Comparison and analysis of Microblog and WeChat based on information spreading models

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Abstract. The important difference of Microblog network and WeChat network is network centralization. Microblog is a platform which pay attention to very important users, but WeChat is a decentralized network. Based on this point, we firstly build a model called $IRC2S$ information spreading model to simulate information spreading process in WeChat, and it includes five groups: ignorants, reviewers, collectors, sharers and stiflers. Secondly, a group called super spreaders is added to the $IRC2S$ information spreading model, which embody the feature of centralization of Microblog network. In order to approach real information spreading rules of Microblog network, we distinguish the average degrees of ordinary nodes and center nodes which reflect the feature that very important users have a great many of fans. Finally, we perform numerical simulation to the above three models and discover that centralization of network make information's propagation speed faster and information's propagation range wider.

Introduction

In recent years, Microblog and WeChat are very popular online social platforms. However, many focusing events are popped up on Microblog but not on WeChat. We build information spreading models to find the reasons. Many information spreading models are built based on classical epidemic propagation models. Zanette [1] studied epidemic-like rumor spreading process on small-word networks. Zhao et al. [2] added forgetting and remembering mechanisms to rumor spreading model on social networks. In addition, trust mechanism [3] were introduced in the classical epidemic propagation models, which was also applied to complex social networks. As the development of WeChat and Microblog, scholars began to study information spreading model on online social networks. Some scholars built information propagation model in online social networks from a tie-strength perspective [4]. Dynamics of information propagation model with cooperative and competitive mechanisms was applied to online social networks [5]. Zhao et al. [6] put the rumor spreading model with forgetting mechanism applying to new media, e.g. microblogging. Above-mentioned models have universality, but they do not aimed at certain online social network and also can not reflect the difference of different online social platforms. So we will build new models to embody the difference of WeChat and Microblog.

This paper is divided two big parts: description of models and analysis of numerical simulation. In one part, we build three models: $IRC2S$ information spreading model which is based on WeChat Moments, $IRC3S$ information spreading model which add a group super spreaders on the basis of $IRC2S$ model, the last one is advanced $IRC3S$ information spreading model which reflect the effect of super spreaders' degree. The advanced $IRC3S$ information spreading model is built to simulate information propagating process on Microblog. In other part, we perform numerical simulation to built three models.

Description of models

The *IRC2S* information spreading model

We build an information spreading model based on WeChat Moments firstly. The population is divided five groups: ignorants (I), reviewers (R), collectors(C), sharers(S_1) and stiflers (S_2).WeChat Moments information spreading model is named *IRC2S* information spreading model in short.

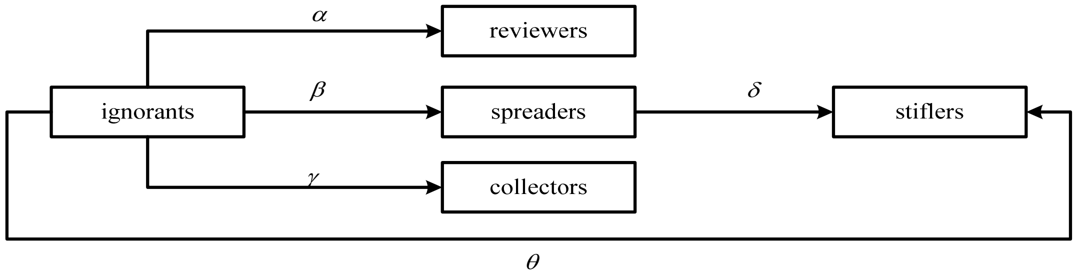

Fig. 1 Structure of the *IRC2S* information spreading model

As shown in Fig1, the information spreading rules of the *IRC2S* model can be summarized as follows. (1) When an ignorant encounters a spreader, there are four possible outcomes: (i) the ignorant may comment on the message or give the message thumbs up with probability α ; (ii) the ignorant may be so interested in the message that he/she shares it in his/her circle of friends with probability β ; (iii) the ignorant deems that the message has collecting value, so he/she collects it with probability γ ; (iv) In addition, the ignorant may have no response to the message with probability θ . (2) When a spreader encounters another spreader, he/she could think the message has been propagated universally. So the sharer becomes a stifler with probability δ .

Denote density of five groups at time t by $I(t), R(t), S_1(t), C(t), S_2(t)$ apart. According to above rules, we can use the mean-field equations to describe the *IRC2S* information spreading model.

$$\frac{dI(t)}{dt} = -(\alpha+\beta+\lambda+\gamma+\theta)\langle k\rangle I(t)S_1(t) \tag{1}$$

$$\frac{dR(t)}{dt} = \alpha\langle k\rangle I(t)S_1(t) \tag{2}$$

$$\frac{dS_1(t)}{dt} = \beta\langle k\rangle I(t)S_1(t) - \delta\langle k\rangle S_1(t)^2 \tag{3}$$

$$\frac{dC(t)}{dt} = \gamma\langle k\rangle I(t)S_1(t) \tag{4}$$

$$\frac{dS_2(t)}{dt} = \theta\langle k\rangle I(t)S_1(t) + \delta\langle k\rangle S_1(t)^2 \tag{5}$$

The $IRC3S$ information spreading model

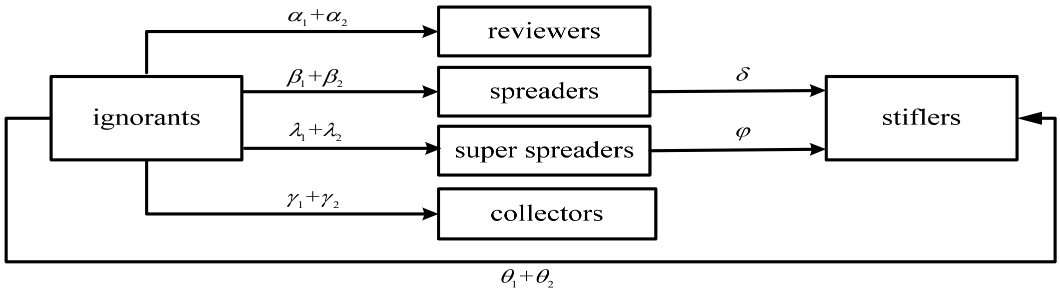

Fig. 2 Structure of the $IRC3S$ information spreading model

Based on the above information spreading model, we can construct a Microblog information spreading model by adding a new group called super spreaders (Ss), which is called $IRC3S$ information spreading model. When an ignorant encounter a super spreader, the ignorant will make response with greater probability. Because his/her influence make an ignorant prefer to make response to the information. So the information will spread according to the figure 2 and the following mean-field equations.

$$\frac{dI(t)}{dt} = -(\alpha_1+\beta_1+\lambda_1+\gamma_1+\theta_1)\langle k\rangle I(t)S_1(t) - (\alpha_2+\beta_2+\lambda_2+\gamma_2+\theta_2)\langle k\rangle I(t)Ss(t) \tag{6}$$

$$\frac{dR(t)}{dt} = \alpha_1\langle k\rangle I(t)S_1(t) + \alpha_2\langle k\rangle I(t)Ss(t) \tag{7}$$

$$\frac{dS_1(t)}{dt} = \beta_1\langle k\rangle I(t)S_1(t) + \beta_2\langle k\rangle I(t)Ss(t) - \delta\langle k\rangle S_1(t)(S_1(t)+Ss(t)) \tag{8}$$

$$\frac{dSs(t)}{dt} = \lambda_1\langle k\rangle I(t)S_1(t) + \lambda_2\langle k\rangle I(t)Ss(t) - \varphi\langle k\rangle Ss(t)(S_1(t)+Ss(t)) \tag{9}$$

$$\frac{dC(t)}{dt} = \gamma_1\langle k\rangle I(t)S_1(t) + \gamma_2\langle k\rangle I(t)Ss(t) \tag{10}$$

$$\frac{dS_2(t)}{dt} = \theta_1\langle k\rangle I(t)S_1(t) + \theta_2\langle k\rangle I(t)Ss(t) + \delta\langle k\rangle S_1(t)(S_1(t)+Ss(t)) + \varphi\langle k\rangle Ss(t)(S_1(t)+Ss(t)) \tag{11}$$

The advanced $IRC3S$ information spreading model

The effect of super spreaders not only reflect on the influence but also on the degree. So we classify nodes as center node and ordinary node. It is well known that the degree of center node is bigger than that of ordinary node. We denote the average degree of ordinary nodes and center nodes by $\langle k1\rangle$ and $\langle k2\rangle$ separately. So the mean-field equations are modified based on the $IRC3S$ information spreading model as follows.

$$\frac{dI(t)}{dt} = -(\alpha_1+\beta_1+\lambda_1+\gamma_1+\theta_1)\langle k1\rangle I(t)S_1(t) - (\alpha_2+\beta_2+\lambda_2+\gamma_2+\theta_2)\langle k2\rangle I(t)Ss(t) \tag{12}$$

$$\frac{dR(t)}{dt} = \alpha_1\langle k1\rangle I(t)S_1(t) + \alpha_2\langle k2\rangle I(t)Ss(t) \tag{13}$$

$$\frac{dS_1(t)}{dt} = \beta_1\langle k1\rangle I(t)S_1(t) + \beta_2\langle k2\rangle I(t)Ss(t) - \delta\langle k1\rangle S_1(t)S_1(t) \text{-} \delta\langle k2\rangle S_1(t)Ss(t)) \tag{14}$$

$$\frac{dSs(t)}{dt} = \lambda_1 \langle k1 \rangle I(t)S_1(t) + \lambda_2 \langle k2 \rangle I(t)Ss(t) - \varphi \langle k2 \rangle Ss(t)(S_1(t) + Ss(t)) \tag{15}$$

$$\frac{dC(t)}{dt} = \gamma_1 \langle k1 \rangle I(t)S_1(t) + \gamma_2 \langle k2 \rangle I(t)Ss(t) \tag{16}$$

$$\frac{dS_2(t)}{dt} = \theta_1 \langle k1 \rangle I(t)S_1(t) + \theta_2 \langle k2 \rangle I(t)Ss(t) + \delta \langle k1 \rangle S_1(t)S_1(t) + \delta \langle k2 \rangle S_1(t)Ss(t))$$

$$+\varphi \langle k2 \rangle Ss(t)(S_1(t) + Ss(t)) \tag{17}$$

Analysis of numerical simulation

In this section, Runge-Kutta method is used to solve the mean-field equations. Numerical simulation is performed in a generated homogeneous network which has 10^5 individuals.

Firstly, we perform numerical simulation on the $IRC2S$ information spreading model. We assume average degree of the generated homogeneous network is 10 and set $\alpha = 0.3, \beta = 0.3,$

$\lambda = 0.01, \gamma = 0.09, \theta = 0.3, \delta = 0.3, \varphi = 0.3$. Secondly, numerical simulation is performed on the $IRC3S$ information spreading model. Average degree of the generated homogeneous network is still set to 10, but set α_1=0.1, α_2=0.2, β_1=0.1, β_2=0.2, λ_1=0.003, λ_2=0.007, γ_1=0.03, γ_2=0.06

θ_1=0.2, θ_2=0.1, δ_1=0.3, φ_1=0.3. Thirdly, we perform numerical simulation on the advanced

$IRC3S$ information spreading model. We set $\langle k1 \rangle = 10, \langle k2 \rangle = 1000$ and other parameters are the same with that in $IRC3S$ information spreading model. Density of each group over time of above three models is in Fig. 3 as follows.

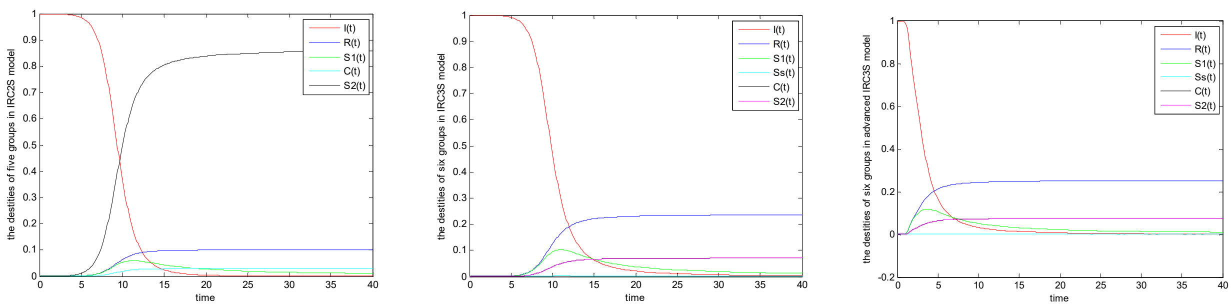

Fig. 3 Density of each group over time in the $IRC2S$ model, in the $IRC3S$ model and in the advanced $IRC3S$ model respectively

From Fig.1 and Fig.2 we can see that the trend of collectors' density over time is similar to that of reviewers'. So we analyze spreading speed and spreading scope only by analyzing density of reviewers and spreaders over time. From Fig. 4 we can see that the peak values of reviewers' and spreaders' density in the $IRC2S$ model get larger than that in the $IRC3S$ model. It indicates that influence of super spreader make information spread more widely.

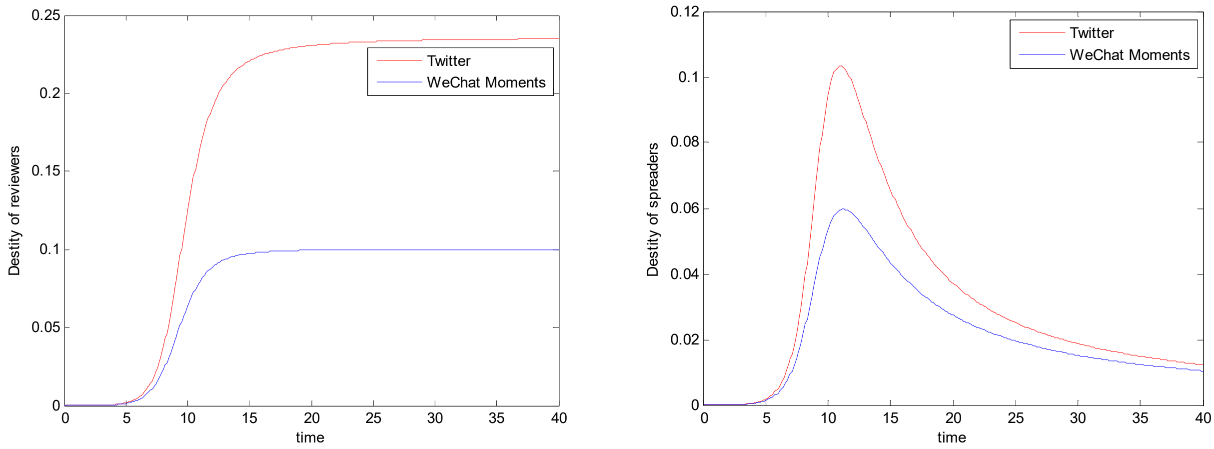

Fig. 4 Compare the densities of reviewers and spreaders over time in the $IRC2S$ model with that in the $IRC3S$ model

The value of $\langle k1 \rangle$ remain the same, which is 10. We analyze the effect of average degree on spreading speed and scope by changing the value of $\langle k2 \rangle$. We detect that the time that two groups' density get peak values get shorter when the value of $\langle k2 \rangle$ get larger from Fig. 5. In other words, the larger of the values of $\langle k2 \rangle$, the faster of spreading speed. In addition, the peak values also get large when the average degree of super spreader get large, but the influence is very little.

Summary

On one hand, influence of super spreaders make ignorant who encounter the information spread by super spreaders more interested in the information so that he/her spread, reviewer or collect the information. So it make information spread widely. On the other hand, because degree of center nodes is bigger than ordinary nodes', spreading speed of information get faster. Overall, centralization of network makes information spread faster and wider as Fig. 6 implies. This is the reason that many news come out in microblog first but not in WeChat Moments.

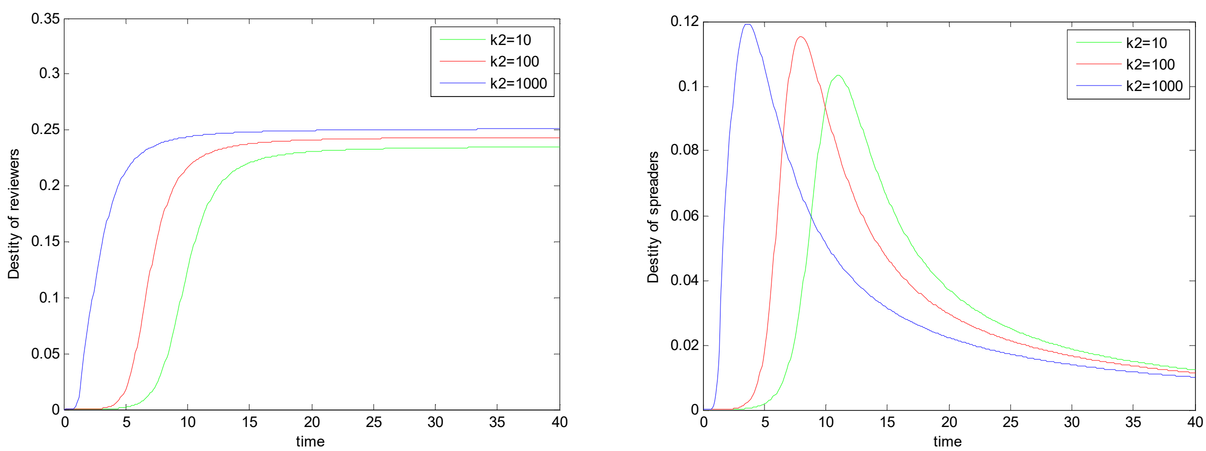

Fig. 5 Densities of reviewers and spreaders over time under different $\langle k2 \rangle$ in the $IRC3S$ model

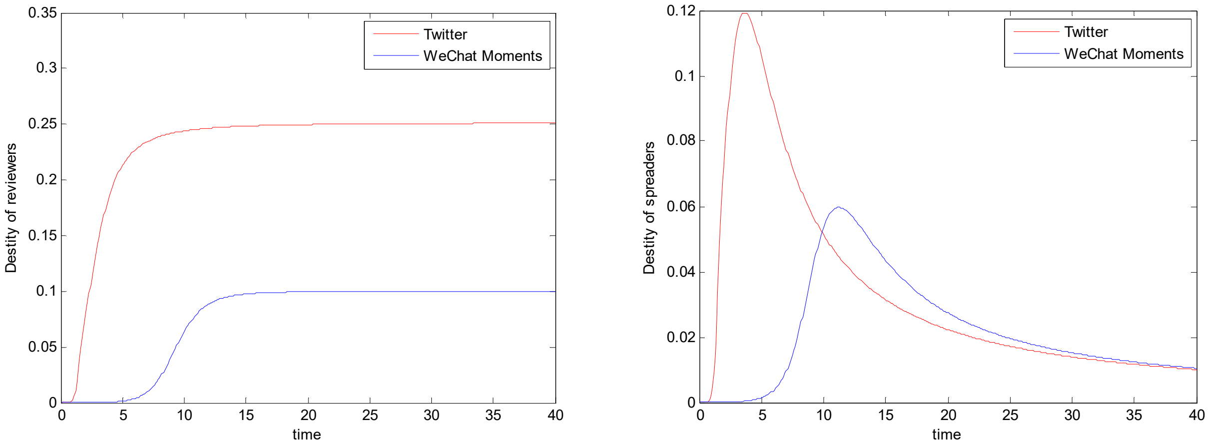

Fig. 6 Compare the densities of reviewers and spreaders over time in the *IRC2S* model with that in the advanced *IRC3S* model.

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