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A CASE STUDY FOR MODELING AND ANALYSIS OF RUMOUR SPREADING RATE IN TWO LAYER COMPLEX NETWORK

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Abstract - The emergence of rumour spreading in social network is an important issue nowadays. Rumours are important form of social communication and their spreading plays a vital role in human affairs. Rumours is a social remark that contains untrue information and not to be confirmed. It spreads on large scale in short time .This work is mainly focused on the analysis of rumour spreading rate in multilayer social network. A mathematical model is developed to study the rate at which the rumour spreads largely in a multilayer network such as (Facebook, Twitter, and Whatsapp). In this work various model such as (Stifler Ignorant Spreader),(Sucessptible infected and recovered) (SIR) Susceptible Exposed Infectious Recovered(SEIR)are considered and in order to model the rumour spreading rate using mean field approximation technique. A stochastic model is defined for various models based on the spreading rate of the rumour and a differential equation is derived. Spreading rate comparison is made initially between two rumours in a two layered model. such that spreading rate is analysed using various models.

I. INTRODUCTION

Rumours are an important form of social communications, and their spreading plays a significant role in a variety of human affairs. The spread of rumours can shape the public opinion in a country greatly impact financial markets and cause panic in a society during wars and epidemics outbreaks. The information content of rumours can range from simple gossip to advanced propaganda and marketing material. Rumour-like mechanisms form the basis for the phenomena of viral marketing, where companies exploit social networks of their customers on the Internet in order to promote their products via the so called 'word-of-email' and 'word-of-web'. Finally, rumour-mongering forms the basis for an important class of communication protocols, called gossip algorithms, which are used for large-scale information dissemination on the Internet, and in peer-to-peer file sharing applications.

Rumor is a kind of social phenomenon that a remark spreads on a large scale in a short time through chains of communication and runs through the whole evolutionary history of mankind. Narrowly speaking, rumour is defined as untrue information, but has not been confirmed. Usually, it is dispersed by some people in order to achieve the specific purpose: slandering others, manufacturing momentum, diverting attention, causing panic, and so on. Most rumors induce panic psychology or economic loss in the accompanying unexpected events. Emergencies cause serious negative impacts on people's life in several ways not only the event itself might lead to financial loss or personal injuries, but also the rumour might lead to panic feelings and irrational behaviour.

Traditionally, rumors are propagated by word of mouth. In this propagation mode, the spreading speed is slower and can produce a small effect on society stability. Nowadays, with the emergence of the internet, rumors can spread rapidly by instant messengers, emails, or publishing blogging's that provide faster velocity of transmission and result in widespread of information. Under this case, it is more difficult to control the rumour spreading. Dynamical model including spreading between individuals and medium-to individuals to describe more accurately the actual pattern of transmission, which has not been studied in previous papers. Then the mechanism under spreading between individuals and by medium can be investigated by resorting to the model. Furthermore, we also give the main influence factors of transmission to government that can propose efficient measures to keep the stabilization of society and development of economy.

II. MATHEMATICAL MODEL

The spreading rate comparison is done in various models such as follows.

1) SIR AND SIS MODEL

Traditionally, susceptible–infected– susceptible (SIS), and susceptible–infected– recovered (SIR) models are the two widely appreciated epidemic models that have been studied in the context of complex networks over the past few years. In the SIS model, the population is divided into two compartments, namely, susceptible (S) and infected (I), where every node is mutually equally susceptible to the infection, as shown in Fig. 1.1 After recovering from the infection, the node returns unprotected to the susceptible class where it is prone to get infected again. Nonetheless, the SIR model applies to cases where the recovered node obtains complete immunity to the infection and, thus, does not return to the susceptible compartment. This

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model is shown in Fig. 1.1 the mean-field approximations (MFAs) of the two afforested models along with their corresponding epidemic thresholds (ETs) in both homogeneous and heterogeneous topologies are also summarized.

Built upon these basic compartmental models, a handful of work explores the fact that transmission of certain infectious diseases such as dengue fever and yellow fever takes place not only through contacts between individuals but also between individuals and other vectors such as mosquitoes. Here, human contacts are considered scale free, but the infective medium may contact an individual without any selectivity, which implies that the epidemic homogeneously spreads between individuals and vectors. This is analogous to the spread of malwares through emails, file sharing, and instant messaging in cyberspace.

In reality, however, infection in an individual node can also develop in multiple stages, resulting in what is commonly known as infection delay. In infectious diseases of humans, such as malaria, transmission is mediated by multiple vectors such as Anopheles mosquitoes, blood transfusion, organ transplants, and contaminated needles. Additionally, the multiple infection stages correspond to the string of attacks experienced by the infected individual such as chills, followed by fever, and then sweating. Similarly, computer viruses are transmitted via various vectors such as e-mail attachments, file sharing, malicious codes in websites, instant messaging, and phishing schemes. Once infected, the infection delay depends on the level and extent of damage caused by the virus. Such refinement is significant to further comprehend the mechanism

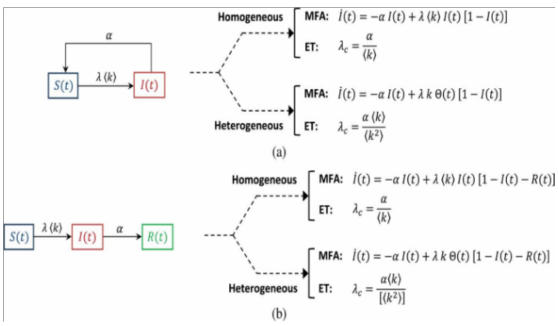

Fig 3 SIS AND SIR MODEL

of infection spread on natural and man-made networks and pave the way to more realistic models.

To the best of our knowledge, there exist no results on the dynamics of SIS models integrated with these two factors from the perspective of complex networks. To this end, a novel mean-field deterministic SIS epidemic model that includes not only the propagation vector but also the infection transmission delay is introduced. Mean field analysis reveals the joint impact of both these factors on the infection spreading characteristics in homogeneous and heterogeneous populations.

2) SEIRS MODEL

Here a model for malware spreading in SFNs by the proposed discrete-time SEIRS model, which considers diversification is discussed. The model, includes L different software packages which are assigned to the graph nodes randomly.

During the epidemic outbreak process, the nodes in the proposed model are categorized as susceptible (S), exposed (E), infected (I) or recovered (R):

- S_k (t): The density of susceptible nodes of degree K at the time t.
- E_k (t): The density of exposed nodes of the degree K at the time t.
- I_k (t): The density of infected nodes of the degree K at the time t.
- R_k (t): The density of recovered or immunized node

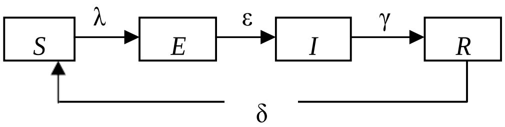

Fig 4 SEIRS MODEL

As shown in Figure 1.2, at each time step, newly infected nodes of type *L* will be able to infect their susceptible neighbours of the same type (the same colour) because of a common vulnerability and cause some of them to turn into the exposed state. The recovered nodes can become susceptible again because some nodes can be partially recovered and can be infected by malware.

The principle of SEIR epidemic model for rumour spreading on SFNs is as follows. Consider a network with N nodes and M links (edges) representing the agents and their interactions. At each time step, each node adopts one of six possible states:

(1) Ignorant (I), a node is called an ignorant if it has not yet received the rumour (ignorant, similar to susceptible state in the SEIR epidemic model).

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(2) Lurker (L), a node is called a lurker if it requires active effort to discern between true and false after receiving the rumour. Generally, ignorant obtains a latent period before it transfers into a spreader (lurker, similar to the exposed state in the SEIR epidemic model).

(3) Spreader (S), a node is called a spreader if it transmits the rumour to all their neighbours after receiving this rumour (spreader, similar to the infective state in the SEIR epidemic model).

(4) Hibernator (H), a node is called a hibernator if it forgets the rumour and later remembers it again after receiving this rumour.

(5) Stifler1 (Ra), a node is called a stifler1 if it accepts the rumour but loses the tendency to spread it after receiving this rumour (stifler1, similar to the removed state in the SEIR epidemic model).

(6) Stifler2 (Ru), a node is called a stifler2 if it never accepts the rumour and transmits this rumour again after receiving it

SPREADER IGNORANT STIFLER (SIR)

The states of nodes in the model are spreader, stifler and ignorant. The model is focussed on Spreading process in multilayer network a generic term that is used to refer to a number of models involving multiple networks called interconnected networks.

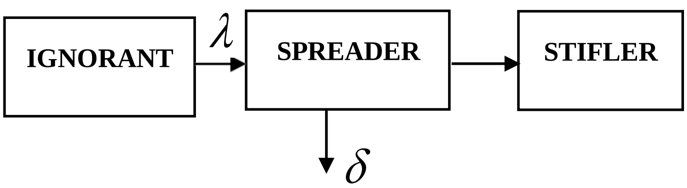

Fig 5: Mathematical Model for Rumour spreading in Multilayer Social Network

λ - Spreading rate

α - Spreading rate to change into stifler

δ - Rate ceases to spread.

$$\frac{ds_i^k}{dt} = \lambda_k \left(1 - s_i^k(t) - r_i^k(t)\right) \sum_{j=1}^{N} A_{ij}^{(k)} s_j^k(t) - \alpha\left(s_i^k(t) - r_i^k(t)\right) \sum_{j=1}^{N} A_{ij} s_j^k(t) - \delta\left(s_i^k(t)\right) \quad (1)$$

$$\frac{dr_i^k}{dt} = \alpha\left(s_i^k(t) - r_i^k(t)\right) \sum_{j=1}^{N} A_{ij} s_j^k(t) - \delta\left(s_i^k(t)\right) \quad (2)$$

The above equation are differential equation for spreading rate of rumours.

III. DESCRIPTION

The various states includes,

Spreader – those who spread rumours with spreading rate

Ignorant – ignorant individuals do not have any information about the rumour and could not spread them.

Stifler - spreader contacts another spreader or a stifler the initiating spreader becomes the stifler at a rate α.

Rumour spreading in the multi-layer network is mathematically modelled based on some criteria

1. Spreading rate
2. Spreading rate to change into stifler
3. Rate ceases to spread

The mathematical model is solved using the mean field approximation equations given by,

Where,

k- Number of layers
i – Number of nodes
j – adjacent nodes
A_{ij} - adjacency matrix

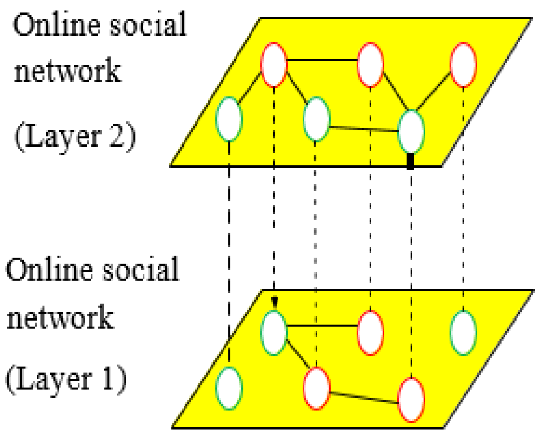

Fig 6: Rumour Propagation in Layered Network

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IV. IMPLEMENTATION

The Mean field Equation (MFE) is implemented using the software tool **(WOLFRAM MATHEMATICA 9.0)** Mathematica is a mathematical symbolic computation program, sometimes termed a computer algebra system or program used in scientific, engineering,

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mathematical, and computing fields. It excels at symbolic manipulation and provides accurate results for numerical computation.

V. RESULTS AND DISCUSSION

Through numerical simulation, rumour spreading with different spreading rates in layers are analysed which are simulated using mathematica. The graph is plotted between the spreading rate that occur in the given population corresponding to the given period of time. Here λ_1 and λ_2 represents spreading rate of two rumours in the given network, n represents the number of nodes.

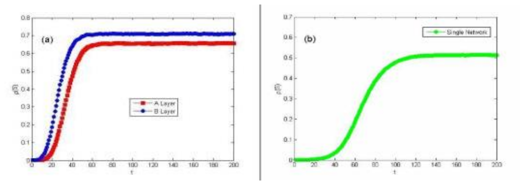

Figure 1.5: The density of spreader as a function of time for both the 2 layer network.

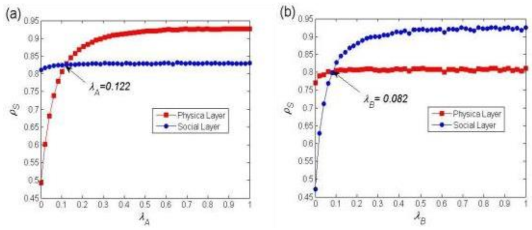

Figure 1.6: The density of spreader as a function of time for both the 2 layer network.

VI CONCLUSION

In this work, through numerical simulation the rumour spreading rate using various model in multilayer network is analysed. The spreading rate comparison is made between two rumours. By varying the spreading rate in the layers one and two, various inferences are made as shown in the graph simulated. From various models it is inferred that Spreader Ignorant Stifler (SIR) model, spreading rate comparison is made more accurate.

Effective and feasible preventive control measures are required to decrease the impact of rumour spreading rate using SIR model.

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