



# Research on Information Transmission Characteristics of Two-Layer Communication Network

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**Abstract.** With the development of the Internet, the marketing model of the communications industry has transformed from call-based to social application-based. Analyzing information transmission of social application helps to develop marketing strategy for different customers' needs. The paper proposes and constructs a two-layer communication user spreading model based on the SIR information dissemination model. Then we analyze the traditional model of virus spread on the network's application, and get the simulation results of immunization strategy and the communication process of social application information on WeChat, microblog and QQ. Combining with the actual data, simulation results show that the spread of the three types of social applications reaches a peak in a short time with the increase of the spreading rate. The spreading scale of WeChat application is larger than the other two types of applications on the same spread rate. Based on the acquaintance (target) immune strategy, the three types of applications have faster transmission inhibition than the random immune strategy. The research results of this paper provide an effective theoretical base for setting up individuality service combination of mobile communication enterprise.

**Keywords:** Immune strategy · Information dissemination · Social application · Two-layer communication network

## 1 Introduction

Nowadays, the way people get information turns from traditional media to social application platform, and social network has become the main place for publishing public opinion, forwarding information, product marketing and so on. With the increase of the number of Internet users and the diversification of social platforms, users have frequent

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exchanges and interactions, resulting in more rapid and extensive information dissemination. Different social networks have different characteristics of information transmission process due to their different structures, functions and emphases. At the beginning of 2020, the COVID-19 outbreak attracted the attention of the world, and the open and transparent release of epidemic information has become an important measure when China fought against the epidemic. The high efficiency, timeliness and universality of information dissemination have won precious time for people to enhance their awareness of self-isolation and stop the spread of the epidemic. In the research on information transmission during the epidemic, Li Jianjun et al. [1] proved that high information transmission efficiency can effectively reduce population mobility and slow down the spread of disease. He Zijie et al. [2] proposed that timely release of foreign-related epidemic information would help foreigners to participate in the prevention and control actions, while the lag or absence of information would easily lead to rumors and even panic. Therefore, in the process of information transmission, positive information should be spread quickly, while some rumors or statements that are not conducive to social stability should be suppressed in a timely manner. Preventing and controlling rumor spreading is of great significance to safeguarding citizens' rights and interests, public interests, national security and social stability.

In order to study the dynamic characteristics of information transmission on social networks, researchers proposed many mathematical models similar to the spread of infectious diseases. Xu et al. [3] introduced information value and user behavior into the information transmission model of social networks, improved and modified the traditional SEIR model, and proposed a new S-SEIR model. Rozenfeld et al. [4] embedded scale-free networks in European space, and found that such networks could promote information transmission and effectively inhibit rumor transmission. Zhu et al. [5] studied the influence of human heterogeneity on information transmission from the perspective of sociology. Zhang Zhaowen et al. [6] explored from the perspective of node heterogeneity that the information transmission process is more consistent with the information transmission in the real world.

At present, many scholars believe that most complex networks are coupled and interact with each other. So, "The network of networks" [6], "Multiplex Networks" [7] and "Multiplex Networks and Interdependent Network" [8] have become the vanguard of research in the field of complex networks. Research on information transmission in multi-layer networks has attracted extensive attention from many researchers [9–12]. The research foundation of information transmission process is the construction of network model. The two-layer social network model originates from the real social communication network. The network layers influence each other, depend on each other, and the nodes have heterogeneity. Du Rong [13] took urban activities in douban film review websites as research objects, analyzed the characteristics of information transmission in the network, and concluded that online information interaction effectively promoted the development of offline activities. Taking the online virtual community platform as the research object, Zhou Junjie [14] constructed the online and offline two-layer network model, proposed the mixed communication mode, and expanded the interaction scope and influence of Shared knowledge and information. By studying symmetric and asymmetric information transmission mechanisms. Yu Kai [15] constructed an information

transmission model on online and offline BCN. Wang [16] constructed an asymmetric two-layer network of “information-disease” and found that faster information.

According to the 42nd Statistical Report on the Development of Internet in China [17]. As of June 30, 2018, the number of Internet users in China has reached 802 million, and the Internet penetration rate has also increased. The utilization rate of comprehensive social applications is relatively high, with WeChat APP ranking the first at 84.3%, QQ at 65.8% and microblog users at 38.7%. The utilization rate of all kinds of social software continues to rise, which enhances the maximum influence of information interaction and information dissemination. Meanwhile, it is also very necessary to suppress the dissemination of negative information such as online public opinion and rumors [18–23].

Aiming at the above problems, this paper constructs a two-layer communication user network model and analyzes the topology characteristics of the network. Based on the classic SIR communication mechanism and combined with the actual data of a university, the communication trajectories of users’ information interaction through social software under different transmission rates are analyzed. At the same time, random immunization strategy, acquaintance immunization strategy and target immunization strategy were used to analyze the suppression process of information transmission under different immunization strategies of different social software, and the time window for the maximum influence of social software was obtained, which provided a theoretical basis for the design of traffic packages in the communication industry.

## 2 Introduction of Basic Concepts

### 2.1 SIR Spreading Model

The analysis of information spreading model started from the disease spreading model. At present, the classic spreading models are SI, SIS and SIR models [24–27]. Building a reasonable information spreading model can generally accurately describe the process of information spreading in the network, and can predict the flow direction of information. Based on SIR spreading model, this paper analyzes the process of information dissemination. In this model, the S state means that the individual has not received the propagation information, but may receive the information after contacting with the propagating state individual. I state means that the individual has received the information and is able to transmit the information to the susceptible individual, R state means that the information cannot be transmitted to the other state.

In the SIR information spreading model, all nodes are in the unknown state S in the initial stage, and the nodes have not contacted the information; when some unknown individuals receive the information, they will have a certain probability. Then, some individuals who lose interest in the information will be transformed into information immune state R with a certain probability, and the immune individuals will not continue to spread after receiving the information. The dynamic propagation mechanism and differential equation of SIR model are shown in formulas 1 and 2.

$$s(i) + I(j) \xrightarrow{\beta} I(i) + I(j) \quad (1)$$

$$I(i) \xrightarrow{\gamma} R(i)$$

$$\begin{cases} \frac{ds(t)}{dt} = -\beta i(t)s(t) \\ \frac{di(t)}{dt} = \beta i(t)s(t) - \gamma i(t) \\ \frac{dr(t)}{dt} = \gamma i(t) \end{cases} \quad (2)$$

Figure 1 shows the change of individual density in each state of SIR propagation model with time. The initial node of the network is 100, where the initial unknown state  $S(0) = 0.92$ , the information dissemination state  $I(0) = 0.07$ , the immune state  $R(0) = 0.01$ , the propagation rate  $\beta = 0.8$ , and the recovery rate  $\gamma = 0.2$ . When the transmission time is  $t = 6$ , the nodes of the three states are similar, but after that, the number of immunized people increases rapidly until the later stage of the transmission cycle, the number of immune persons reaches stable, and the transmission and susceptible individuals tend to 0, which is in line with the law of the transmission cycle of a conquered disease in real life.

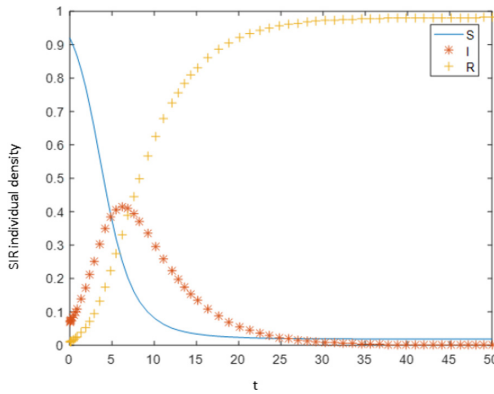


Fig. 1. Change of individual density with time in each state of SIR spreading model

## 2.2 Introduction of Immunization Strategy

For the information spreading on complex networks, it is a very significant and challenging problem to choose appropriate immune strategies to suppress the spread of negative information. The traditional immune strategies mainly include random immunization, target immunization and active immunization [28].

Random immunization strategy completely random selection of nodes in the network for immunization. Target immunization is carried out selectively. All nodes in the network are not equal and have different positions in the network. If these nodes with relatively important positions are found for immunization, better effects may be achieved. Acquaintance immunization: randomly select a certain proportion of nodes from the network for immunization, and then randomly select neighbor nodes from the selected nodes for immunization. Therefore, acquaintance immunization strategy can achieve good immune effect without knowing the information of global nodes. At present, the

commonly used immune algorithms are target immunity and acquaintance immunity and the improvement of these two immune algorithms. In order to reduce the harm caused by rumors and public opinions on the complex network, immunization strategy arises at the right moment. Whether the current immunization strategy meets the requirements of the actual network and whether it can be used in the actual network is still a problem to be solved.

### 3 Two-Layer Network Modeling

In the real world, many complex networks are not running in isolation, but connected and influenced each other. The heterogeneity of nodes can divide the network into different levels. In online social network, different types of people are distributed at different levels, and they are related to each other. Aiming at the multi-path and multi-level problems of information dissemination in real life, this paper constructs a double-layer network model, and explores and analyzes the process of information dissemination based on the characteristics of the two-layer network model.

In this paper, the BA-BA two-layer network model is constructed. The BA-BA scale-free network generation algorithm is used in the model layer, and the random connection algorithm is used to connect the edges between interlayers. The network does not contain duplicate edges.

**Step 1 Initialization:** The scale of the two single layer networks is  $N$ , at the beginning, the single layer network has  $m_0$  node and  $m_1$  edges.

**Step 2 Growth and preferential connection of scale-free network:** In each time step, a new node is introduced and connected to  $m$  existing old nodes. Here  $m \leq m_0$ , at the same time, the probability  $\prod_i$  of a new node connecting with an existing old node satisfies the following relationship with the degree of the node  $k_i$ :  $(k_i + 1) / \sum (k_j + 1)$ , when the total network node reaches  $N$ , the algorithm ends.

**Step 3 Interlayer connection:** Given that the interlayer connection probability is  $P$ , traverse the nodes  $i$  in the Layer A layer and the nodes  $j$  in the Layer B, and generate a probability  $P_2$  randomly. If  $P > P_2$ , then in the adjacency matrix  $a(i, j) = 1$ , otherwise  $a(i, j) = 0$ , node traversal in the Layer A is completed, and the algorithm is finished.

As shown in Fig. 2, the topological structure diagram of the network is given. The node scale of the single layer network is set as  $N = 30$ ,  $m_0 = 5$ ,  $m = 3$ , and the link probability between layers is  $P = 0.2$ .

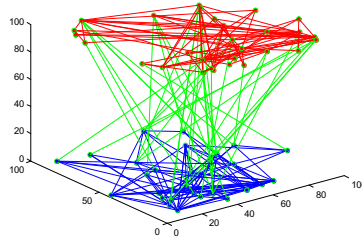


Fig. 2. Two-layer network model

## 4 Information Spreading Model of Two-Layer Communication Network

The information transmission between two-layer communication users can effectively observe the information transmission path between different types of nodes, and through the analysis of the information transmission of the whole network, we can get how the information is transmitted across layers and achieve the overall range of transmission between different levels. Therefore, this paper constructs a two-layer communication network based on the mobile communication data of college students, and analyzes the information transmission process between college students based on wechat, QQ, microblog and other application platforms combined with the information interaction data in popular social software. Based on the mobile communication data of college students, this paper constructs a two-layer communication network between sophomores and juniors, and analyzes the information dissemination process of popular social software such as WeChat, microblog, QQ based on SIR communication mechanism.

### 4.1 Data Preprocessing

The data of communication users comes from the actual questionnaire, and the data of information transmission between users comes from the data analysis library of mobile system. Based on the real data of mobile communication behavior, the information dissemination process is analyzed. In order to ensure the validity of the data, the communication data between students of a university from 2016 to 2019 are processed, and their social behaviors are analyzed. The usage of WeChat, QQ and microblog obtained from the data are shown in Tables 1 and 2.

Table 1. Total user data table

Years	2016	2017	2018	2019
Users	873	470	354	101

From Table 2, we can see that in 2017 and 2018, the APP ranked high in frequency: APP, QQ and microblog; low frequency APP used basketball forum, tiktok, short video

**Table 2.** Statistical table of average daily usage times

Users		Average open times		
		≤50	50–100	≥100
Second year class	WeChat	87	127	140
	QQ	274	71	9
	Microblog	133	56	2
	Douyin	153	2	0
	Hupu	8	0	0
	Alipay	149	0	0
	Mooc	28	0	0
Third Years class	WeChat	105	177	188
	QQ	337	83	20
	Microblog	172	43	5
	Douyin	15	10	0
	Hupu	17	2	0
	Alipay	173	1	0
	Mooc	53	0	0

APP, voice, APP Alipay, and learning software APP Mogao. It is not difficult to see that students tend to use social apps such as wechat. At the same time, it can be seen that the average daily number of users using wechat in 2017 was 72 times, and that in 2018 was 76 times. The WeChat utilization rate of Internet users in the past two years was very close. WeChat has its own social communication function, which can quickly spread and spread information. Therefore, it can be used as a source of information dissemination between users who have access to the network in 2017 and users who have access to the network in 2018. In the experiment, users who use WeChat more than 100 times a day are defined as communicators, and users who use less than 20 times a day are defined as immune users. The propagation rate is set according to the experience value. The experiment analyzes the spread of WeChat, QQ and microblog.

## 4.2 Model Construction and Characteristic Analysis of Two-Layer Communication Network

### 4.2.1 Construction of Two-Layer Network Model

In 2017, the number of communication users accessing the network was 354, and that in 2018 was 474. According to the actual data, a two-layer communication user network is constructed.

Step 1 Initialization: The scale of the two single-layer networks are 354 and 474, layer a is the network access users in 2017, and layer B is the access communication users in 2018.

Step 2 Intra layer connection: The number of calls between two mobile phone communication users is greater than or equal to 1, and the two user nodes are connected with edges, excluding duplicate edges.

Step 3 Inter layer connection: If the number of calls between two mobile communication users is greater than or equal to 1, an edge is added between the two user nodes, otherwise, no edge is added.

According to the above algorithm, a two-layer network model of communication between sophomores and juniors in a university is constructed. The network diagram is shown in Fig. 3.

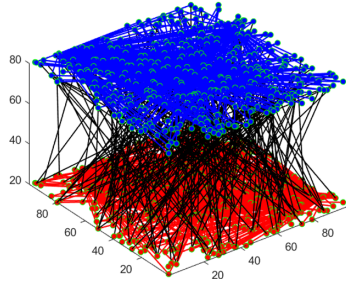


Fig. 3. Topology of two-layer communication network

#### 4.2.2 Analysis of Topology Characteristics of Two-Layer Communication Network

According to the network model, the degree distribution, average clustering coefficient and average path length are analyzed.

##### 1) Degree distribution

The degree  $k_i$  of a node  $v_i$  refers to the total number of other nodes adjacent to the node, which is recorded as the average degree of all nodes in the network, and is recorded as  $\langle k \rangle$ . For a given adjacency matrix  $A = (a_{ij})_{N \times N}$  of network G, the calculation formulas of node degree and average degree are as follows:

$$k_i = \sum_{j=1}^N a_{ij} \tag{1}$$

$$\langle k \rangle = \frac{1}{N} \sum_{i=1}^N k_i = \frac{1}{N} \sum_{i,j=1}^N a_{ij} \tag{2}$$

In the two-layer communication network, the degree value of the node represents the number of users who have called with other users. This parameter is one of the indexes reflecting the importance of nodes. The node degree distribution of the two-layer network is calculated as shown in Fig. 4. The analysis shows that the overall node

degree distribution of the network tends to power-law distribution, most users have small degree value, only a few users have larger degree value and stronger activity.

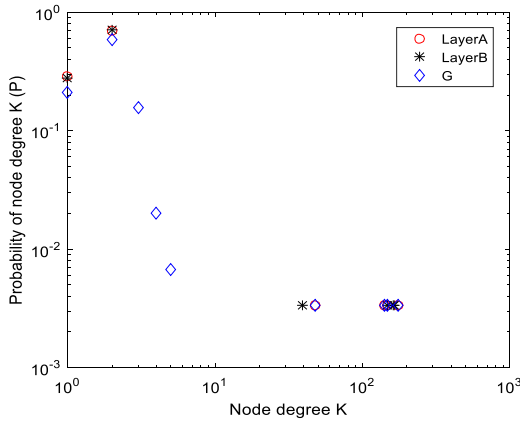


Fig. 4. Degree distribution of two-layer communication network

### 2) Average clustering coefficient

The clustering coefficient is used to quantitatively describe the probability that any two of your friends are friends with each other in complex networks. It reflects the aggregation of the whole network. The larger the clustering coefficient, the better the clustering of the network. The formula is defined as follows:

$$C_j = \frac{2M_j}{N_j(N_j - 1)} \tag{3}$$

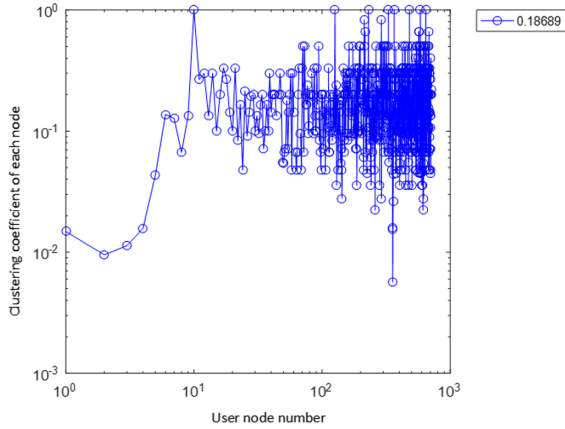
Where,  $M_j$  is the actual number of connected edges between adjacent nodes  $N_j$ , and  $N_j(N_j - 1)/2$  is the estimated maximum number of connected edges between adjacent nodes  $N_j$ . By averaging the aggregation coefficients of all nodes in the network, the aggregation coefficient of the whole network can be obtained

$$C = \frac{1}{N} \sum_{i=1}^N C_i \tag{4}$$

The average aggregation coefficient of the two-layer network is 0.187, and the network connection is sparse (Fig. 5).

### 3) Average path length

The average path length is defined as the average distance between any two nodes, also known as the average distance or characteristic path length, which is usually used

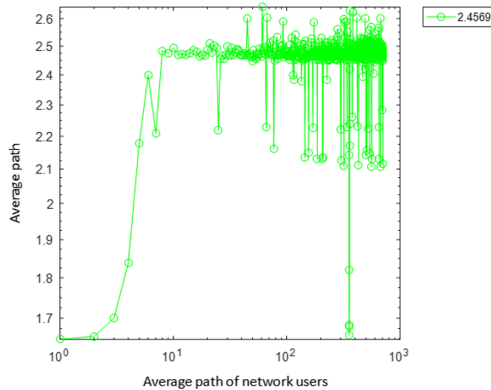


**Fig. 5.** Average clustering coefficient of two-layer communication network

to measure the speed of information transmission between nodes. The expression is as follows:

$$L = \frac{2}{N(N-1)} \sum_{i \geq j} d_{ij} \tag{5}$$

Where  $d_{ij}$  is the number of connected edges on the shortest path from node  $i$  to node  $j$ . Through numerical calculation, the average shortest path of the network is 2.4569 (Fig. 6).



**Fig. 6.** Average path length of two-layer communication network

By analyzing the topological properties of degree distribution, average clustering coefficient and average path length of the two-layer communication user network, it is found that the user interaction distribution of the two-layer network is extremely uneven. Most of the users have less interaction, only a small number of users have

dense connections, frequent and extensive communication, and the overall aggregation coefficient of the network is small, which is due to the number of inter layer connections of the two-layer network model. Therefore, the overall network connection is sparse. This also contributes to the shorter average path length of the network, which also helps users to connect to each other over a shorter path.

## 5 Information Dissemination of Two-Layer Communication Network Based on SIR

This section studies and analyzes the information transmission in the Sir Propagation mechanism of the two-tier user communication network. By adjusting the propagation rate and recovery rate, we can observe the network transmission at different times and the state transition of individuals at different times. At the same time, through the analysis of the corresponding immune strategy results, we can know how to control the spread of information, so that the research results can be better applied to real life, and provide corresponding reference for communication operators to make better decisions.

### 5.1 Analysis of Propagation Threshold Conditions

1. The influence of different transmission rates on individual density of simultaneous interpreting

Table 3 shows the frequency statistics of users' daily use of WeChat app. It can be concluded from the table that the average daily frequency of using WeChat app was 72 times among the communication users who had access to the network in 2017, and 76 times in 2018. In the SIR communication mechanism, users who use WeChat more than 100 times a day at the initial time are regarded as transmission individuals, those who use WeChat less than 20 times a day are regarded as immune individuals, and other users are set as susceptible individuals. Thus, the initial conditions are obtained as follows:  $s(0) = 0.814$ ,  $i(0) = 0.16$ ,  $r(0) = 0.026$ , the propagation rate  $\beta$  is 0.3, 0.5, 0.8, and the recovery rate is  $\gamma = 0.2$ . The test results are shown in Fig. 7(a). In order to further explore whether the propagation process is related to the clustering coefficient and average path length of the network, set  $\beta = C/L$ . The ratio of the average clustering coefficient to the average path length is 0.08, and the recovery rate is  $\gamma = 0.2$ . Through 100 simulations, the experimental results as shown in Fig. 7(b) are obtained.

**Table 3.** Statistics of WeChat users

Years	Average daily opening times				
	Less than 20 times	More than 80 times	More than 100 times	More than 150 times	More than 200 times
2017	8	115	61	14	4
2018	11	139	63	8	2

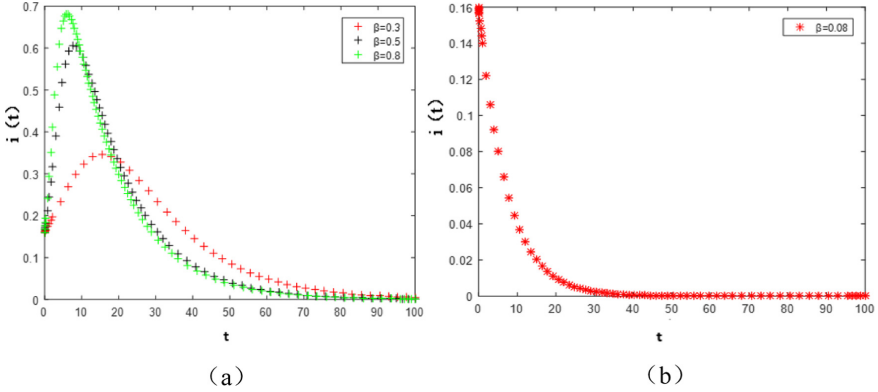


Fig. 7. Change trend of WeChat app propagation behavior

Based on the analysis of the experimental results, two different situations are obtained: (1) from Fig. 7(a), when  $t = 9$ , the proportion of disseminators reached the peak at  $\beta = 0.8$ . When  $t = 11$ , the proportion of disseminators reached the peak at  $\beta = 0.5$ . When  $t = 15$ , the proportion of disseminators reached the peak at  $\beta = 0.3$ . The results show that with the increase of the transmission rate, the time when the proportion of communicators reaches the peak decreases in turn. At  $t \approx 90$ , the proportion of communicators reaches the steady state under three kinds of transmission rates.

- 2) The ratio of the average clustering coefficient and the average path length of the network can get a smaller propagation rate. The number of communicators has reached the peak at the initial time, but when the network reaches the peak, the proportion of communicators is 0.16, which indicates that the overall propagation is slow and the spread range is small due to the sparse connection. To sum up, with the increase of propagation rate, the propagation speed is accelerated and the propagation range is expanded, and the influence of network communication is also enhanced.

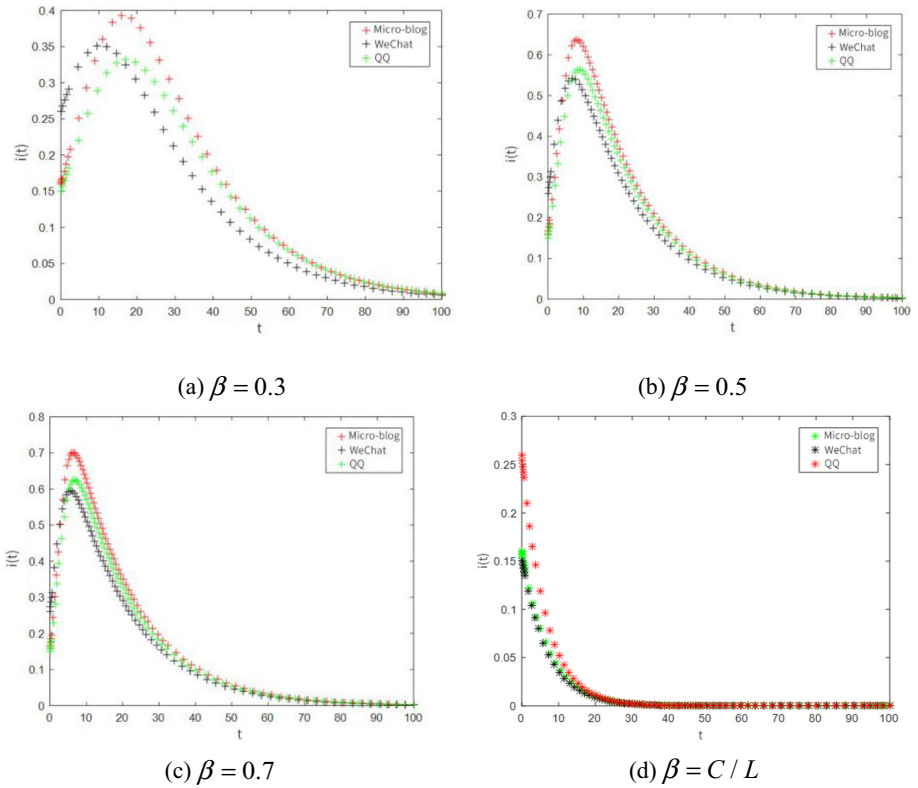
### 5.1.1 Analysis of Three Types of APP Communication Behavior

In addition to WeChat, QQ and microblog usage frequency can also be used to analyze users' communication behavior. According to the empirical data, the daily average usage data of QQ and microblog are obtained, as shown in Table 4.

Similarly, users who use more than 100 times a day are regarded as communicators; those who use less than 10 times a day are regarded as immune individuals, and other users are regarded as vulnerable individuals. The initial conditions are as follows: in QQ social software, the proportion of susceptible individuals, transmission individuals and immune individuals is  $s(0) = 0.58, i(0) = 0.26, r(0) = 0.16$ ; In microblog social software, the proportion of susceptible individuals, communicators and immune individuals is  $s(0) = 0.74, i(0) = 0.15, r(0) = 0.11$ ; Let the transmission rate  $\beta$  be 0.3, 0.5 and 0.8 respectively, and the recovery rate  $\gamma = 0.2$ . The results of 100 simulation experiments are shown in Fig. 8.

**Table 4.** Statistics of daily average usage times (microblog, QQ)

Years	Average daily opening times		
	Less than 10 times	More than 50 times	More than 100 times
2017 (QQ)	56	80	9
2017 (microblog)	63	103	20
2018 (QQ)	33	58	2
2018 (microblog)	47	48	5



**Fig. 8.** Trend of density spread of individuals with different propagation rates in three types of APP simultaneous interpreting

According to the analysis of the experimental results, two different situations are obtained: (1) according to the analysis of Fig. 8(a) (b) (c), the communication rate of  $\beta = 0.3$ ,  $\beta = 0.5$  and  $\beta = 0.5$ , microblog app communication individuals first reached the peak, QQ and WeChat users almost reached the peak at the same time, when the peak, WeChat users accounted for the largest proportion of individuals, followed by WeChat, the smallest was QQ. Among them, the higher the transmission rate, the faster the peak

time of the three apps. (2) It can be seen from Fig. 8(d) that when the transmission rate is  $\beta = C/L$ , at the initial stage of transmission, the size of individual network communication is the peak value. Due to the low transmission rate, the transmission efficiency in the network is also very limited.

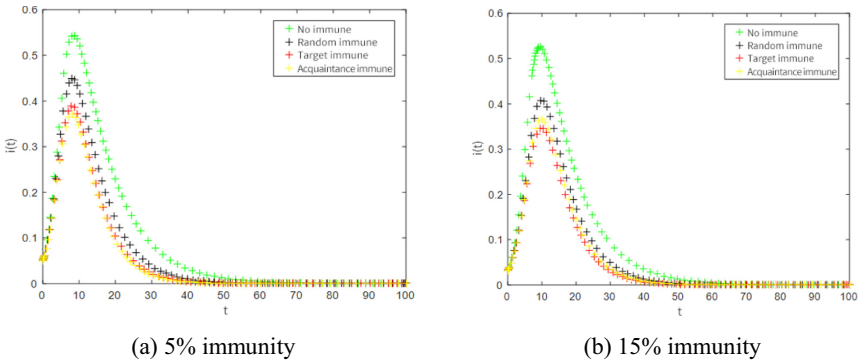
Comprehensive analysis shows that with the increase of the transmission rate, the propagation speed of the three types of app is accelerated, among which WeChat app has the highest transmission efficiency. When the network transmission rate is very small, the number of people affected in the network transmission process is the least, that is, the communication effect is weak.

## 5.2 Research on Immune Strategy in Two-Layer Communication Network

By analyzing the structural properties of double-layer network and the dynamic process of information dissemination, the corresponding immune strategies are formulated to suppress the spread of rumors and rumors. The communication behavior is analyzed by implementing immune strategies in WeChat, QQ and microblog.

### 5.2.1 Immune Strategy Analysis Based on WeChat Communication

Based on SIR propagation mechanism, immune results were analyzed on the two-layer network, and the immune results were analyzed in WeChat app using random immunization, target immunization and acquaintance immunization strategies. The initial setting parameters of the experiment are as follows:  $s(0) = 0.814$ ,  $i(0) = 0.16$ ,  $r(0) = 0.026$ ; The recovery rate is set to  $\gamma = 0.2$ , and the propagation rate is set to  $\beta = 0.5$ . In the two-layer network, the nodes with  $F = 5\%$  and  $F = 15\%$  are immunized respectively, and the propagation experiment is simulated for 100 times. The experimental results are shown in Fig. 9.



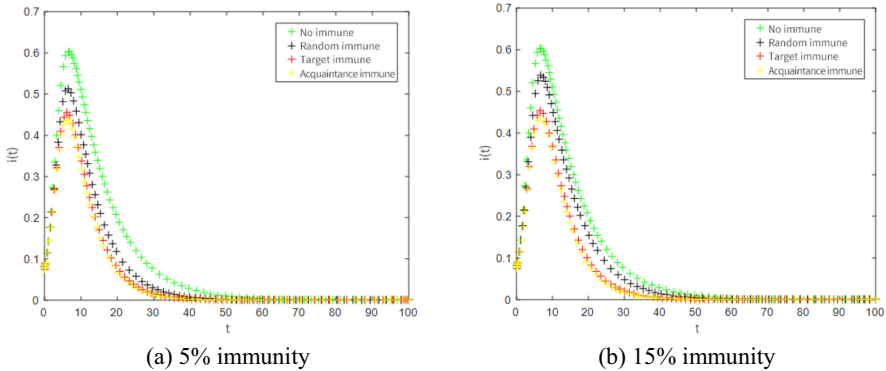
**Fig. 9.** Change trend of network infection index QC of double layer communication users with time step (WeChat)

Through the analysis of the experimental results, two cases are obtained: (1) in Fig. 9(a), it can be seen that when 5% of the nodes are immunized, when  $t = 10$ ,

the density of communicators under the non-immune strategy and the three immune strategies reaches the peak almost at the same time; the number of communicators without immune strategy is the largest, and the density is close to 0.55. The second is random immunization, and the transmission trend and peak value of target immunization and acquaintance immunization are almost the same. (2) It can be seen from Fig. 9(b) that when the time step  $t = 12$ , the immune strategies reach the peak. Under the non-immune strategy, the number of communicators is the largest, followed by the non-immune strategy, and the change trend of target immunization and acquaintance immunity is roughly the same.

### 5.2.2 Analysis of Immune Strategy Based on QQ Propagation

In the QQ application data center, the initial setting parameters of the experiment is  $s(0) = 0.58, i(0) = 0.26, r(0) = 0.16; \gamma = 0.2, \beta = 0.5$ . In the two-layer network, the nodes with  $F = 5\%$  and  $F = 15\%$  are immunized respectively, and the propagation experiment is simulated for 100 times. The experimental results are shown in Fig. 10.

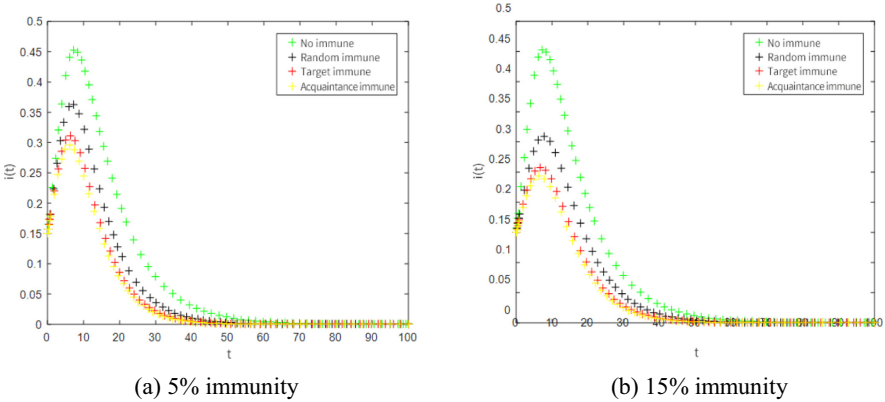


**Fig. 10.** Change trend of network infection index QC of double layer communication users with time step (QQ)

By analyzing the experimental results, two cases are obtained: (1) In Fig. 10(a), we can see that when 5% of the nodes are immunized, the density of communicators under the no immune strategy and the three immune strategies almost reach the peak at the same time in time step  $t = 10$ ; the number of communicators without immune strategy is the largest, and the density is close to 0.6. The second is random immunization, and the transmission trend and peak value of target immunization and acquaintance immunization are almost the same. (2) It can be seen from Fig. 9(b) that when the time step  $t = 12$ , the immune strategies reach the peak. Under the non-immune strategy, the number of communicators is the largest, followed by the non-immune strategy, and the change trend of target immunization and acquaintance immunity is roughly the same.

### 5.2.3 Immune Strategy Analysis Based on Microblog

In the microblog application data center, the initial setting parameters are as follows:  $s(0) = 0.74$ ,  $i(0) = 0.15$ ,  $r(0) = 0.11$ ,  $\gamma = 0.2$ ,  $\beta = 0.5$ . In the two-layer network, the nodes with  $F = 5\%$  and  $F = 15\%$  are immune respectively, and the simulation of propagation experiment is carried out for 100 times. The experimental results are shown in Fig. 11.



**Fig. 11.** Change trend of network infection index QC of double layer communication users with time step (Microblog)

Through the analysis of the experimental results, two cases are obtained: (1) In Fig. 11(a), it can be seen that when 5% of the nodes are immunized, the density of the communicators under the no immune strategy and the three immune strategies almost reaches the peak at  $t = 10$ ; The number of communicators under the non-immune strategy is the largest, and the density is close to 0.45. The second is random immunization, and the transmission trend and peak value of target immunization and acquaintance immunization are almost the same. (2) It can be seen from Fig. 9(b) that when the time step  $t = 12$ , the immune strategies reach the peak at the same time when 15% nodes are immunized. Under the non-immune strategy, the number of communicators is the largest, followed by the non-immune strategy, with the same target immunization and maturity. The change trend of human immunity was similar.

In this two-layer communication user network, the non-immune strategy is compared with other immune strategies, and it is known that the random immune strategy, the target immune strategy and the acquaintance immune strategy have good network inhibition effect. Under different transmission rates, the impact of the ratio of the three APP carriers to the network propagation and the characteristics of the simultaneous interpreting of the two tier networks are very consistent with the characteristics of the research.

Through a series of simulation experiments on the empirical network, it is concluded that the information dissemination of social app with high utilization rate has similar propagation rules, but in the process of communication, the scale of individuals in each state, network topology index and immune strategy will affect the propagation trajectory. The larger the scale of the network, the larger the clustering coefficient and the smaller

the average path, the more widely the use of app and the spread of information. In this paper, the immune strategy involved is applied to the fixed-point traffic package publicity strategy in real life. As the empirical network in the long-term development, there will be stagnant state, this is because people are immune to the old information, resulting in burnout. Therefore, we should always keep innovation and update the operation system to achieve long-term, stable and sustainable development. In Sir Propagation mechanism, with the increase of time in the network, most node states will be transformed into immune state. The immune state includes either saturated or low utilization rate. Therefore, immune strategy is introduced to carry out fixed-point traffic package publicity strategy for users with low utilization rate. In the process of transmission, the peak size of individual disseminator is particularly important, communication operators can observe the scale of individual communication, and observe the use of an app and its joint effect to achieve a communication effect. For example, starting from WeChat, QQ and microblog apps, they can bundle and set their traffic packages to better meet people's demand for traffic packages. However, in real life, there will be a small number of APP usage rate is low. In order to meet the growing demand of communication network traffic packages, we can bundle the app with high utilization rate with the app with low utilization rate to serve the people with demand, so that the communication operators can better maximize the communication and make its benefits grow steadily.

## 6 Conclusion

In this paper, a double-layer B-B network model is constructed, and the Sir Propagation mechanism is introduced to analyze the relevant characteristics of propagation in the double-layer network. At the same time, a two-layer homogeneous communication network is constructed by using the communication data of college students. The communication process of WeChat, microblog, QQ and other apps in the communication network is analyzed. The results show that the communication of the empirical communication network conforms to the characteristics of information dissemination in the two-layer network. At the same time, according to the analysis of the three types of APP propagation path, the corresponding marketing strategy is formulated, which provides a theoretical basis for the communication operators to set and promote the app traffic package better.

Compared with the information dissemination in real life, there is still a lot of work to be improved. There is still a lot of room for development of the current communication mechanism in the application of the two-layer network. For example, the construction of two-layer network model, the diversity of the connection between layers, the heterogeneity of network level, and the more complex network model. Secondly, it is the improvement of immunization and marketing strategy, which can make the effect more obvious by hierarchical immunization or marketing recommendation through the attribute structure of the network itself, and also provide reference for the control of communication phenomenon in real life in the future.

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