Using Mobile Nodes to Control Rumors in Big Data Based on a New Rumor Propagation Model in Vehicular Social Networks

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ABSTRACT Vehicle data, which may have some errors, provide a source for big data analysis. Car owners sometimes publish false information to protect their privacy or interests. The spread of these false messages will contribute to potential loss as rumors. Recently, the emergence of the vehicular social network (VSN) has further accelerated the spread of rumors and anti-rumors. Researchers have proposed a number of methods to reduce the loss caused by rumors. However, these methods do not account for the fact that it takes some time for users to reply to the message after receiving the rumors. Each user responds differently to rumors, but previous methods do use fixed conversion rates in different states. To overcome these difficulties, individuals are classified as susceptible, trustful, contagious, immune or recoverable (STCIR). We propose a novel STCIR model to study the dynamic propagation of rumors. Each user is assigned a time threshold attribute to indicate the time delay of the user’s response. In some cases, a user may receive a rumor repeatedly in the course of the time threshold. Furthermore, we introduce vehicular nodes as authorities that produce correct information to curb rumors through user forwarding, and the anti-rumors starting from users are regarded as a rumor cascade. The experimental results reveal that vehicular nodes can reduce the scale and number of rumors. Vehicular nodes emerge early and move fast, and by moving to a greater degree, these nodes can increase the efficiency of mitigating rumors.

INDEX TERMS Vehicular social networks; Rumor propagation model; Vehicular node; Time delay.

I. INTRODUCTION

SOCIAL networks (SNs) have resulted in convenience for the public. An SN makes it possible for people in different regions to become friends and share their views. In recent years, several aspects of SNs have been studied, such as trust evaluation [1], [2], and privacy protection [3]–[6], social influence analysis [7], [8]. In big data, security and efficiency issues are also challenges [9], [10]. The vehicular social network (VSN) is an emerging communication network with relevant concepts and characteristics from two fields, i.e., SNs and vehicular ad hoc networks (VANETs) [11]. Large-scale social networks such as Facebook and Twitter have accelerated the spread of rumors. This phenomenon also exists in VSNs and can result in panic or potential loss [12].

For example, malicious comments about a taxi driver can influence his credibility and lead to financial loss.

A rumor is generally defined as unconfirmed information [13], and such a message can include misunderstandings, fake news [14], and misinformation. We use the definitions in [15]: The term “news” refers to any story or claim with assertions, and a “rumor” is a social phenomenon of a news story or claim that spreads or diffuses through a social network. In VSNs, false information is regarded as rumors. Controlling the spread of rumors is an urgent task that cannot be delayed.

A simple idea is to limit spreaders, and the essential step is detecting rumors in big data. Therefore, several rumor detection techniques are being developed. Yang et al. [16] analyze and extract rumor features and propose rumor detection
technology based on Bayesian networks for classification. Kong et al. [17] propose LoTAD to to detect abnormal traffic data in the long term. These methods are time consuming and face challenges in big data applications. Moreover, it is virtually impossible to determine if each user’s information is false.

To study the mechanism of rumor communication, researchers have modeled the propagation process. The majority of rumor propagation models in SNs are based on epidemiological models. The first rumor spreading model is proposed by Daley and Kendall [18]. The population is divided into spreaders, ignorant and stiflers. Considering the real situation, which involves individuals and authorities involved in rumor diffusion, many researchers have made improvements based on the traditional spreaders, ignorant and stiflers (SIR) model [19]. This type of model uses differential equations and mean-field theory to calculate the spreading efficiency for restraining rumors. Related research has improved the classical SIR model to satisfy the actual situation. Recently, Dhar et al. [22] propose the susceptible, thinker and active immune (SEI) mathematical model of news spreading and then present the standard for rumors detection and validation. The control strategy is to release a counter statement through the media in the model at any time to reduce the spread of rumors. Li et al. [23] design a credulous, spreader, rumors-killer, and rational (CSER) model, where the rumor-killer node is introduced to kill rumors. Their model is effective in both heterogeneous and homogeneous networks. A novel SIDR rumors propagation model considering the “doub” psychological factor is presented by Han et al. [24]. The authors also deploy a full coverage monitoring scheme based on a greedy algorithm to collect data and confute rumors. Dong et al. [25] hold that previous research ignores population dynamic factors. They establish an SEIR propagation model with varying total number of users and their deactivation rates. The latent nodes (E) are used to indicate changes in population.

In [26], the authors focus on external (the actions of authorities) and internal (forgetting nature of mankind) factors, noting that the diffusion behavior is time-dependent. Therefore, time-dependent function forms are used in SIR-like models. They also find that the network structure is important in the dynamic spreading of rumors. Wang et al. [27] propose a model of dynamic rumor influence minimization with user experience (DRIMUX). In the model, each node is assigned a tolerance time threshold: if the blocking time exceeds this threshold, the utility of the network will decrease.

Chen et al. [28] analyze three immune mechanisms: the forgetting, contact and active immune mechanisms. They believe that the contact immune mechanism does not conform to the real situation and propose an active immune mechanism. In our model, we assume that the individuals’ forgetting nature and the rumor refutation information must be generated by the authority (mobile node).

Zanette [29] study the spread of rumors in a small-world network and provide proof of the propagation threshold. Mazzoli et al. [30] introduce a scale-free network to study
the spread of rumors based on an agent. Li et al. [31] explore the collective propagation of multiple rumors and find that repetitive users can serve as a high-quality feature for rumor detection. Ma et al. [32] investigate the influence of bipolar social reinforcement on rumor diffusion, namely, an individual requires multiple prompts from neighbors before adopting an opinion or behavior. They find that controlling the nodes with large degrees or weights is an effective strategy to suppress the propagation of rumors. [33] presents a two-layer online and offline social network model to study the communication process of rumors.

Information dissemination can be used for viral marketing whose goal is to select the vertices that maximize information diffusion. Murata et al. [34] propose three new approximation approaches for the influence maximization problem. Serrano et al. [35] use the problem of rumor diffusion in SN to design and validate viral marketing strategies. Kong et al. [36] note that the lack of social vehicle data blocks the study of social features in VSN and present a process for generating a mobility dataset. Their other work [37] presents a taxi service recommendation model to solve the paradoxical situation of the inconvenience of taking a taxi for passengers and the empty carrying phenomenon for taxi drivers. Arif et al. [38] use fog computing to solve the threats of vehicle location and the leakage of personal information.

These SIR-based methods use the mean-field equation to calculate the threshold and the conversion rate of the differential models. Furthermore, these models do not take into account the time at which rumors are received by users. Time delays, such as data forwarding delays [39], are ubiquitous. In our STCIR model, every node is assigned a time threshold, and the probability of state transition is affected when a node receives the information (neglect the spreading delays, such as data forwarding delays [39], are ubiquitous). Therefore, the complex social network topology can be described as a weighted directed graph $G = (V, E, W, D)$. The weighted directed graph is presented in Figure 1.

The distance and the speed of vehicular node $A = \{a_1, \cdots, a_m\}$, where $m$ is the number of vehicular nodes, can be used to calculate the moving time of nodes. Therefore, the complex social network topology can be described as a weighted directed graph $G = (V, E, W, D)$. The weighted directed graph is presented in Figure 1.

III. STCIR MODEL

A. MODEL ASSUMPTION

The spread of rumors in a VSN is complicated. Many types of networks exist, including small-world networks and scale-free networks, and many factors influence the spread of rumors. In our model, the users are considered to be nodes or vertices $V = \{v_1, \cdots, v_i, \cdots, v_n\}$, where $n$ is the number of individuals, and $i$ indicates the $i$th user. The value of $v_i$ represents the node state, which is initialized to susceptible ($S$). The contacts between individuals can be represented by edges $E \in \mathbb{R}^{n \times n}$, where $\mathbb{R}^{n \times n}$ refers to a matrix of $n$ rows and $n$ columns, i.e., a symmetric matrix that is described by equation (1):

$$E = \begin{bmatrix} e_{11} & \cdots & e_{1n} \\ \vdots & \ddots & \vdots \\ e_{n1} & \cdots & e_{nn} \end{bmatrix} \quad (1)$$

where $e_{ij}, 1 \leq i \leq n, 1 \leq j \leq n$, is the edge that $v_i$ points to $v_j$. If $e_{ij} = 0$, there is no connectivity between $v_i$ and $v_j$. If $e_{ij} = 1$, there is a directed edge from $v_i$ to $v_j$. The influence between people is defined as the weight $W \in \mathbb{R}^{n \times n}$ in equation (2).

$$W = \begin{bmatrix} w_{11} & \cdots & e_{1n} \\ \vdots & \ddots & \vdots \\ w_{n1} & \cdots & w_{nn} \end{bmatrix} \quad (2)$$

$w_{ij}$ is the probability that user $i$ can affect user $j$. The distances between users is set as $d_{ij}, d_{ij} = d_{ji}$, and the matrix is given as below,

$$D = \begin{bmatrix} d_{11} & \cdots & e_{1n} \\ \vdots & \ddots & \vdots \\ d_{n1} & \cdots & e_{nn} \end{bmatrix} \quad (3)$$

FIGURE 1: The partial directed graph with weights of a social network.

Specifically, our model makes the following assumptions:

- The number of nodes is limited. When the model is established, the number of nodes and the relationships, distances and influences among the nodes are no longer changed.
- All the users in the network are active users because when they receive the information (neglect the spreading
time of information on the network), they reply within a certain time delay or threshold. If the user does not respond, they are considered to be an immune node.

- Users only spread the same type of information once. In a short period of time, the user has no new friends, even if it is forwarded multiple times, it does not have much impact. The state of the node will change after propagation.
- The response delay of every user is different. We simulate the actual delay by randomly generating a range from a Gaussian distribution.
- The recoverable node is generated by the vehicular node and is not affected by rumors. Information is disseminated by forwarding, and information is not distorted in the process of dissemination.
- The vehicular node is an official user that can force a change to the other node states even if this node is contagious.

B. NODE CLASSIFICATION

Nodes in the classical SIR model can exist in one of three states. In our model, the nodes and vehicular nodes can exist in one of five states. These nodes have different meanings, as illustrated in Table 1.

<table>
<thead>
<tr>
<th>Node state</th>
<th>State name</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Susceptible node</td>
<td>Initial users who do not receive information.</td>
</tr>
<tr>
<td>T</td>
<td>Trustful node</td>
<td>Users who have spread rumors and no longer spread.</td>
</tr>
<tr>
<td>C</td>
<td>Contagious node</td>
<td>Users who believe in and will spread rumors.</td>
</tr>
<tr>
<td>I</td>
<td>Immune node</td>
<td>Users who do not trust any information.</td>
</tr>
<tr>
<td>R</td>
<td>Recoverable node</td>
<td>Users who spread information to curb rumors.</td>
</tr>
</tbody>
</table>

Nodes $S$, $T$, $C$, $I$, and $R$ constitute the rumor propagation model, as shown in Figure 2. We define $C$ and $T$ as unhealthy ($U$) nodes. The users can move around and change the other nodes to recoverable nodes are defined as mobile (vehicular) nodes $M$.

C. NODE STATE TRANSITION

The $S$ node may accept a rumor and become a $C$ node or reject the rumor to convert to an $I$ node. After spreading a rumor, a $C$ node will convert to a $T$ node. Upon receiving information from an $R$ node, the $S$, $C$ and $T$ nodes all have a probability of recovering and becoming an $R$ node. We assume that $C$ and $R$ nodes propagate the same type of information only once. The $M$ node can force the other nodes to change to $R$ nodes. All nodes eventually turn into $I$ or $T$ nodes. Figure 3 describes the transformation relationships.

Regardless of how the nodes transform, the total number is deterministic.

$$n(S) + n(T) + n(C) + n(I) + n(R) = n$$

In equation (4), $n$ is the total number of users, and $n(\cdot)$ is the number in a specific state.

D. INFORMATION DISSEMINATION PROCESS

In our STCIR model, the goal is to solve three problems. One is how the information source node spreads the information, the second is how the receiver receives the information, and the third is how the receiver reacts to the received information. To address these problems, rumor propagation is divided into two processes: information broadcast and node state update.

1) Information broadcast

Rumors and anti-rumors have similar mechanisms of dissemination, which are combined into the process of information diffusion. In this process, nodes in states $C$ and $R$ will send the message to neighbor nodes, so we must determine the
Algorithm 1 Information broadcast

| Input: All users and their state V; link set between users E |
| Output: Collection \( \{v_j\} \) who receive information |

1. if \( v_i \) send rumors
2. \( v_j \) send rumors
3. for each \( v_j \) satisfies \( e_{ij} \neq 0 \)
4. if \( v_j \) == C then
5. \( v_j \) receive rumors
6. end if
7. end for
8. end if
9. if \( v_i \) == R then
10. \( v_j \) send anti-rumors
11. for each \( v_j \) satisfies \( e_{ij} \neq 0 \)
12. if \( v_j \) == S \( \| \) \( v_j \) == U then
13. \( v_j \) receive anti-rumors
14. end if
15. end for
16. end if

Algorithm 2 Node status update

| Input: All users and their state V; link set between users E; influence between people W; each node time threshold \( T \); receive information set \( \{v_j\} \) from Algorithm 1 |
| Output: Updated user state V |

1. if \( v_i \) send rumors then
2. \( v_i \) = T
3. else
4. \( v_i \) receive anti-rumors
5. \( v_i \) = I
6. end if
7. if Delay for receiving rumors of \( v_j \) >= \( T_i \) then
8. if \( v_j \) receive rumors then
9. Calculate \( P_j \)
10. Randomly generate a number \( R_j \) between 0 and 1
11. for each \( P_j \)
12. if \( R_j < P_j \) then
13. \( v_j \) = C
14. Break
15. end if
16. end for
17. end if
18. end if
19. if Delay for receiving anti-rumors of \( v_j \) >= \( T_i \) then
20. if \( v_j \) receive anti-rumors then
21. Calculate \( P_j \)
22. Randomly generate a number \( R_j \) between 0 and 1
23. for each \( P_j \)
24. if \( R_j < P_j \) then
25. \( v_j \) = R
26. Break
27. end if
28. end for
29. end if
30. end if

states of the nodes. Before the vehicular node \( M \) appears, only the C state node in the network transmit information, which represents the spread of rumors. For example, the state of \( v_i \) is C in Fig. 4(a). This node broadcasts information to its neighbors, as shown in Fig. 4(b). Fig. 4(c) shows that after spreading rumors, the state of \( v_j \) changes to \( T \).

When an R state node is generated from a mobile node, the C and R nodes together affect the nodes in the network. Algorithm 1 describes this dynamic process.

2) Node status update

This section addresses the two problems mentioned above, how to receive the information and how to update the node state. In the dynamic propagation process, we add the user’s time delay \( T = \{T_1, \cdots, T_n\} \) because in the real word, it is impossible to reply as soon as a message is received. In this way, when the user looks at their phone, there may be multiple users sending the same message, which would make the user more likely to accept the rumor. The probability of acceptance is related to the multiple neighboring users. Assume that node \( v_i \) receives messages from three adjacent nodes \( v_1, v_2, \) and \( v_3 \) with time delay \( T_i \). The probabilities that user \( i \) believes the messages are \( w_{1i}, w_{2i}, \) and \( w_{3i} \). The probability that user \( i \) accepts this rumor is calculated in equation (5):

\[
P_i = w_{1i} + (1 - w_{1i})w_{2i} + (1 - w_{1i})(1 - w_{2i})w_{3i} \tag{5}
\]

Based on these ideas, Algorithm 2 demonstrates how the nodes are updated.

IV. VEHICULAR NODE TO RELIEVE RUMOR DISSEMINATION

A. THE EMERGENCE OF THE VEHICULAR NODE

Vehicular nodes are authorities that can spread messages to control rumors. The R state nodes are generated by the vehicular nodes. Vehicular nodes also have a time delay. Before the vehicular nodes appear in the networks, only rumors spread in the STCIR model. After vehicular nodes appear, the model begins to control the spread of rumors. We assume that the vehicular nodes appear at random because it takes time for the authority to react. Time is an important parameter in preventing rumors from spreading. The earlier the vehicular node emerges, the better the effect will be.

B. MOVING STRATEGIES OF VEHICULAR NODES

The vehicular nodes can transform the states of other nodes to the R state. To make the vehicular node as functional as soon as possible, proper moving strategies must be designed. In our paper, the vehicular node cannot repeatedly go across the same node. The movement pattern of the vehicular node is described in Algorithm 3.
Algorithm 3 Moving strategy of the vehicular node

**Input:** All users and their state $V$; link set between users $E$; vehicular node $M$; distance between users $D$; vehicular node speed $A$; texttime $\text{texttime}$

**Output:** Changed $V$

1. The appearance time $T_a$ of $M$ and the current index $CI$ of the node are randomly generated.
2. $t = T_a$, staytime = 0 and $v_{CI} = R$
3. if $t < \text{texttime}$ then
   4. for each $M$ do
      5. Calculate the next index $NI$ of each $M$ according to one of the mobile strategies and $E$
      6. Calculate vehicular node time delay $T_M = A \ast \text{distance}(CI, NI)$
      7. if Staytime > $T_M$ then
         8. $t = t + \text{Staytime}$
         9. CI = NI
        10. else
            11. Staytime = 0
            12. Staytime = Staytime + 1
        13. end if
      14. end for
15. end if

Three scheduling strategies are used to determine the next position of a mobile node:
1) Vehicular node moves toward the farthest neighbor node.
2) Vehicular node moves toward the nearest neighbor node.
3) Vehicular node randomly moves to a neighbor node.

We will compare the three move methods in the experiments and analyze the results.

The time complexities of Algorithms 1 and 2 are both $O(n)$ because for $n$ users, each user needs to consider only his neighbors, and the number of neighbors is much smaller than $n$. In Algorithm 3, the number of mobile nodes and their neighbors and the total time are all small. Moreover, we do not need to consider all the users, so the time complexity is $O(1)$. Therefore, our algorithm has very little time cost.

V. EXPERIMENTS

A. PARAMETER SETTINGS

In this section, we design a simulation to validate our method. Our dataset is from Facebook and include 38865 users, their node degrees, their relationships and the influences among nodes. The detailed network attributes are described in Table 2. Since the dataset does not contain the distance between neighbors, the distance between nodes is generated by a random algorithm. The overall representation is a normal distribution with an expected value of 10. The maximum value is 20, and the minimum value is 1. This range is related to mobile node speed. In all tests, only one vehicular node is used.

All the experiments are conducted on a server running Microsoft Windows 10 with 2 CPUs and 32 GB memory. The integrated development environment is Visual Studio 2015, and the programming language is C#. The time for each test is 100 unit time. To reduce the impact of unexpected errors, the test results are the averages of 100 rounds.

### TABLE 2: The attributes of the experimental network

<table>
<thead>
<tr>
<th>Data</th>
<th>Facebook</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of users</td>
<td>38865</td>
</tr>
<tr>
<td>Total degrees</td>
<td>416448</td>
</tr>
<tr>
<td>Total links</td>
<td>7316052394</td>
</tr>
<tr>
<td>Max degree</td>
<td>199</td>
</tr>
<tr>
<td>Average degree</td>
<td>10.7152</td>
</tr>
</tbody>
</table>

B. EXPERIMENTAL RESULTS

In the initial conditions, the nodes in the network are all in the $S$ state. At the beginning of each round of testing, the source of the rumors is randomly generated. We use Algorithms 1 and 2 to simulate the propagation process. The process of rumor propagation in the SCTIR model is shown in Figure 5.
The number of $S$ nodes is reduced by receiving rumors. The propagators lose interest after a while. The $I$ nodes account for only approximately 15.86% of the nodes. However, the $T$ nodes, which believe the rumors, account for 81.94%. The node status reaches stability at approximately time 45 due to the limited network size. No $R$ nodes exist because the rumor information has not yet begun to propagate. At time 10, we add a vehicular node to generate anti-rumors. Figure 6 shows the SCTIR model under these conditions.

In Figure 6, there is not much change in the number of $S$ and $C$ nodes. The vehicular node appears at time 10, and the $R$ node is working. The movements of vehicular nodes are random, and the movement speed is 1. The proportion of $T$ nodes drops to 0.24% after peaking at 54.68%. The biggest change is in the $I$ nodes, which account for 99.56% of the total.

To study the impact of the appearance time of the vehicular node on the STCIR model, we consider three time points: 10, 20 and 30. The vehicular nodes move randomly at speed 1. Figure 7 shows the results of these situations.

In Figure 7, when there is no mobile node, the STCIR model reaches stability after time 55. When the vehicular nodes appear at times 10, 20, and 30, the time at which the unhealthy nodes fall are 35, 42, and 47, respectively. Stability is achieved at times 68, 83 and 92, respectively, and the final proportion of $U$ nodes is approximately 0.25%.

Figure 8 shows the impact of node speed on the $U$ nodes. We consider only one mobile node with movement speeds of 1, 2 and 8. The mobile node is randomly moved and appears at time 20. When the speed is 2, the point of decline in the number of $U$ nodes is at time 42. The number of nodes begins to decrease for speed 1 and 3 at time 41. The time to reach stability is 95, 84 and 76, and the final proportion of $U$ nodes is approximately 0.25%.
FIGURE 9: The number of unhealthy nodes for different mobile strategies.

The above mobile strategy is random movement. To study the influence of the mobile strategy on our model, we consider three mobile strategies. Move randomly to the neighbors, move to the maximum degree of the neighbors and move to the nearest point of the neighbors. The vehicular node appears at time 20, and the movement speed is set to 1. The results of different strategies are shown in Figure 9. Table 3 shows the specific paths of the three strategies, assuming that the movement starts at node 1000.

TABLE 3: Mobile paths of every step

<table>
<thead>
<tr>
<th>Mobile strategies</th>
<th>Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>Move randomly to neighbors</td>
<td>1000 → 38079 → 19348</td>
</tr>
<tr>
<td></td>
<td>→ 3114 → 198 → 6465 →</td>
</tr>
<tr>
<td></td>
<td>8108 → 6465 → 13036</td>
</tr>
<tr>
<td>Move to the maximum degree of neighbors</td>
<td>1000 → 38079 → 8614 →</td>
</tr>
<tr>
<td></td>
<td>12717 → 3045 → 1293 →</td>
</tr>
<tr>
<td></td>
<td>6345 → 113 → 4580</td>
</tr>
<tr>
<td>Move to the nearest point of neighbors</td>
<td>1000 → 12097 → 18296</td>
</tr>
<tr>
<td></td>
<td>→ 3184 → 28474 → 6335</td>
</tr>
<tr>
<td></td>
<td>→ 22110 → 10485 →</td>
</tr>
<tr>
<td></td>
<td>28517 → 165</td>
</tr>
</tbody>
</table>

C. ANALYSIS

Figure 5 shows the dynamic process of rumors. The very few C nodes will result in a significant increase in the number of I nodes, although the C nodes account for a minor percentage of U nodes. Even if there are rumors, many people will not believe in the rumors. These characteristics are very similar to the real situation. When the C nodes lose interest and decrease, the T nodes still increase until the peak.

Figure 5 and Figure 6 indicate that mobile nodes can control rumors. In the case of spreading anti-rumors, the T nodes begin to decline, eventually leading to an increase in I nodes. This is the main principle of controlling rumors.

In Figure 7, the number of U nodes increases in each moment due to the diffusion of rumors. If the vehicular node appears early, the U nodes start to decrease earlier. Therefore, the appearance time of the vehicular node strongly affects the spread of rumors. In short, the earlier the vehicular node appears, the better the control.

Figure 8 shows that better results are achieved when we choose the maximum movement speed of 8. Faster movement speeds reduce the number of U nodes. The rumor propagation time can also be reduced, but the different speeds have no effect on the time corresponding to the peak. Therefore, the speed does not affect the time at which the decrease begins.

Figure 9 compares three mobile strategies, which all perform better than the case with no vehicular nodes. The maximum degree node priority movement produces the best results in terms of decreasing the spread of rumors. The mobile strategy also does not affect the time required for the U nodes to reach their maximum.

Figure 6–Figure 9 show that the vehicular node has the ability to convert almost all the U nodes, but approximately 0.25% U nodes remain in the network. The remaining nodes may appear to be a hidden danger. However, the neighbors of these nodes and most other users have accepted the anti-rumors and will no longer easily believe such rumors.

VI. CONCLUSION

Rumors are ubiquitous on the Internet and cause enormous losses. The same is true in the VSN. Therefore, the mechanism of rumor proliferation must be studied. Previous work of rumor propagation models considers only the transition between states while ignoring the fact that multiple users may also have differences in the same state. In our paper, the population is divided into S, T, C, I, and R states, and we propose a new STCIR rumor diffusion model. This model considers the behavior of all the users. For example, user may receive rumors at different times and reply with different delays. Our model adds a time delay mechanism, and each user is assigned their own state transition probability. Within each user’s time delay, receiving rumors repeatedly increases the transition probability. Our model shows that a small number of users spreading rumors can make more than 80% of the other users believe the rumor.

To control the spread of rumors, we use a vehicular node as an authority to publish real news that overwhelms rumors. The vehicular node can move to the connected nodes and change the state of these nodes. Since there are fewer vehicular nodes and C nodes, the probability of their encounter is small. The main controlling processes are as follows: M nodes change S nodes to prevent them from being infected, and M nodes transform T nodes to allow them to recover to reduce potential losses. Finally, these nodes are all converted into I nodes. Furthermore, if we can find and react to rumors quickly, the scale of the rumors and the time required for sweeping will be greatly reduced. The mobile speeds and mobile strategies of the vehicular nodes cannot make the rumors start to decrease at an earlier time point, but they can reduce the overall spread and propagation time of rumors.
Therefore, the best measure is to find the rumors as soon as possible, send the mobile node, and move to the neighbor nodes of greater degree as fast as possible.

REFERENCES


