DRIMUX: DYNAMIC RUMOR INFLUENCE MINIMIZATION WITH USER EXPERIENCE IN SOCIAL NETWORKS

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Abstract: **The large development in online social networks, online information sharing is becoming ubiquitous every day. Various information is propagating through online social networks including both the positive and negative. In this paper, we focus on the negative information problems such as the online rumors. Rumor blocking is a serious problem in large-scale social networks. Malicious rumors could cause chaos in society and hence need to be blocked as soon as possible after being detected. In this paper, we propose a model of dynamic rumor influence minimization with user experience (DRIMUX). Our goal is to minimize the influence of the rumor (i.e., the number of users that have accepted and sent the rumor) by blocking a certain subset of nodes. A dynamic Ising propagation model considering both the global popularity and individual attraction of the rumor is presented based on realistic scenario. In addition, different from existing problems of influence minimization, we take into account the constraint of user experience utility. Specifically, each node is assigned a tolerance time threshold. If the blocking time of each user exceeds that threshold, the utility of the network will decrease. Under this constraint, we then formulate the problem as a network inference problem with survival theory, and propose solutions based on maximum likelihood principle. Experiments are implemented based on large-scale real world networks and validate the effectiveness of our method.**

IndexTerms - Social network, rumor blocking, survival theory.

I. INTRODUCTION

Online social network analysis has also attracted growing interest among researchers On one hand, these online social platforms provide great convenience to the diffusion of positive information such as new ideas, innovations, and hot topics. On the other hand, however, they may become a channel for the spreading of malicious rumors or misinformation For example, some people may post on social networks a rumor about an upcoming earthquake, which will cause chaos among the crowd and hence may hinder the normal public order. In this case, it is necessary to detect the rumor source and delete related messages, which may be enough to prevent the rumor from further spreading. However, in certain extreme circumstances such as terrorist online attack, it might be necessary to disable or block related Social Network (SN) accounts to avoid serious negative influences. For instance, in 2016, the families of three out of the forty nine victims from the Orlando nightclub shooting incident filed a lawsuit against Twitter, Facebook and Google for providing "material support" to the terrorism organization of the Islamic State of Iraq and Syria (ISIS). Most of the previous works studied the problem of maximizing the influence of positive information through social networks. Fast approximation methods were also proposed to influence maximization problem. In contrast, the negative influence minimization problem has gained much less attention, but still there have been consistent efforts on designing effective strategies for blocking malicious rumors and minimizing the negative influence. Budak et al introduced the notion of a "good" campaign in a social network to counteract the negative influence of a "bad" one by convincing users to adopt the "good" one. We studied the problem of minimizing the propagation of malicious rumors by blocking a limited number of links in a social network. They provided two different definitions of contamination degree and proposed corresponding optimization algorithms. Fan et al. investigated the least cost rumor blocking problem in social networks. They introduced the concept of "protectors" and try to select a minimal number of them to limit the bad influence of rumors by triggering a protection cascade against the rumor cascade. However, there are a few limitations in those works. First, they consider the rumor popularity as constant during the whole propagation.

The large development in online social networks, online information sharing is becoming ubiquitous everyday. Various information is propagating through online social networks including both the positive and negative. In this paper, we focus on the negative information problems such as the online rumors. Rumor blocking is a serious problem in large-scale social networks. Malicious rumors could cause chaos in society and hence need to be blocked as soon as possible after being detected. In this paper, we propose a model of dynamic rumor influence minimization with user experience (DRIMUX). Our goal is to minimize the influence of the rumor (i.e., the number of users that have accepted and sent the rumor) by blocking a certain subset of nodes. A dynamic Ising propagation model considering both the global popularity and individual attraction of the rumor is presented based on realistic scenario. In addition, different from existing problems of influence minimization,

we take into account the constraint of user experience utility. Specifically, each node is assigned a tolerance time threshold. If the blocking time of each user exceeds that threshold, the utility of the network will decrease. Under this constraint, we then formulate the problem as a network inference problem with survival theory, and propose solutions based on maximum likelihood principle. Experiments are implemented based on large-scale real world networks and validate the effectiveness of our method.

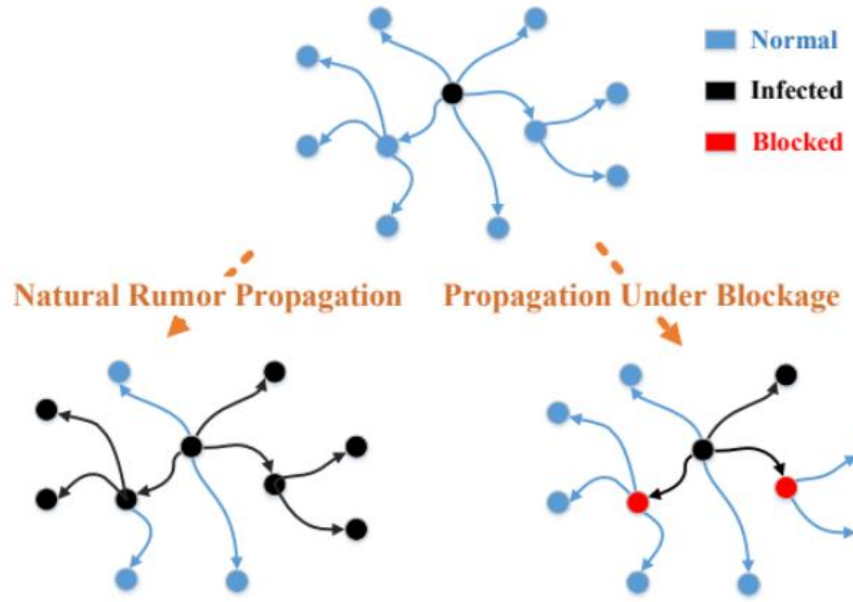


FIG 1: ARCHITECTURE

METHODOLOGY:

MODELS

Topic Dynamics

Researchers have studied the temporal dynamics of we-b topics based on real-world statistics. Yang et al. analyzed how the number of tweets related to a specific theme (i.e., the popularity of a topic) changes with time, and revealed that a topic evolution generally consists of three phases, i.e., a rising phase from the start, a peak period and then a fading phase. Fluctuations in each phase may result in different temporal characteristics. Yang et al. proposed K-Spectral Centroids clustering algorithm for classifying online content according to their temporal patterns and finally extract six representative patterns.

Energy Model

Rumor propagation can be considered as a type of social contagion process with several special characteristics. Firstly, people's interest of a rumor tends to decrease with time, which indicates the probability of a node willing to forward the rumor. That process is similar to the simulated annealing process. We proposed a novel energy model to describe the rumor propagation process. They introduce the heat energy calculation formula E = cm T in Physics to analogize the rumor impact. The rumor's influence on individual node is formulated as the amount of accumulated heat energy. Based on the model proposed we define the expression of individual tendency with respect to the success activation probability between a pair of nodes. In addition, even though an activated node does transmit the rumor to its neighbors, the probability of these neighbors accepting the rumor is still to be determined. In that case, we can define the acceptance probability of the rumor recipient.

Ising Model

The Ising model is a widely applicable model in the research of Physics theory. It is a simple theoretical description of the concept of ferromagnetism in Physics. Specifically, it describes the phenomenon that when an array of atomic spins align in the way that the magnetic moments associated to them will all point in the same direction. Then it will create a

macroscopic magnetic moment. Generally speaking, the Ising model contains two parts – the microscopic and macroscopic parts. The microscopic part represents the local or individual behavior which is the alignment of each of the atomic spins. Correspondingly, the macroscopic part stands for the global or collective behavior which is the exterior magnetic moment. Based on its intrinsic attributes, the Ising model can be generalized to other similar scenarios. In our work, we utilize it to model the rumor propagation process in social networks.

User Experience

User experience is an important factor for various services including social networks. Existing rumor blocking strategies block either nodes (users) or links (connections between users) in social networks to prevent the rumor from further propagation. However, none has analyzed the impact of blocking nodes. Generally speaking, the longer the user is blocked, the less satisfactory the user feels about the social network. Therefore, if the blocked time surpasses a certain threshold, it is possible that the user may quit the social network or at least lodge a complaint to the administrator. Bhatti et al. analyzed the user-perceived quality in web server design and found that users' tolerance for latency decreases over the duration of interaction with a site. A utility function was presented to measure the customer satisfaction. Inspired by that, in our work, we apply a modified utility function to measure user experience in rumor blocking.

RESULTS

In this section, we analyze the DRIMUX optimization problem from the perspective of a network inference problem with survival theory and then propose the greedy algorithm and dynamic blocking algorithm based on different nodes selection schemes and the maximum likelihood principle.

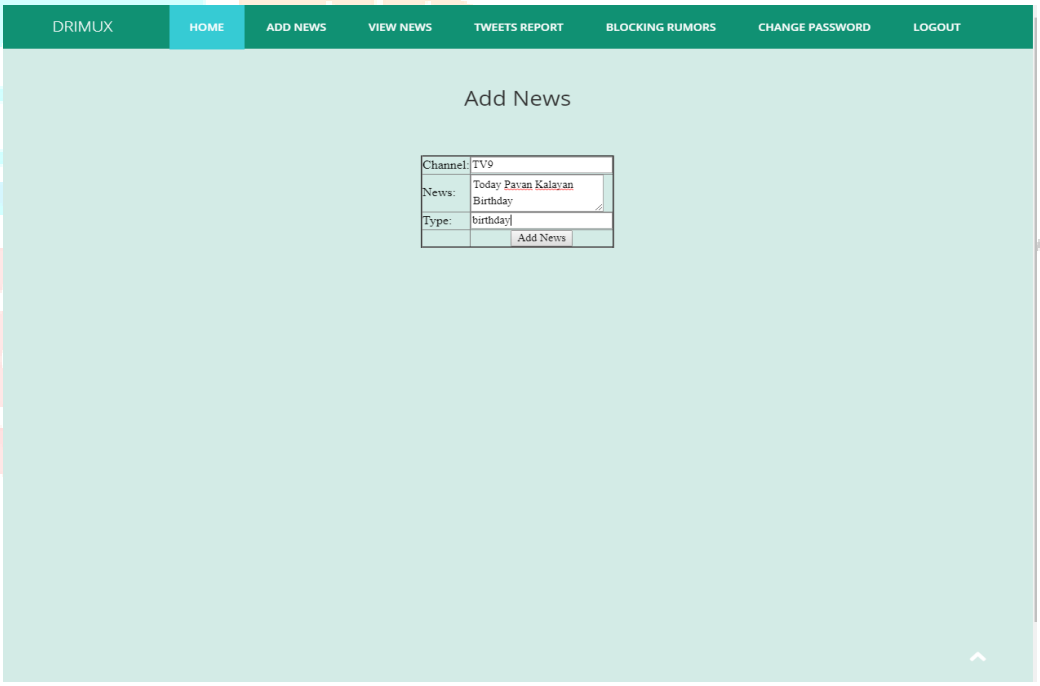
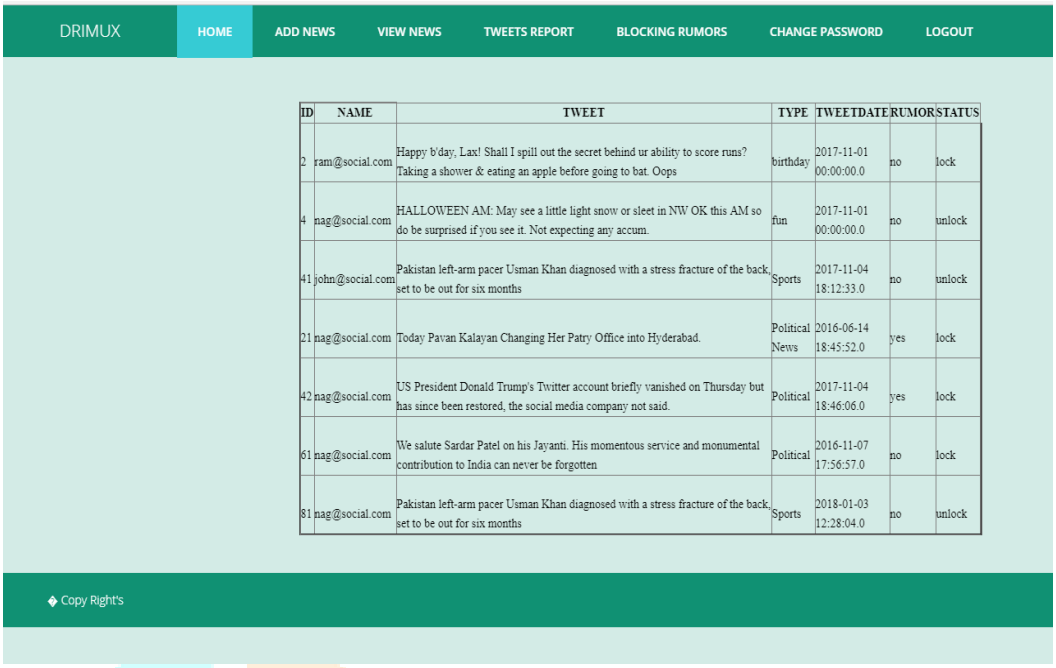
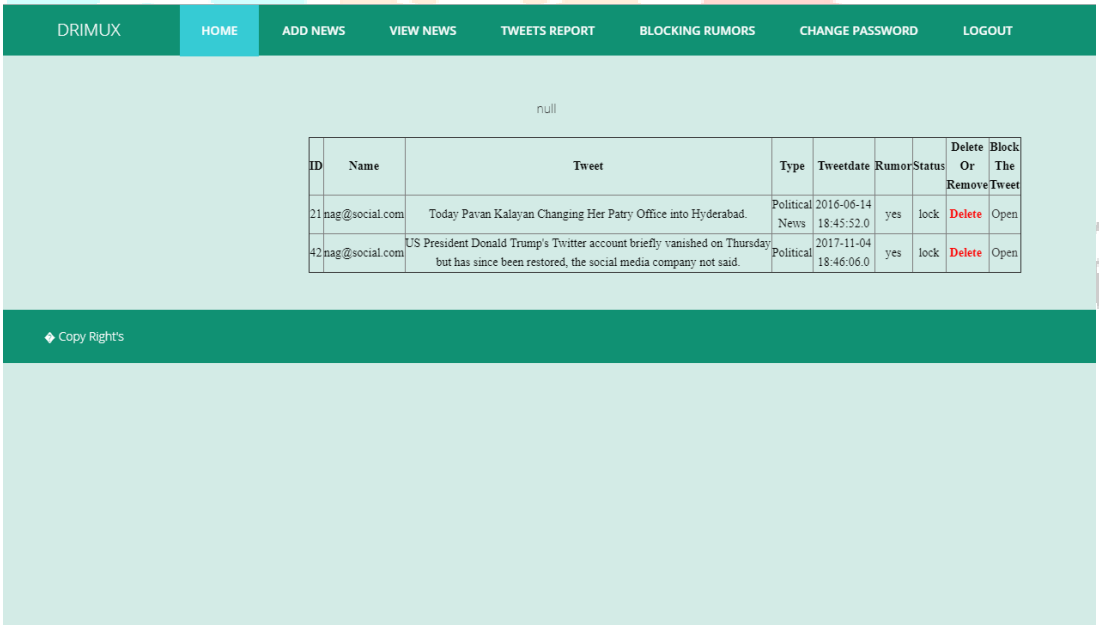


FIG 2: ADD NEWS



ID	NAME	TWEET	TYPE	TWEETDATE	RUMOR	STATUS
2	ram@social.com	Happy b'day, Lax! Shall I spill out the secret behind ur ability to score runs? Taking a shower & eating an apple before going to bat. Oops	birthday	2017-11-01 00:00:00.0	no	lock
4	nag@social.com	HALLOWEEN AM: May see a little light snow or sleet in NW OK this AM so do be surprised if you see it. Not expecting any accum.	fun	2017-11-01 00:00:00.0	no	unlock
41	john@social.com	Pakistan left-arm pacer Usman Khan diagnosed with a stress fracture of the back, set to be out for six months	Sports	2017-11-04 18:12:33.0	no	unlock
21	nag@social.com	Today Pavan Kalayan Changing Her Patry Office into Hyderabad.	Political News	2016-06-14 18:45:52.0	yes	lock
42	nag@social.com	US President Donald Trump's Twitter account briefly vanished on Thursday but has since been restored, the social media company not said.	Political	2017-11-04 18:46:06.0	yes	lock
61	nag@social.com	We salute Sardar Patel on his Jayanti. His momentous service and monumental contribution to India can never be forgotten	Political	2016-11-07 17:56:57.0	no	lock
81	nag@social.com	Pakistan left-arm pacer Usman Khan diagnosed with a stress fracture of the back, set to be out for six months	Sports	2018-01-03 12:28:04.0	no	unlock

FIG 3: TWEET DATA



ID	Name	Tweet	Type	Tweetdate	Rumor	Status	Delete Or Remove	Block The Tweet
21	nag@social.com	Today Pavan Kalayan Changing Her Patry Office into Hyderabad.	Political News	2016-06-14 18:45:52.0	yes	lock	Delete	Open
42	nag@social.com	US President Donald Trump's Twitter account briefly vanished on Thursday but has since been restored, the social media company not said.	Political	2017-11-04 18:46:06.0	yes	lock	Delete	Open

FIG 4: BLOCK RUMORS

CONCLUSION

In this paper, we investigate the rumor blocking problem in social networks. We propose the dynamic rumor influence minimization with user experience model to formulate the problem. A dynamic rumor diffusion model incorporating both global rumor popularity and individual tendency is presented based on the Ising model. Then we introduce the concept of user experience utility and propose a modified version of utility function to measure the relationship between the utility and blocking time. After that, we use the survival theory to analyze the likelihood of nodes getting activated under the constraint of user experience utility. Greedy algorithm and a dynamic blocking algorithm are proposed to solve the optimization problem based on different nodes selection strategies. Experiments implemented on real world social networks show the efficacy of our method. In our future work, we plan to design more sophisticated rumor blocking algorithms considering the connectivity of the social network topology and node properties. We intend to separate the entire social network into different communities with different user interests and then analyze the rumor propagation

characteristics among communities. We are also interested in investigating how to prevent the rumor propagation effectively at a late stage.

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