International Journal of Computer Science and Information Technology
ISSN: 3005-9682 (Print), ISSN: 3005-7140 (Online) | Volume 5, Number 1, Year 2025
DOI: https://doi.org/10.62051/ijcsit.v5n1.25
Journal homepage: https://wepub.org/index.php/IJCSIT/index

Social Network Rumor Propagation Model Considering Blockchain Content Consensus

Can Zhang *

College of Computer Science and Technology, Qingdao University, Qingdao, China
*Corresponding Author: zhangcan@qdu.edu.cn

ABSTRACT

In order to better explore the information dissemination characteristics of social networks, a trust evaluation mechanism is constructed based on the consensus mechanism and incentive mechanism of blockchain, and the participation consensus probability function is introduced, and a rumor propagation model of blockchain social networks is proposed. In the experimental simulation, the influence of trust degree on consensus participation probability and rumor acceptance probability is quantified, and the influence of this model on rumor propagation is explained through the analysis of consensus probability and propagation probability, and the comparison with the existing model is made. The experimental results show that the propagation range of the proposed model is reduced by 12%-41% compared with the classical model, which verifies that the proposed model can effectively suppress rumor propagation.

KEYWORDS

Social network; SEIR; Rumor propagation model; Blockchain; Consensus mechanism

1. INTRODUCTION

With the vigorous development of digital social media, the way people share information, opinions and news on social networks has undergone profound changes. However, this transformation has also brought a serious challenge: the abuse and spread of rumors. Rumors are inaccurate information about people or social events, and most of them have negative functions. The harm of rumors is no longer limited to the individual level, but has evolved into an information dissemination storm that affects the entire society. In the Internet environment, the speed of information update is fast, the exchange of information is not restricted by space, the cost of information exchange is low, and it is easy to meet the personalized needs of different users. These characteristics make the information consumption behavior of social network users no longer restricted by time and space. The diverse and continuous interactions of social network users, such as forwarding, commenting, liking, and recommending, enable various information to spread rapidly in social networks. False information may spread throughout the entire social network in an instant, causing public anxiety, misleading decisions, and having a profound impact on social stability and trust.

Due to the complexity of social networks and the spread of rumors, most studies have been unable to find universal and effective methods to control the spread of rumors. The vulnerability of the traditional social network architecture makes the problem of false information dissemination particularly serious. Information is transmitted on centralized platforms, lacking sufficient transparency and anti-tampering mechanisms, and is vulnerable to malicious behavior. Against this background, the rise of blockchain technology provides us with a new way of thinking and a solution. As a relatively mature data technology, blockchain's decentralized nature, traceability of information sources, autonomy, and difficulty in tampering can effectively address the data privacy issues, trust issues, and the impact of low-quality information on the social network environment caused by the centralized management of traditional social networks. Blockchain's unique incentive mechanism and consensus mechanism further promote user community autonomy. Users are not only content creators, disseminators, and information consumers, but also community managers. Through user self-governance, a better community environment can be created. A high-quality community environment and economic incentives encourage users to create high-quality content. High-quality content brings economic rewards to users and increases their enthusiasm for participating in community management, forming a virtuous cycle. Due to the technical characteristics of blockchain changing the social network ecosystem, it is necessary to further study the communication patterns affected by it, and then summarize and construct reasonable communication models. This is of great theoretical and practical value for improving the information dissemination mechanism in existing social networks and preventing the spread of false information.

2. RELATED WORK

2.1. Blockchain Technology

Blockchain is a data structure formed by orderly linking of blocks according to time series, and each block contains information such as transaction records, time stamps and hash functions of a certain size [1]. According to the depth and breadth of blockchain application, Melanie Swan divided the development process of blockchain application into three different stages [2]: blockchain 1.0 stage, the main body is cryptocurrency; Blockchain 2.0 stage, the main body is programmable financial system; Blockchain 3.0 stage, is also the current stage of blockchain application, in this period of blockchain application beyond the currency, financial fields, in this stage blockchain began to be widely used in government affairs, science, social public services and other fields.

In the financial sector, Peters and Panayi pointed out and explored in detail the huge potential of blockchain to disrupt the banking industry [3]. Large software companies such as IBM [4] and Microsoft Azure [5] have started offering blockchain services and are actively working with more than 40 banks around the world. Global banking giants have joined forces to form the R3 Consortium [6] and set up the R3 Development Fund, which aims to support companies using blockchain for global commerce.

In the field of Internet of Things [7] (IoT), Reyna A et al. [8] identified the opportunities for the development of the combination of iot and blockchain, and studied the integration of iot and blockchain in depth. Hardjono and Smith [9] propose an innovative architecture designed to assist devices in proving their manufacturing source, without third-party authentication, and to support anonymous registration, thereby significantly improving privacy issues in iot applications. IBM also released a proof-of-concept for Telemetry (ADEPT) [10], which uses blockchain technology to build a distributed network of devices.

In the field of social public services, Yi Chen, Shuai Ding [11] and other researchers have used blockchain technology to create a scheme for managing medical data that does not rely on any third-party data storage, thus successfully solving the security problem of personal medical data and privacy data in the medical field. Zhaoxiong Meng [12] et al. proposed a copyright management system, which integrates technologies such as blockchain and perceptual hash function to successfully ensure data security. In terms of sustainable energy use, Gogerty and Zitoli [13] proposed a concept of a solar coin designed to incentivize and promote the use of renewable energy.

2.2. Rumor Propagation Model

Some scholars have explored the practical application of blockchain in social networks. Chakravorty[14] proposes a user-centric, blockchain-enabled social media network that enables truly decentralized, secure, and traceable content distribution. In literature [15], Barbara Guidi reviewed the leading blockchain-based online social media platforms, placing users in the core role of the system, and proposed a new model of online social networking. Gyuwon Song [16] proposed a social media notarization service combined with blockchain, using blockchain technology to achieve real archiving of social media content, and finally conducted a proof of concept through real-time messaging scenarios. These studies aim to solve the problems of user privacy data leakage, low data security, high centralization of social networks, and difficulty in tracing the source of data that exist in traditional social network frameworks by utilizing blockchain technology.

Most researches on rumor propagation are based on infectious disease transmission model and complex network communication. Previous studies mostly focused on traditional Internet social networks such as Twitter, Facebook and Weibo, while there were few studies on rumor propagation on blockchain-based social networks.

Swan M [17] was the first to point out that information dissemination can be combined with blockchain. Ma Qiang [18] et al. took Steemit social network as an example to conduct an in-depth study on how to use blockchain for online rumor governance. Jia [19] used the social network analysis method to explore the law of public opinion dissemination in social networks with blockchain as the underlying architecture, and believed that blockchain social networks presented the characteristics of scale-free networks. Lin Haohan et al. [20] studied how to use blockchain technology to control online rumors. Guo Sulin [21] conducted an in-depth study on the network public opinion dissemination and risk management based on blockchain. However, most of these studies have not explored rumor propagation from the perspective of information transmission dynamics.

Zhao Dan [22] proposed a conceptual model of public opinion communication on social networks based on blockchain from an empirical perspective. Wang Xiwei et al. [23] proposed a new model based on blockchain, which aims to detect online rumors and promote the development of rumor governance and public opinion guidance. Sun Gengxin et al. [24] introduced the revenue-risk matrix, improved the warehouse model, reinterpreted the node states of the model, and proposed an information propagation model suitable for the blockchain environment. Cui Zengle optimized the information dissemination model on the basis of literature [25]. The current research mainly focuses on analyzing the application prospect of blockchain technology in information dissemination, improving the efficiency of information dissemination in blockchain, and reducing the cost of information storage. Only a few scholars have studied the information dissemination model under the blockchain architecture, but it has not yet formed a systematic system. Therefore, the research on the information dissemination model under the blockchain architecture still needs to be further in-depth.

The main contributions of this paper are as follows:

• Starting from the content consensus of blockchain social networks, this paper analyzes the impact of content consensus on rumor propagation, and proposes a rumor propagation model based on information transmission dynamics.

• In order to describe the impact of consensus cost on the probability of users participating in consensus, a trust evaluation mechanism is constructed from the aspects of network topology and user attributes by combining the influence analysis of complex networks and social networks. Based on this trust evaluation mechanism, the influence of trust degree on the consensus probability and rumor acceptance probability of users is quantified.

3. RUMOR PROPAGATION MODEL BASED ON BLOCKCHAIN SOCIAL NETWORK

3.1. Communication Characteristics

Blockchain can efficiently form information consistency in highly decentralized systems through the use of consensus mechanisms such as PoW and PoS. In blockchain, these consensus mechanisms guarantee the output of the block, which is used to store information and issue token rewards. At the level of social networking applications, consensus mechanisms are used by community users to assess whether content is a rumor, that is, users exposed to a piece of information can reach a consensus on its authenticity.

However, unlike the "likes" and "points" in traditional social networks, when the content of the blockchain social network is consensus, the user needs to carry out economic mortgage, that is, mortgage a part of the token, and mortgage their credibility. This means that user consensus on the quality of content is actually a double mortgage involving both financial and reputation. This can be seen as an investment, where users invest in authentic, high-quality content. If the content is proven to be authentic and of high quality, the users who participate in the consensus will receive the platform's financial returns and reputation returns. Conversely, if the information is proven to be false or inferior, due to the nature of the blockchain, the false information is first hidden rather than removed, at which point the user cannot recover the cost and may be punished in terms of financial and reputation. This mechanism provides users with a more direct and economical way to participate in the evaluation of social network content.

In a blockchain social network, when users receive information and consider whether to spread it, the user will consider the number of tokens and credit value held by the creator or disseminator of the information, as well as their own thinking. In the process of information consensus, the investment behavior of users is similar to the investment decision of shareholders in reality. Whether or not other users invest also depends on their judgment of the investee and their credit assessment of various information about existing investors. For simplicity, this article combines the number of tokens held by each user and the creditworthiness as Proof of Credit (PoC). This approach, which takes into account both token and creditworthiness, aims to more fully assess how trustworthy users are in the dissemination of information.

3.2. Model Building

In order to study how rumors spread in blockchain-based social networks, we abstract different users in blockchain social networks into nodes with five transformable states based on information transmission dynamics: susceptible node S, hesitant node H, consensus node C, propagation node D, and immune node R. Where S node is an unknown node; H node is the group that has not made any communication behavior temporarily after S contacts the information; C node refers to the node that makes a consensus on the information with its own certain PoC as collateral after contacting the information; D node represents the node that has been propagated but not reached consensus; The R node indicates that the user is no longer interested in the information and is no longer affected by the information. The state transition process is shown in Figure 1.

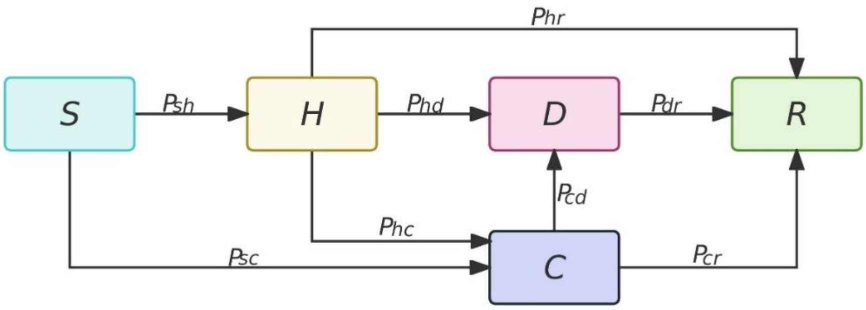


Figure 1. The state transition process of the SHCDR model

Let S(t), H(t), C(t), D(t), R(t) represent the density of susceptible nodes, hesitant nodes, consensus nodes, propagation nodes, and immune nodes respectively, and in the SHCDR model, at any time there should be: S(t)+H(t)+C(t)+D(t)+R(t)=1, the dynamics of these five types of nodes are as follows:

1) Susceptible node S. Node S is similar to a healthy individual who has not been exposed to the virus and has no antibodies during the transmission of an infectious disease. In this model, node S may be skeptical about the truth of rumors and not easily spread information. At this time, node S will transform into node H with probability p_{sh}. Node S may also reach a consensus on whether the information is a rumor after its own rational thinking, and then node S transforms into node C with probability p_{sc}.

2) Hesitating node H. Node H is similar to an individual who is infected with the virus during the transmission of an infectious disease, but the virus is in incubation period. As with individuals in the incubation period, the hesitant node may eventually be affected by the rumor and choose to spread the rumor. In this case, node H will transform into node D with probability p_{hd}. Different from virus transmission, in the process of rumor transmission, node H chooses to reach a consensus on the rumor after its rational thinking and research. At this time, node H will transform into node C with probability p_{hc}. At the same time, node H may not be interested in this information at all after contact with the rumor, at which time it will transform into immune node R with probability p_{hr}.

3) Consensus node C. Node C may carry out operations such as information forwarding during the consensus process, that is, it may transform into node D with probability p_{cd}. Node C may also revoke its consensus decision during the rumor propagation, and the node will become node R with probability p_{cr} and no longer be interested in the rumor.

4) Propagation node D. Node D is similar to an individual who is infected with a virus and becomes ill during the transmission of an infectious disease, and will infect other individuals while being infected with the virus. Different from virus transmission, the individual spreader may no longer be interested in the rumor and stop spreading the rumor with the development of the situation and their own research after a period of transmission. At this time, it will transform the probability p_{dr} into node R.

5) Immune node R. Node R is usually no longer interested in information, so it is a state that terminates and absorbs other nodes, and an increase in the number of immunizers usually helps dispel rumors.

The propagation dynamics equation of SHCDR model is summarized as Eq. 1:

$$
\begin{cases}
\frac{dS(t)}{dt} = -(P_{sh} + P_{sc})\theta S(t)D(t) \\
\frac{dH(t)}{dt} = P_{sh}\theta S(t)D(t) - P_{hd}H(t) - P_{hc}H(t) - P_{hr}H(t) \\
\frac{dC(t)}{dt} = P_{sc}\theta S(t)D(t) + P_{hc}H(t) - P_{cr}C(t) - P_{cd}C(t) \\
\frac{dD(t)}{dt} = P_{hd}H(t) + P_{cd}C(t) - P_{dr}D(t) \\
\frac{dR(t)}{dt} = P_{cr}C(t) + P_{dr}D(t) + P_{hr}H(t)
\end{cases}
\tag{1}
$$

Where θ is the probability that any edge in the network is connected to the spreader node.

3.3. Trust Evaluation Mechanism Based on Social Influence Research

Under what circumstances will the susceptible node S and hesitant node H choose to pledge their own economy and reputation to participate in the consensus? They need to assess whether the source of the information (propagation node D) and other individuals participating in the consensus can be trusted, and when the degree of trust of the above two individuals meets their expectations, they will participate in the consensus. This process is regarded as the process in which the propagation behavior of susceptible node S and hesitant node H is affected, and the social influence of nodes is the main factor influencing the behavior of their neighbors.

By building influence analysis methods adapted to the reality of blockchain social networks, it is possible to evaluate the trust of nodes. The existing influence measurement methods include those based on network topology, user behavior and user interaction information [26]. The degree attribute of a node is widely used in influence measurement [27, 28]. At the same time, Wang Xiwei et al. [29] also studied opinion leaders and influence in social networks based on the topology of blockchain social networks. In order to prevent the mass spread of messages in blockchain social networks, literature [30] combines blockchain smart contracts to design a protocol containing both private and public part contracts to evaluate the cumulative credit of each participant at different moments. This design is designed to effectively manage the spread of messages and evaluate the credit accumulation of nodes in the social network through the contract system. Trust is generated between nodes and their neighbors in a social network. When nodes can evaluate the trustworthiness of neighboring nodes through the PoC of neighboring nodes and the importance of neighboring nodes in the network, they can finally choose the appropriate propagation behavior.

Based on the summary and analysis of existing studies in literature [26], combined with the actual information dissemination, when users evaluate the credibility of other users: (1) Users usually start from the number of friends, fans or recommendations of other users, and the inbound and outbound centrality of nodes can well describe the above factors; (2) In the blockchain social network, the number of tokens held by the user and its credit value also reflect the credibility of the user to a certain extent. Therefore, we optimize the calculation of node trust by integrating the centrality of entry, centrality of exit and PoC (number of tokens held by nodes and reputation value).

Let the graph G=(V, E),V is the node set, let n=card(V), $v_i \in V$,i=(1,2,3... ,n), $e_{ji} \in E$, e_{ji} indicates the directed edge from node v_j to node v_i, and the direction indicates the direction of influence propagation. The inbound centrality and outbound centrality of node v_i are respectively shown in Eq. 2 and Eq. 3 :

$$
DC^{in}(v_i) = \frac{deg^{in}(v_i)}{n-1} = \frac{\sum_j e_{ji}}{n-1} \tag{2}
$$

$$DC^{out}(v_i) = \frac{deg^{out}(v_i)}{n-1} = \frac{\sum_j e_{ij}}{n-1} \tag{3}$$

Where, $\sum_j e_{ji}$ and $\sum_j e_{ij}$ represent the inbound degree and outbound degree of the node, respectively. Suppose the number of tokens held by the node is T_{v_i}, the credit value is C_{v_i}, the global maximum T_{v_i} and C_{v_i} are normalized, and the PoC of the node v_i is obtained as follows:

$$PoC_{v_i} = \omega_T \frac{T_{v_i}}{max(T_{v_i})} + \omega_C \frac{C_{v_i}}{max(C_{v_i})} \tag{4}$$

The final result:

$$DoT = \omega_{DC^{in}} * DC^{in}(v_i) + \omega_{DC^{out}} * DC^{out}(v_i) + PoC_{v_i} \tag{5}$$

In the above formula, $\omega_{DC^{in}}$, $\omega_{DC^{out}}$), ω_T and ω_C are the weights of the node's entry centrality, exit centrality, number of tokens held and credit value in the node's trustworthiness evaluation, respectively. In the actual application, different numerical values can be used for simulation according to different scenarios.

3.4. The Influence of Trustworthiness on User Participation Consensus

At present, most researches on rumor propagation on social networks assume that the probability of each node changing into other states is the same, but in real social networks, the probability of individuals choosing their own propagation behavior is different. Whether users are influenced by others can be influenced by a number of factors, such as the level of trust in other nodes mentioned above. In blockchain-based social networks, participation in content consensus requires users to double mortgage, and this cost behavior makes users pay more attention to whether the nodes that have participated in the consensus are trustworthy.

Many studies have answered the question of how trust spreads in social networks and how trust affects user behavior. Zhang Shaowu [31] et al. proposed a probability-based propagation model based on node similarity and combined with Bayesian conditional probability formula based on trust propagation model. Hou Lisong et al. [32] pointed out that platform trust and institutional trust have significant impacts on users. On the other hand, Liao Lifa [33] et al., starting from the actual social network wechat, fully considered the impact of trust on rumor propagation, proposed a communication probability calculation formula for wechat environment, and established a corresponding rumor propagation model. Based on the above research, combined with the actual situation of blockchain social networks, the probability formula of user participation in content consensus is defined as follows:

$$P(n) = |(\alpha - \beta)e^{-\varphi\rho n} - \alpha| \tag{6}$$

In Eq. 6, P(n) is the actual probability that the user will participate in the content consensus, n is the number of nodes participating in the consensus at time t, φ is the average trust degree of all nodes participating in the consensus at present, ρ is the influence factor of trust, α is the positive and negative identifier of the user affected by the trust degree, and β is the initial probability of participating in the consensus.

If α=0, then the user is negatively affected by the trust degree, that is, it is difficult for the user to trust the node participating in the consensus at this time, then according to Eq. 6 :

$$P^{-}(n) = \beta e^{-\varphi\rho n} \tag{7}$$

If α=1, then the user is positively affected by the trust degree, that is, the user is easy to trust the node participating in the consensus at this time, then according to Eq. 6:

$$P^{+}(n) = 1 - (1 - \beta)e^{-\varphi\rho n} \tag{8}$$

Let n=0, β=0.5, then P(n)=β=0.5 The probability change of users participating in content consensus under the influence of trust is shown in the figure:

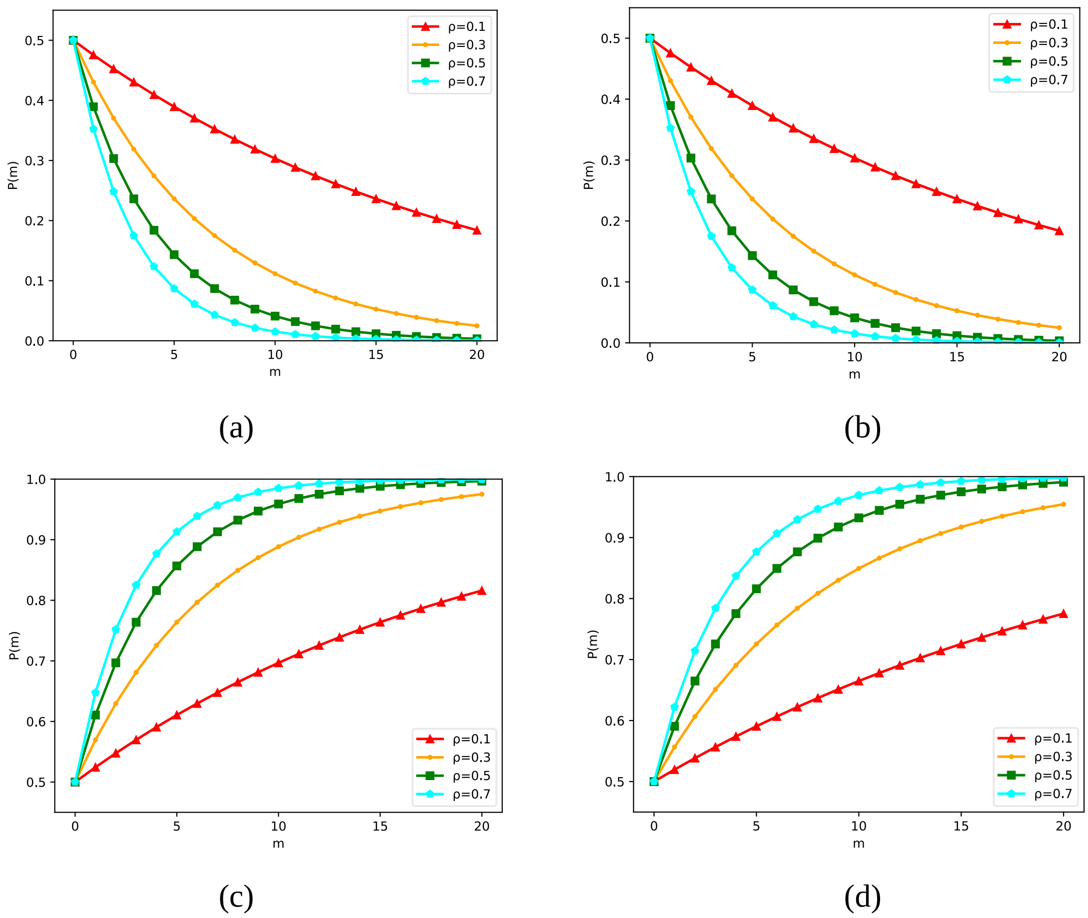


Figure 2. Participation consensus probability for different influence factors and trust levels

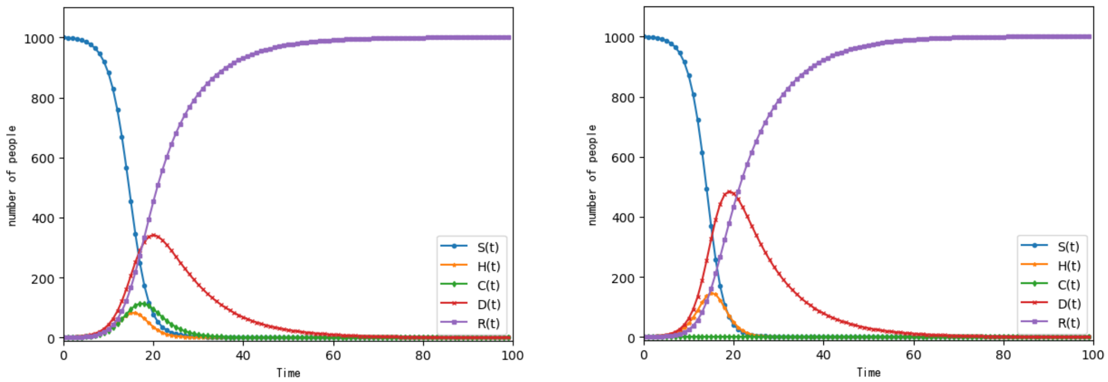
φ=0.5 in Fig. 2 (a) and φ=0.4 in Fig. 2 (b). The two figures show the influence of trust factor ρ and average trust degree φ on the probability of users participating in consensus when users are negatively affected by trust degree. It can be seen that with the increase of trust factor, the probability of users participating in consensus gradually decreases. By comparison with (a) and (b), it can be seen that with the decrease of average trust in the network, the decrease speed of user participation in consensus probability also slows down. Similarly, φ=0.5 in Fig. 2 (c) and φ=0.4 in Fig. 2 (d). The two figures show the influence of trust factor ρ and average trust degree φ on the probability of users participating in consensus when users are positively affected by trust degree. At this time, with the increase of trust factor, the probability of users participating in consensus gradually increases. By comparison with (c) and (d), it can be seen that with the decrease of average trust, the increase rate of user participation in consensus probability gradually accelerates.

4. EXPERIMENTAL RESULTS AND ANALYSIS

4.1. The Influence of Consensus Nodes on the Trend of Network Evolution

In this part of the experiment, from the perspective of communication dynamics, the influence of the addition of consensus nodes on rumor propagation was explored, focusing on the peak density of disseminators, the speed of rumor propagation and the duration of rumor propagation.

When t=0, that is, starting from S(0), H(0), C(0), D(0), R(0), the total capacity of network nodes is set to 1000 in the experiment. In this case, if no consensus node is introduced, the parameters related to node C should be 0, that is, p_{sc}, p_{hc}, p_{dc}, $p_{cr} = 0$. The node density changes of two types of networks with and without consensus nodes are shown in Fig. 3:



(a) (b)

Figure 3. The process of rumor propagation in two kinds of networks with and without consensus nodes

As can be seen from Fig. 3, susceptible node S and immune node R show the same change trend in (a) and (b) because their change trends are not only affected by consensus node C. Hesitation node H and propagation node D show the same trend of change in the network with and without consensus nodes, but the peak value is different. In the network with consensus nodes, node H reaches a peak value of 81.68 when t=16, and node D reaches a peak value of 341.17 when t=20. In a network without consensus nodes, node H reaches a peak value of 146.30 when t=15, and node D reaches a peak value of 484.48 when t=19. In the network with the introduction of consensus nodes, node H selects the communication behavior by evaluating the average trust of all the current consensus nodes and the trust of the propagation nodes. It is confirmed that the hesitant node H behaves more rationally in the communication process due to the addition of consensus node C. In the network without the introduction of consensus nodes, the number of node D increases rapidly after node S is exposed to rumors, while the growth rate of node D slows down relatively and the maximum propagation range decreases relatively after the introduction of consensus nodes. In the blockchain social network, the communication behavior of users is more rational, which effectively inhibits the generation of distorted messages.

4.2. Influence of Consensus Mechanism on Rumor Propagation Performance

In this model, node C and node D are two different nodes, but node C may also play a role in promoting rumor propagation, so the density change of rumor propagators in the two networks is compared separately. The following experiments are discussed in two situations:

(1) When node C and node D are regarded as the disseminators of rumors, the comparison of the change trend of the disseminators in the two networks with and without consensus is shown in Fig. 4:

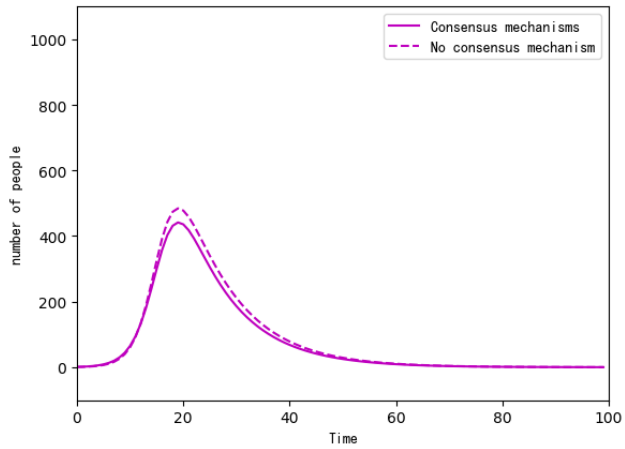


Figure 4. Node C and node D are regarded as the disseminators of rumors

As can be seen from Fig. 4, the peak value of rumor propagators without consensus mechanism is 48.45%, while the peak value of rumor propagators with consensus mechanism is 44.16%, which is smaller than the former. Secondly, it can be clearly seen that the rumor propagation speed is faster when there is no consensus mechanism than when there is consensus mechanism. From the peak density of disseminators and the speed of rumor propagation, it can be seen that members of social networks without blockchain consensus mechanism are more likely to believe rumors, and if some people become consensus nodes, the propagation peak, propagation speed and duration of rumors can be reduced.

(2) When only node D is regarded as the spreader of information, the comparison of the change trend of spreaders in the two networks with and without consensus is shown in Fig. 5:

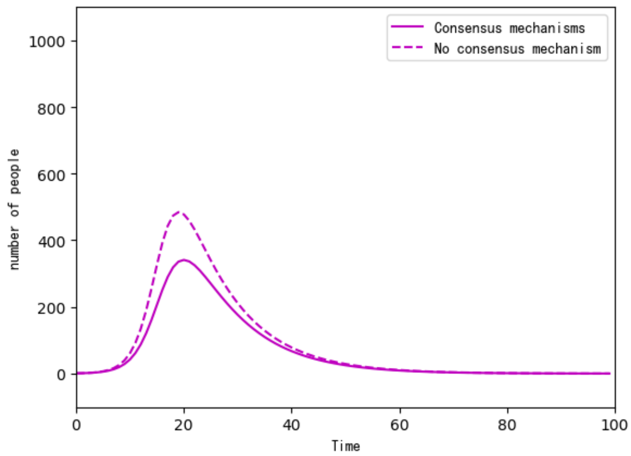


Figure 5. Only node D is regarded as the disseminator of information

Similarly, in Fig. 5, if node D is only regarded as the spreader of information, the peak value of rumor spreader on the social network without consensus mechanism is 48.45%. However, in the social network with consensus mechanism, the peak value of rumor disseminators is 34.12%, which is lower than the former. It can be clearly seen that the propagation rate at this time is lower than the former.

Based on the analysis of the above two situations, it can be seen that the consensus mechanism of blockchain can effectively reduce the spread scope and rate of rumors and reduce the propagation time of rumors. This proves that blockchain can inhibit the spread of rumors to a certain extent, and this inhibition effect can be described by the model in this paper.

4.3. The Influence of Trust Degree on Node Participation Consensus

The experiment in the previous section compares the rumor propagation performance of the network with and without consensus nodes, and proves the effectiveness of the blockchain consensus mechanism. In this section, we observe the influence of social network trust on consensus nodes through experiments. In a blockchain-based social network, hesitant node H is positively or negatively affected by the degree of trust. After coming into contact with the information, node H will evaluate the source of the information and the trust degree of all nodes participating in the current consensus to choose its own communication behavior.

As shown in Fig. 6, when hesitant node H was positively affected by trust, the number of consensus nodes was observed to change over time by adjusting p_{hc}. It can be seen that consensus nodes increase slowly at the beginning and decrease rapidly after reaching the peak. With the increase of p_{hc}, the maximum value of consensus node also increases, and the time to reach the peak value is delayed. Similarly, as shown in Fig. 7, when hesitant node H was negatively affected by trust, the number of consensus nodes was observed to change over time by adjusting p_{hd}. Under the influence of different p_{hd}, the change trend of consensus nodes is roughly the same, increasing slowly at the beginning stage, increasing rapidly at a certain stage, and decreasing rapidly after reaching the peak value. With the increase of p_{hd}, the maximum value of consensus node decreases, but the time of consensus node peak is advanced. It can be seen that after the positive influence of trust is increased, the probability of users participating in consensus is increased, which makes the truth of rumors spread more widely and makes the choice of communication behavior more rational, thus restraining the spread of rumors. On the contrary, when the negative influence of trust is increased, the probability of users accepting rumors increases, and users are more inclined to become the disseminators of rumors, which further expands the spread scope of rumors and promotes the spread of rumors.

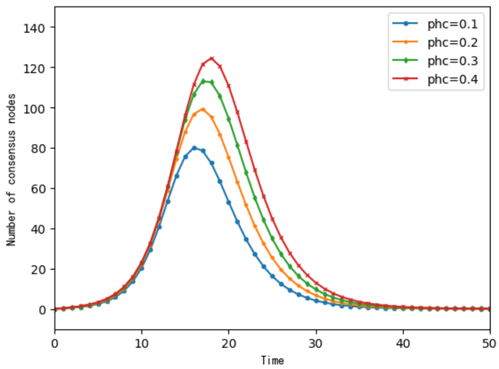


Figure 6. The positive effect of trust

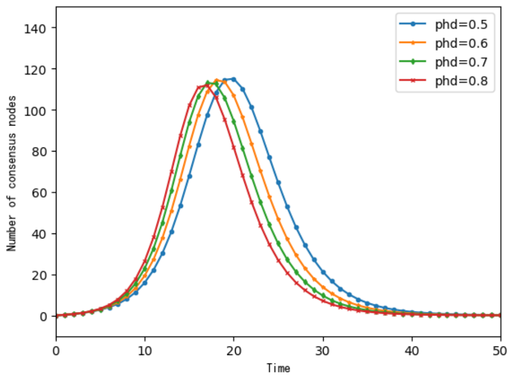


Figure 7. Negative effects of trust

4.4. Comparative Analysis of Experimental Simulation

In order to further explore the impact of blockchain consensus mechanism and trust on user participation in consensus, this paper was conducted on the publicly available Steemit blockchain social network user relationship dataset, which includes 86,277 directed edges from 1,989 nodes. In order to demonstrate the advantages of the model proposed in this paper, it will be compared with the optimized blockchain social network propagation model (UECSR) in literature [34], the SBIR model introduced by intelligent nodes in literature [25], and the traditional SEIR model to further prove the superiority of the model proposed in this paper (SHCDR). The number of initial propagation nodes is set at 5. Due to the short propagation time, the dynamic change of network size is not considered in this experiment.

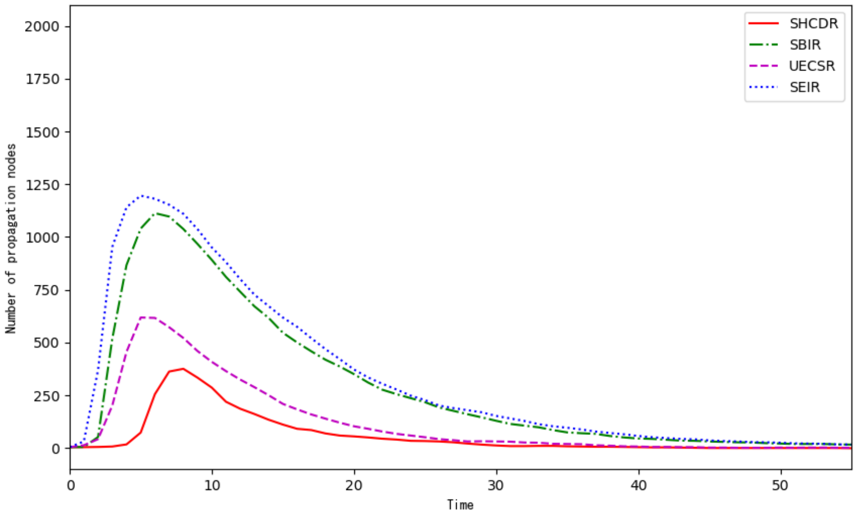


Figure 8. Comparison of the number of propagation nodes in different models

As can be seen from Fig. 8, the propagation speed of the model proposed in this paper is slower than that of other models, with the smallest propagation range and the shortest existence time of information. The SEIR model reaches the maximum propagation range of 1196 when t=5, and the number of propagation nodes tends to 0 when t=54. The UECSR model reaches a maximum value of 1113 when t=6, and the number of propagation nodes tends to 0 when t=52. The SBIR model reaches the maximum range of 619 when t=5, and the propagation node tends to 0 when t=38. The SHCDR model proposed in this paper reaches the maximum propagation range of 376 when t=8, and the number of propagation nodes tends to 0 when t=33. UECSR model and SBIR model are both blockchain-based social network models, so compared with the traditional SEIR model, the propagation range is reduced by 4.17% and 29.01% respectively, and the time to reach the peak is delayed, and the existence time of information is relatively shortened. Because SBIR model improves the evaluation method of user trust and quantifies the value of economic benefit, the effect is better than UECSR model. Compared with the traditional SEIR model, the propagation range of the SHCDR model proposed in this paper is reduced by 41.23%, and that of the SBIR model is reduced by 12.22%, indicating that the model proposed in this paper plays a better role in suppressing the spread of rumors. The model in this paper has the longest peak time, the smallest propagation range, the slowest propagation rate, and the shortest duration in the network, which confirms that the model in this paper can better describe the user's more cautious choice of communication behavior in the early stage of information transmission, demonstrating the superiority and rationality of the model in this paper.

5. SUMMARY

Blockchain technology is considered to be one of the major disruptive technologies of this century. In this paper, based on the blockchain social network, we first consider the consensus mechanism unique to blockchain, and introduce consensus nodes to build a new rumor propagation model. Secondly, by combining the influence analysis of complex networks and social networks, we improve the trust evaluation mechanism, and quantify the influence of trust degree on the consensus probability and rumor acceptance probability of users. Simulation experiments were conducted on the real data set of the Steemit platform and compared with traditional models and blockchain-based models to assess the impact of the model on the spread of rumors. The experimental results show that: (1) Considering the consensus of blockchain content, users have more references to distinguish the credibility of information when they choose the propagation behavior of rumors, so as to be more rational. (2) Compared with other models, the model in this paper greatly improves the reduction of rumor propagation scope, propagation rate and duration, which reflects that the model in this paper is helpful to avoid large-scale rumor propagation. This has important theoretical and practical value for improving the information dissemination mechanism in the existing social network and preventing the spread of false information.

ACKNOWLEDGEMENTS

This research was funded by Shandong Natural Science Foundation of China, grant number ZR2021MG006.

REFERENCES

[1] Nakamoto S. Bitcoin: A Peer-to-Peer Electronic Cash System [J]. consulted, 2008. DOI:http://dx.doi.org/.

[2] Melanie Swan. 2015. Blockchain: Blueprint for a New Economy (1st. ed.). O'Reilly Media, Inc.

[3] Peters W G, Panayi E. Understanding Modern Banking Ledgers through Blockchain Technologies: Future of Transaction Processing and Smart Contracts on the Internet of Money [J]. CoRR, 2015, abs/1511.05740.

[4] Modernizing enterprise business: Connecting application data with IBM Blockchain [R/OL]. (2019-02) [2022-1-19]. https://www.ibm.com/downloads/cas/VZPLDP04.

[5] What are Blockchain-Enabled Digital Ecosystems [R/OL]. (2020-04-29) [2022-1-20]. https:/ /azure.microsoft.com/en-us/resources/what-are-blockchain-enabled-digital-ecosystems/

[6] Bonneau J, Miller A, Clark J, et al. Sok: Research perspectives and challenges for bitcoin and cryptocurrencies[C]//2015 IEEE symposium on security and privacy. IEEE, 2015: 104-121.

[7] Kuo Z, Yongheng. Research review on Internet of Things security driven by blockchain technology [J]. Inform Xation. Network Security, 2017, (05): 1-6.

[8] Reyna A, Martín C, Chen J, et al. On blockchain and its integration with IoT. Challenges and opportunities [J]. Future Generation Computer Systems, 2018, 88: 173-190.

[9] Hardjono T, Smith N. Cloud-based commissioning of constrained devices using permissioned blockchains[C]//Proceedings of the 2nd ACM international workshop on IoT privacy, trust, and security. 2016: 29-36.

[10] IBM and Samsung: IBM ADEPT Practitioner Perspective - Pre Publication Draft. [R/OL]. (2015-06-07) [2022-1-22].https://zh.scribd.com/doc/252917347/IBM-ADEPT-Practictioner-Perspective-Pre-Publication-Draft-7-Jan-2015.

[11] Chen Y, Ding S, Xu Z, et al. Blockchain-based medical records secure storage and medical service framework [J]. Journal of medical systems, 2019, 43(1): 1-9.

[12] Meng Z, Morizumi T, Miyata S, et al. Design scheme of copyright management system based on digital watermarking and blockchain[C]//2018 IEEE 42nd Annual Computer Software and Applications Conference (COMPSAC). IEEE, 2018, 2: 359-364.

[13] Gogerty N, Zitoli J. DeKo: An electricity-backed currency proposal [J]. Social Science Research Network, 2011.

[14] Chakravorty A, Rong C. Ushare: user controlled social media based on blockchain[C]//Proceedings of the 11th international conference on ubiquitous information management and communication. 2017: 1-6.

[15] Guidi B. When blockchain meets online social networks [J]. Pervasive and Mobile Computing, 2020, 62: 101131.

[16] Song G, Kim S, Hwang H, et al. Blockchain-based notarization for social media[C]//2019 IEEE international conference on consumer electronics (icce). IEEE, 2019: 1-2.

[17] Swan M. Blockchain: Blueprint for a new economy [M]. " O'Reilly Media, Inc.", 2015.

[18] Qiang M, Han-han L. Analysis on the Governance Model of Internet Rumors based on Blockchain Technology -- taking news platform Steemit as an example [J]. News Forum, 2018, 4: 29-33.

[19] Jia P, Yin C. Research on the characteristics of community network information transmission in blockchain environment[C]//2019 IEEE 4th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC). IEEE, 2019, 1: 2296-2300.

[20] Han-han L. Research on Internet rumor governance based on blockchain technology [D]; Inner Mongolia University, 2019.

[21] Sulin.G. Research on Network Public Opinion Dissemination and Risk Management under blockchain environment [D]; Jilin University, 2020

[22] Zhao D, Wang X, Han J, et al. Research on the Propagation Characteristics and Rules of Network Public Opinion Information in Block Chain Environment [J]. Information Science, 2018, 37(09): 127-133.

[23] Xiwei W, Liu Z, Bo H, et al. Research on Network rumor screening model and simulation based on blockchain [J]. Journal of Information Technology, 2021, 40(02): 194-203.

[24] Sun G, Bin S, Jiang M, et al. Research on public opinion propagation model in social network based on blockchain [J]. CMC-Computers Materials & Continua, 2019, 60(3): 1015-1027.

[25] Zengle C, Xiaodong Q. Research on Optimization of Blockchain Social Network Information Propagation Model [J]. Computer Engineering and Applications, 2019, 57(07):59-69. (in Chinese)

[26] Xin-Dong W, Yi L, Lei L. Influence analysis of Online Social Networks [J]. Journal of Computers, 2014, 37(04):735-752.

[27] Borgatti S P, Everett M G. A graph-theoretic perspective on centrality [J]. Social networks, 2006, 28(4): 466-484.

[28] Ghosh R, Lerman K. Predicting influential users in online social networks [J]. arXiv preprint arXiv:1005.4882, 2010.

[29] Xiwei W, Xizhi J, Tingyan L, Liu Z. Research on the identification and Influence of Social Network user Opinion Leaders in the context of blockchain [J]. Information Theory and Practice, 2021, 44(05):84-91.

[30] Chen Y, Li Q, Wang H. Towards trusted social networks with blockchain technology [J]. arXiv preprint arXiv:1801.02796, 2018.

[31] Shaowu Z, Hongfei L, Xiaoxia L et al. Probabilistic trust propagation model [J]. Computer Science, 2014, 41(08):90-93+114. (in Chinese)

[32] Lisong H, Zeying C, Junjie T. Influencing factors and mechanism of customer trust in wechat environment [J]. Journal of Finance and Economics, 2017, (02):75-87.

[33] Lefa L, Xiangmao M, Xiaoyan W et al. Research on CASR rumor Propagation Model on wechat Social Network [J]. Small and Micro Computer Systems, 2016, 37(01):110-113. (in Chinese)

[34] Guanglai T. Research on Information Dissemination Model based on Blockchain Social Network [D]. Qingdao University, 2021.