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A multi information dissemination model considering the interference of derivative information

Ling Sun [a], Yun Liu [a,*], Michael R. Bartolacci [b], I-Hsien Ting [c]

[a] Key Laboratory of Communication & Information Systems Beijing Municipal Commission of Education, Beijing Jiaotong University, Beijing 100044, China

[b] Information Sciences and Technology, Penn State University - Berks, Reading, PA 19610, USA

[c] Department of Information Management, National University of Kaohsiung, Kaohsiung, 811, Taiwan

HIGHLIGHTS

- We find that derivative information can effectively retard diffusion rate, final range and extend the diffusion period of subject information.
- The timeliness of interference is new factor. Random network shows a higher requirement for the timeliness than regular network.
- The interference is mainly concentrated in individuals who have already known about subject information.
- For reducing interference, increasing initial forwarding probability is much better than increasing influence parameter in random network.

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ABSTRACT

With the tremendous growth of social network research, many information diffusion models have been proposed from multiple perspectives with the intent of finding out key factors. However, most models only focus on the individual behavior patterns or the usage habits of social applications; the potential interrelationships between information items have not been explored. From this point of view, we propose an information interference model that takes into account the interrelationships between information items in social network. The effect of interference and anti-interference abilities of information in diffusion are analyzed in highly clustered regular networks and also the random networks. We find that information diffusion in regular networks is more easily affected by interference information; but the corresponding reduction of the information diffusion range is the negative consequence in random networks. We also find that the individuals who know about information are the main spreaders of interference. From the aspect of the interference, random network shows a higher timeliness requirement to interference. Furthermore, simulation results indicate that increasing initial forwarding probability of information is much better than increasing the influence of it in reducing interference.

1. Introduction

The dynamics of epidemic spreading is not a new topic. More and more attention on this area has allowed this phenomena be applied across more and more areas of everyday life. Information diffusion in social networks is one of the more popular

* Corresponding author.
E-mail addresses: 12111031@bjtu.edu.cn (L. Sun), liuyun@bjtu.edu.cn (Y. Liu), mrb24@psu.edu (M.R. Bartolacci), iting@nuk.edu.tw (I.-H. Ting).

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research issues related to this area of research. The result of traditional research is to focus on the nodal features or the information itself and how it may affect the diffusion tendency [1–7]. However, the information dissemination process is not an independent process. Individuals in social networks can easily acquire different sources of information and there are mutual influences between these sources. For instance, the promotion of a new product may lose an individual's attention due to a news item exposing quality problems for products by the same manufacturer. As a result, the information on the new product cannot be widely spread due to this interference. This creates the research question: what are the most critical factors affecting the dissemination of information in a social network? Our initial answer is that people's attitudes related to and opinions of the information being disseminated are the most important factors. Only when people are concerned about an item of information and motivated to share it will that information actually be spread. From the perspective of user behaviors, if a subsequent message can influence the diffusion trend of a previous one, it has the ability to alter attitudes and opinions in its effect. In light of this supposition, the establishment of a suitable model to reflect this process is the goal of this work.

Early researches in this are involved scientists proposing two valuable spreading models in order to describe the spread of disease: susceptible–infected–recovered (SIR) and susceptible–infected–susceptible (SIS) [8–16]. However, the structure of traditional models are fail to explain the multiple information situation in the online social networks [17–22]. According to Centola's online experiment [23], it indicates that social reinforcement plays an important role in the propagation of information. Different from specific features of information, social reinforcement can be interpreted as the situation in that individuals require multiple interactions with neighbors before forwarding opinions or adopting behaviors.

For Centola's valuable experimental results, we conducted a further verification for which the memory effects, social reinforcement and the non-redundancy of contacts are taken into account [24]. Zheng constructed a similar model to discover the changes in different the network structure [25]. Simulation results show that information can be spread farther and faster across clustered-lattice regular networks than across corresponding random networks [23,26,27]. However, this is the result in the environment with a single kind of information. From the perspective of a multi-information diffusion process, the connection between the information will become an external force to accelerate the evolution of information.

Rumor spreading is the most common diffusion phenomenon accompanied by interference [28]. As an opposite external force to rumor, truth randomly comes from one or more individuals who have a resolution capability, and disseminates in feedback mode along with the rumor diffusion. As the results, the active range of rumor will shrink with the gradual popularization of the truth, and finally is covered by the truth. This intervention result inevitably arises because it is based on the premise that rumor is false. But in fact, most results of intervention cannot be easily forecasted in complex network. Thus, it needs a suitable model to analyze the specific process of interference.

In this paper, we will introduce a simple information interference model. The Mutual interference between multi-source information is realized with respect to the individual's side [29,30]. The structure of social reinforcement is also involved. The rest of this paper is organized as follows: Section 2 presents the model structure with five states and introduces the interference process in detail with a mathematical analysis. Section 3 reviews and analyzes the simulation results. Section 4 summarizes and concludes our study.

2. Model

Considering the interaction between related information, we build a multiple information diffusion model considering two kinds of information. One is the *Subject Information* (simplify as SI) which is the main observation object in our model that spreaders intend to disseminate. The other is the related information of SI which named as *Derivative Information* (simplify as DI). DI can be a variety of information containing positive or negative views related to SI. There is a high correlation between SI and DI in content, but DI always appears after a few dissemination of SI. For instance, when eye-catching news cause a certain range of diffusion, such as when an unknown director wins an Academy Award (Oscar), then the personal stories of this director will be excavated by other netizens. Likewise, if this personal news is merely rumor, the truth will be released by others at a later time. We consider this phenomenon to be a "stress response" of the numerous netizens to the new information. As a DI contains different views related to an SI, individuals who have already accessed the DI before receiving the SI, their judgment on forwarding the SI will become more complex or convoluted.

Firstly, we introduce the spread process in our model. The information spread rule is almost the same to the SIR model which spreaders inject others node by node. The difference is that there are two spreading stages. In the first stage, only SI spreads in the network. In the second stage, DI comes up and spreads together with SI. We suppose that, when the spreading range of SI R_{SI} exceeds the threshold $T = R_{SI}/N$, one of the nodes in the period of hesitation to forward SI will become the source of DI and begin to transmit it to its neighbors. In reality, only when the information reaches a certain degree of popularity, people will talk about it and post their own ideas. Thus, threshold T is used to describe this phenomenon. Also, it is easy to understand that if someone has not received SI, he would not have any knowledge to it and cannot put forward any DI. When it enters into the second spreading stage, both DI and SI are diffusing in the network. Furthermore, if individual keeps stay in the period of hesitation to forward information in the second stage, he may receive both SI and DI at different time. According to arrival order of information and results of interference, we use five states to describe individuals in the network:

(i) *Unknown* state. The individual has not received the information, analogous to the susceptible state of the SIR model.
(ii) *Known* state. The individual is aware of the information (i.e., received the signal at least once,) but hesitates to forward it.