select a subtopic, generate join event
- For each timestep
  - For each events of current time
    - If post event
      - insert the message to message buffer
      - create new post event
        - select next user to send according to K-step probability
        - select time for next post (message interarrival time)
      - update K-step probability (probability history list)
    - If join event
      - add user to subtopic
      - If first user in the subtopic,
        - create a post event
        - update K-step probability (probability history list)
    - If leave event
      - remove user from subtopic
  - Shuffle the message buffer
  - Log the messages to a file

The Model - Output

- Sample chat log

  TIME 6 USER 20

  TIME 7 USER 15

  TIME 9 USER 61

  TIME 12 USER 41

  TIME 12 USER 24

  ……
- User to subtopic assignments

Subtopic	Members
1	15
2	20,41
3	61
4	24

Algorithms

- Initial processing of message logs
  - Consider every consecutive messages
  - Generate list of node pairs and the corresponding interarrival times

Sample Log

TIME 6 USER 20
TIME 7 USER 15
TIME 9 USER 61
TIME 12 USER 41
TIME 12 USER 24

Node-pair, Interarrival list

users (20,15) int. time 1
users (15,61) int. time 2
users (61,41) int. time 3
users (41,24) int. time 0

Algorithms – Kmeans

- Simple Clustering (K-Means)
  - K-means clustering algorithm is applied on Interarrival list
  - Generates two clusters
    - Red: pairs which has small interarrival times are put into this cluster
    - Blue: pairs which has large interarrival times are put into this cluster

Algorithms – Kmeans (cont.)

- Simple Clustering (K-Means)
  - K-means clustering on Interarrival list
  - Generates two clusters:
    - Red: pairs which has small interarrival times
    - Blue: pairs which has large interarrival times
  - Declares:
    - Red pairs as <u>not engaged</u> in conversation
    - Blue pairs as <u>engaged</u> in conversation
    - Idea: interarrival time between messages of two users, who exchanges messages over a subtopic, can not be smaller then a threshold:
      - It takes time for user to read, interpret , prepare answer
      - Network and servers introduce additional latency

Algorithms – Kmeans (cont.)

- Issues:
  - Incomplete, it does not identify members of sub topics (conversing groups)
  - May include contradictory information
    - For group of three users a,b,c
    - (a,b) and (a,c) are blue, (b,c) is red
    - Are (a,b,c) in the same subgroup???
- Algorithms ***Connect*** and ***Color_and_Merge***
  - Reconcile possible contradictions
  - Produce complete output

Algorithms – Connect

- Takes blue and red clusters
- Trusts blue cluster
- Considers blue cluster as the edge set of a graph **B**
  - Finds connected components in **B**
    - breath-first search on **B**
  - Consider previous example
    - For group of three users a,b,c
    - (a,b) and (a,c) are blue, (b,c) is red
    - Connect concludes that (a,b,c) are in the same subgroup.

Algorithms – Color

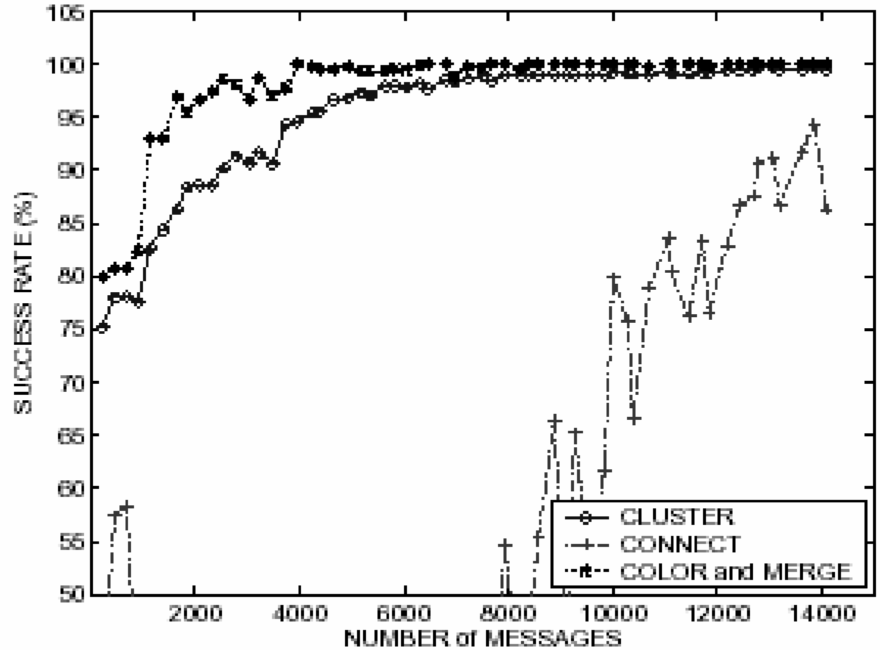
- Takes blue and red clusters
- Trusts red cluster more than blue cluster
- Considers red cluster as the edge set of a graph **R**
  - Applies vertex coloring
    - Uses heuristic Greedy to find an approximate solution
  - Generates color classes

Algorithms – Merge

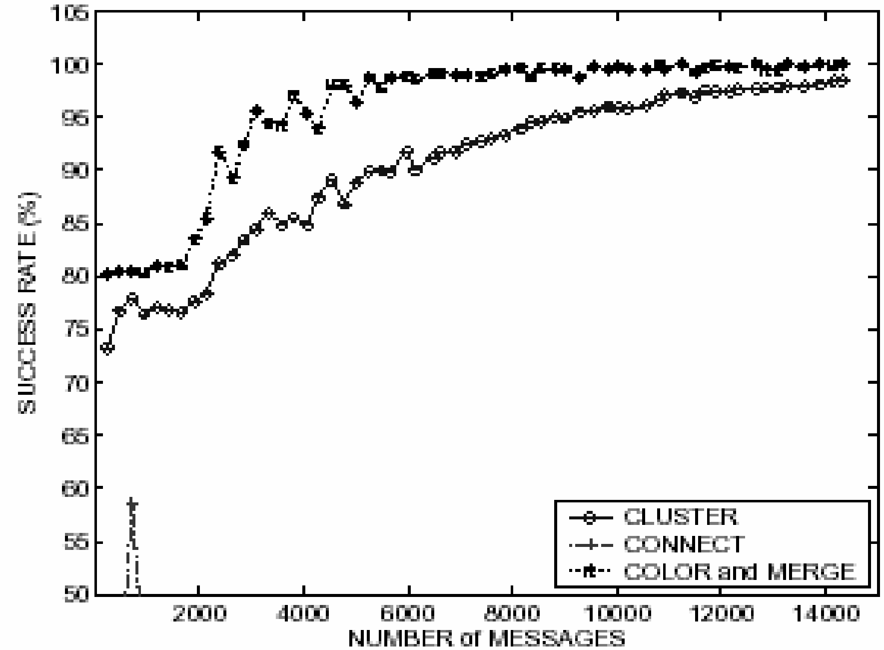
- Takes color classes generated by ***color***
- For each pair of color classes C_1 and C_2
  - e_b = number of user pairs (x, y) where
    - (x, y) in blue cluster
    - (x in C_1 and y in C_2) or (y in C_1 and x in C_2)
  - If ($e_b/|C_1|.|C_2| \geq$ threshold) merge C_1 and C_2
  - For our model, we found that threshold 0.7 gives good results
- Announce final color classes as subtopics.

Tests

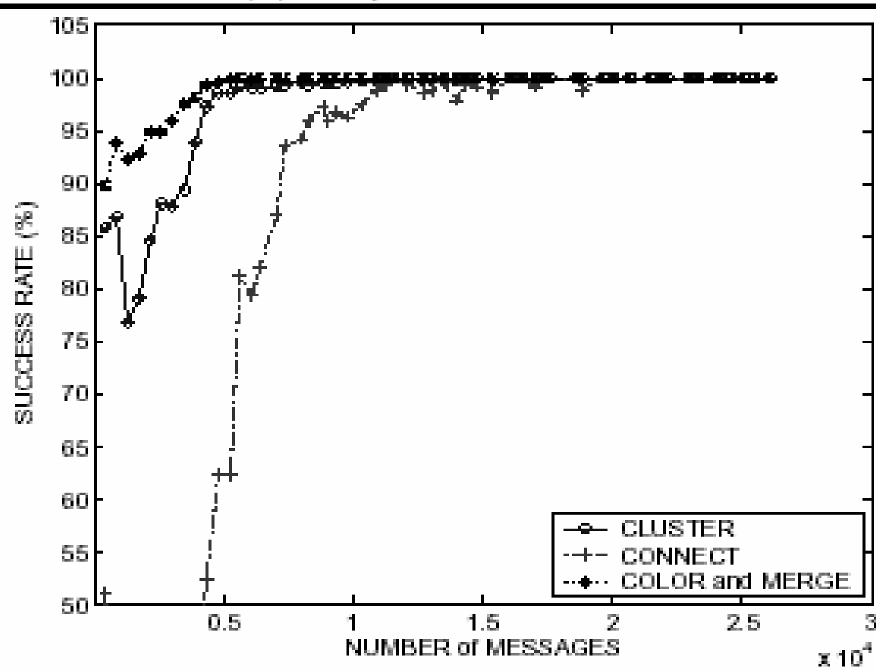
- Parameters of the model are tuned according to observations and statistical analysis over real chatroom logs.
- A user pair which is announced correctly as being in the same subtopic is accepted as a correct result
- Success rate = # correct results / all
- Following slide lists results for:
  - 5 topics, 50 users
  - 5 topics, 75 users
  - 10 topics, 50 users
  - 10 topics, 75 users



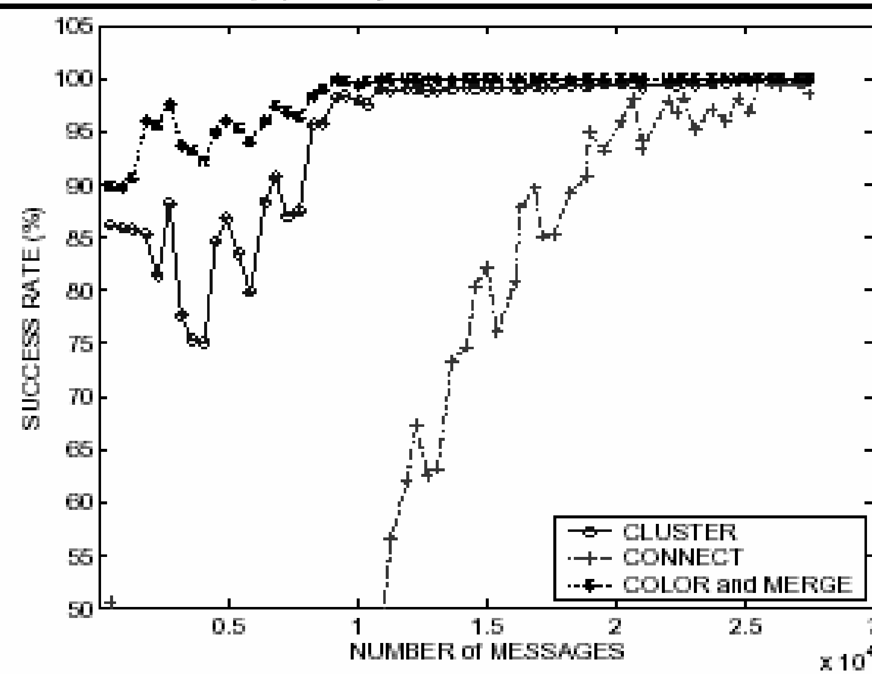
(a) 5 Topics and 50 Users



(b) 5 Topics and 75 Users



(c) 10 Topics and 50 Users



(a) 10 Topics and 75 Users

Results

- For sufficiently long log size, all algorithms converges to 100% success
- Critical factor is number messages per user.
  - As the number of users increases, larger logs are required
- Color_and_Merge algorithm provides the best result.
  - Converges to 100% success very quickly
- Connect is the most sensitive algorithm to log size
- As the log size decrease, connect fails faster
  - Why? A single false edge may connect two components yielding too much false results

Conclusion

- We presented a model for which we showed that it is possible to accurately determine the conversation
- Ideas can be generalized to more elaborate models
- Future work:
  - Enhance the model
    - Users may belong to multiple conversations
    - Users may switch between conversations
  - Apply algorithms to real chatroom logs