What do we see from CollegeMsg temporal network?

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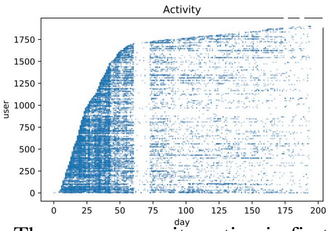
Introduction

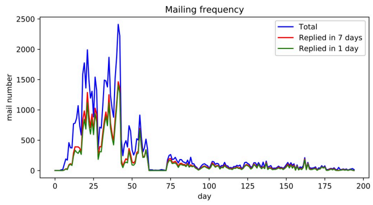
This data is comprised of private message sent on an online social network at the university. Users could search each other and initiate conversation based on the profile information. One edge *(u,v,t)* means user *u* send a message to *v* at time *t*.

Nodes	1899	Temporal edges	59835	Edges in static graph	20296	Time span	193 days

Topology

First, we did experiments on user behavior during whole time span, like overall activity, mailing frequency and reciprocation.





The users are quite active in first 60 days, with the rapid increase on the outline reflecting the influx of new users up to 1700, and the dense spots showing the frequent mailing in left figure. After a gap at day 60-70 by unknown reason, the sparse spots imply the relative passive activities. From right figure, the mailing frequency tendency visualizes the corresponding activities in left. It raises up around 2000 emails per day, then drops under 500 after the gap.

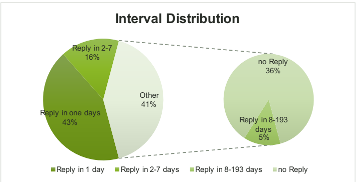


Figure left shows the reply interval distribution, from which 36% emails have no reply and 43% have reply in one day showing the high rate of real-time interaction. And small rate(16%) of reply in 2-7 days is corresponding to the little gap between the red and green lines.

Immunity Model

In this part, we have simulated the viral spreading procedure for this network. Furthermore, we have implemented possible immunity strategy to control the spreading in the procedure. Our intention is to figure out relationship between characteristics of immunized user and immunity performance, then summarize effective strategies for such immunities.

Viral spreading rules

1. An email sent from an infected user will surely infect the receiver, but the receiver can only infect other users from the next day.
2. The virus will be planted to a random user only once in a random day.
3. 100 users will be immunized in the same day of virus planted. An immunized user will not be infected.
4. We assume the temporal network after immunity action is unknown, which means, the immunity strategy can only be based on former user behavior.

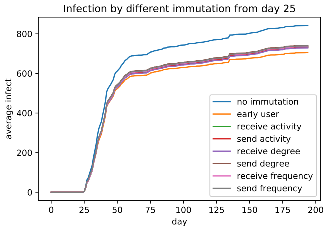
Immunity strategy

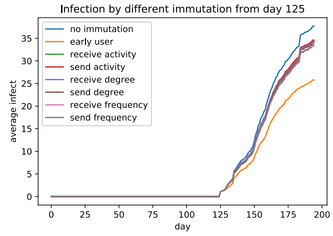
Based on these assumptions, we have started our simulation. As for which nodes to be immunized, we have came up with these strategies:

1. Users registered early.
2. Users that have contacted most other users(in degree and out degree).
3. Users that have largest mailing frequency.
4. Users that have longest active days(count days that have sending or receiving activity)

Spreading simulation

We have selected the starting day at 25 and 125 respectively to visualize the average infect number while spreading. These two starting days are selected by regarding the whole temporal network as two periods: increasing period where user increased fast and with frequent activity, and stable period where user number remains stable and with less frequent activity.

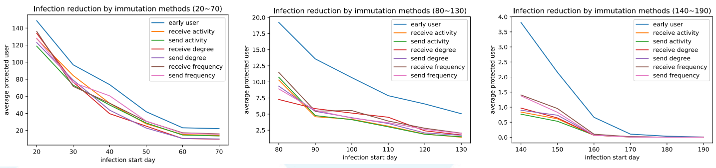




From the two figures we can see the spreading gets slow as time goes. However, the spreading speed at the start period is significantly fast. As for immune strategy, immunizing early users is the most effective way of preventing infections.

Immunity performance

Following figures shows the immunity performance by different starting day. From these figures we can see that the best strategy for immunity is to block early users. However, this may result from the specific characteristics that the early users are more active than other all the time(can be seen in the first figure). Therefore, when we leave out the early user strategy(to make it more general), none of the other strategies significantly outperform others though they are all effective in some extent.



Conclusion

In this research, we have explored a temporal network dataset of a college mailing service. We have first investigated the overall user behavior respecting to time and found the slack activity and short reply interval. In addition, we have tried several different immune strategy for slowing down viral spreading and have compared their performances, and concluded that for this network the best strategy is to block early registered users.

Reference

Pietro Panzarasa, Tore Opsahl, and Kathleen M. Carley. "Patterns and dynamics of users' behavior and interaction: Network analysis of an online community." Journal of the American Society for Information Science and Technology 60.5 (2009): 911-932.