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Based on the Complex Network of Local Routing Strategy Scale-free Networks

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Abstract

This paper, the factors to consider the dynamic and static local routing strategy of scale-free networks. Don't have access to global information for large network, put forward a kind of combined with the current static topology information of network and node of the traffic flow situation of considering the dynamic factors of routing strategy of local information. Based on scale-free networks in the simulation model, analyses the network congestion in the shift. Through simulation experiments and research, found that there are optimal control parameters, makes the network throughput can reach maximum.

Keywords: *Scale-free Networks; Congestion Control; Routing Strategy; Local Information*

1. Introduction

The birth of the Internet, which makes people's life richer and more convenient, and enriched people's spiritual world and material world, promote the progress of the society around the world. Today's society, network is everywhere, ever-present, large communication network represented by the Internet, air transport network, scientists cooperation network, biological networks, human social networks, *etc.*, they are all closely related to our life, and play an extremely important and decisive role. Can be figuratively speaking, in real life world is a composite composed of a variety of network. Although each network has its unique features, however, these complex systems can be used to describe a wide variety, different forms of network, that is to say, we can abstract them into complex network, namely the interaction of individuals in the real world is regarded as the nodes in the network, due to the interaction between the individual and has a certain relationship with edge to depict. Nowadays, the emerging field of complex networks become numerous scholars in the field of disciplines and start the focus of attention and research, they explore a variety of complex networks and try to find the commonness between them, can go to great lengths to find the universal method to solve the problem effectively. Therefore, studying the characteristics of the real network topology structure, function and the relationship between them, so as to understand the mechanism behind these phenomena has important practical significance. With the continuous development of science and technology, scholars research on complex networks are not limited to the scope of classical physics and statistical physics, but more from the perspective of overall and global awareness and the study of complex networks. In complex networks, communication process belongs to a typical network dynamic process, some of the network scale is more and more big, also dramatically increased the number of packets in the network, as a result, due to the limited memory of the router, a large number of

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information flow will inevitably occur in the process of transmission congestion phenomenon, thus easy to reduce network communication performance of the whole, the packets in the network transmission delay increased significantly, the network packet throughput dropped significantly. Congestion will not only bring inconvenience to the life of people, to a certain extent will adverse impact on social economy. Congestion phenomenon in reality, however, is inevitable, which requires people to adopt effective policies and measures to control and avoid congestion, as far as possible to minimize the incidence of congestion, thus ensuring the efficiency of network transmission. So the network traffic congestion has important practical significance and theoretical value. So, how to alleviate congestion? In life, we often can widen the road width, or increase the bandwidth of the network, and so on, in short, is done by increasing the flow of traffic resources, but from another point of view, the economy of the price of doing this is huge. So, is there a more economical way to solve the problem of traffic jam? The answer is yes. Congestion phenomenon closely relationship with optimized routing policy, mutual influence, and can be used as a measure of the performance of the dynamic characteristics of complex network. In the network system could be abstracted as a complex network model, to adapt to these new routing strategy of network model, namely by optimizing the transportation resources in the network. In recent years, the network congestion and route optimization strategy is affected by the related network topological structure characteristics, the research of this direction caused the attention of the scholars and the wide interest, such as to improve the effectiveness of the road network by strategy, whether can make use of existing network topology structure of the local information and global information to implement; Routing algorithm efficiency is to be due to the change of network topology change caused by the influence of, makes the routing strategy with adaptive ability should be how to design the network topology changes, and so on. Therefore, for this complex network topology characteristics of relevant research, scholars have been trying to interpret happened on these network forms of dynamic process, and corresponding strategies are proposed according to the topology of the network characteristics to analyze, control and improve the dynamic behavior. Based on complex network model, on the other hand, can be in the network traffic dynamics simulation on the computer, it's for the scholars in the study of complex network traffic congestion principle and the influence of the network structure of traffic flow provides a great convenience. Therefore, may say, traffic dynamics research, based on complex network model not only has important theoretical significance, and has important application and practical value.

At present, the dynamics of complex network traffic the research of this field mainly includes four parts: the topology of the network, the packet generation rate, the ability to deal with the packet routing policy and node [1-2]. Which four parts corresponding to many real networks, such as the Internet network, the four parts respectively correspond to the data link layer, packets flow network nodes, the network layer routing protocol, and parallel processing ability. Them in the traffic flow model also has a corresponding specific meaning, namely by observing in the network traffic by the phase change of the free state to congestion state values for use as a measure of network performance, when the network packets generated rate is greater than the critical value of phase transition, the network will be in a state of congestion. In the field of complex network traffic dynamics research, there are many scholars were studied. Many of the early literature has been in the topology of the network and network were studied

respectively, and the dynamic process, however, until recently there are some literature began to study the relationship between the two.

Some studies show that in different network topology structure, dynamic mechanism is similar to that of the dynamic behavior of the showing forms. But there are also some literature from the perspective of optimizing study how to optimize the network topology structure, thus making the network packet transfer rate is highest, and to guide the design criterion of network topology in reality [3-6]. Value of note is that, however, most of the communication network topology structure is fixed, to make any changes the topology of the network cost price is huge, and sometimes this change could not be achieved. Relatively, change the dynamic mechanism of network is feasible, such as routing algorithm is designed. In some of the early studies, packets are generally according to the following a few routing rules for delivery, such as the shortest path [7], random walk, in combination with the shortest path routing selection strategy and waiting time, effective path strategy [8], nearest neighbor search routing strategy [9] and local information routing strategy [10]. In the traffic flow model, the first assume that the whole R a packet network per unit time, and need to be from the start node to the destination node, starting node and destination node is randomly selected, once selected, they won't be changed. The entire delivery process, as long as the packet not reach its target, the packet has been wandering in the network. Each node can send, receive and produce packets, packet router and transmission. In addition, in these studies, they will packet processing capacity is defined as a finite constant C. When the number of nodes in waiting for delivery of packets over the constant C, after the arrival of the packet will be waiting in line at the node, according to the principle of first in first out for delivery. In order to avoid the same packet to roam repeated in the same path in the network transmission performance greatly reduced, use the path to the repeated avoid rules and regulations the same packet can't repeat the same path. When the rate of the network packet R exceeds a certain threshold, the network queuing packet will increase with the increase of time, and eventually lead to network congestion.

2. Related Works

The simplest method of routing strategy based on global information is breadth first search way, the algorithm is this: assuming the packets in the network transmission process, the need for s delivery by the source node to the destination node for t, first of all, the source node s will search all its neighbor nodes to see whether there is a target node t, if found to have the target node t, the route search is complete; Otherwise, will be in the midst of a node s packets are transmitted to all its neighbor nodes, and receive packets nodes continue to find their respective neighbor nodes, repeat the process, until we find the target node t. This routing lookup algorithm implementation process is very fast, for the small world network, need only a few steps can almost throughout the entire network. However, with the development of the society, the network scale is constantly expanding, will eventually make the network have a lot of repetitive packets, thus causing a significant increase in the network information flow, thus cause the network congestion and even make the whole system crash or paralysis. Thus, while the algorithm in the search of theory has been widely used in the analysis, however, to get effective in actual application is difficult to achieve. Yan and others in the process of research found that domestic scholars in the network node and is related to the degree of relationship, that is, if a larger degree of each node, the node usually will be relatively large. However, if these nodes using the shortest path routing strategy, the load on the normally will be very big, and most of the other node in the network will be

idle, thus, is not conducive to the network information transmission rate and to improve the performance of integrated communication network. To solve this problem, [9] proposed routing policy known as "valid path" strategy; it is an improved routing policy. Chain strategy the core idea is: at the time of computing the shortest path, need to take into consideration of the actual path node congestion situation, the flow of information in the process of allocation need according to the different congestion situation of nodes to be allocated on the center node and other nodes, so as to make the information flow to avoid along the shortest path in the process of transmission caused by too much a few a few larger degree of node, further reducing the congestion occurred in the probability of a major on the node degrees. In the network information flow from the center node to the scattered around the center node metastasis process by effective path algorithm efficiently achieved.

Routing method based on local information is usually based on complex network of local information to establish routing information. Under normal circumstances, the local information including load and local information, neighbor node of packet processing, etc. This strategy considering only partial information, so, it is relatively easy to implement. [10] put forward a kind of typical information based on neighbor node degree value of local routing strategy, known as the traditional local routing strategy. Use this strategy when doing routing, only consider the neighbor node degree value information, calculated according to the value of neighbor node routing forwarding probability, make routing. This method is simple and easy. The literature [11], Mr Valverde presents a shortest path algorithm based on local information; this strategy in the implementation of packet delivery m defines the visibility of the node scope. Chain strategy rule is defined like this: if m is greater than the path to reach the target node, then when the packet transmission is carried out in accordance with the rules of the shortest path; If m is less than to the path of the target node, at this time is to deliver the packet with following the rules of random walk strategy; If m and the network of equal diameter D, which the traditional strategy of shortest path algorithm will become. [12] an improved routing strategy, it is the source node can not completely know the shortest path routing information under the premise of this policy will still be able to choose a larger probability with the shortest path length difference is as small as possible path for routing search, and best may reduce the node to store the packets needed memory.

Mixed strategy is a method of combining global and local information, it should consider a node to the destination node of the shortest path length, the degree of each node and the node of the comprehensive factors such as the cache size. Echenique presents a Traffic perception algorithm (Traffic Awareness Protocol, TAP). The routing algorithm is mainly combines the shortest path length and the congestion control of two key factors. Here, will be treated as individual nodes information packet is defined as the ability of local congestion. In which the algorithm proposed in will determine whether the network congestion phenomenon occurs is implemented based on node packet queue length, at the same time to avoid a large number of packets in the node accumulation can take corresponding measures to achieve. In this algorithm, if there is no delay when the packets in transit, will be in accordance with the rules of the shortest path for delivery; Otherwise, if the packets during transmission delay happens, node of excess load will be spread to other links. It reduces caused by using the algorithm of shortest path of nodes in the line of the packet queue length, thus improving the performance of the network as a whole. [13] put forward a kind of dispersed in the space of the scale-free network search strategy, it is a distance combined with a degree

of routing strategy. Such a strategy is trying to send packets from the source node to the destination node along the edge of the network for delivery in the process, each node knows the location of the target node, its neighbor node location and degree of its neighbor nodes.

3. Combining Network Static and Dynamic Information of Improved Routing Policy

3.1. The Design of Routing Policy

In actual network, the router has a limited ability to store and process the packets, thus, at each time step, a node can only handle a certain number of packets, when the network packet generation rate increases, due to the accumulation in the network packets cannot be processed as soon as possible, will inevitably produce congestion phenomenon, and makes the transmission increasing average delay of packets. Although there are literature has considered due to the accumulation of node packet in network performance degradation, design a combination of packet waiting time can sense the flow routing strategy, however, these strategies, must want to understand global network topology can obtain the shortest path information, and only a single node of the local dynamic information as a measure, by means of a parameter to measure the relationship between the two, so that the transmission capability of the network. This strategy in the middle and small scale network, can achieve good effect, but in large communication network, can't get a global routing information or get global routing overhead, this strategy is meaningless. So this chapter in this paper, a combination of static and dynamic information network routing strategies for improvement. We to the traditional routing strategy based on local information made two improvements, specific as follows: first, consider the transmission capacity of the buffer queue length and the node effects such as node itself the current situation of traffic flow of factors,

$$P_i = \frac{(k_i e^{-t_i})^{\alpha}}{\sum_j (k_j e^{-t_j})^{\alpha}} \qquad \text{where} \quad t_i = \frac{l_i + 1}{C_i} \tag{1}$$

Here, will take the prior probability P_i of the packets sent to the field of the ith node, the node degrees k_i, l_i said is a node in the buffer queue length of i, C_i says the biggest processing capacity, t_i node i waiting time for packets in the node i, summation, said to all neighbor node summation, α is an adjustable parameter. We are doing this because when α is larger, larger degree of node will be preferred choice as the next target; When alpha is small, smaller node degree is preferred. Here, e^{-t_i} as the attenuation, when waiting for the time, the longer the attenuation of the more powerful, the smaller the probability of making choice node i. This means that the index e^{-t_i} of items in a certain extent, make packets during transmission to avoid the node needs to wait for a considerable time. This process usually rush driving similar with us, we according to the known at the beginning of the shortest path, when seen from a distance the front intersection congestion occurs, we usually choose a relatively smooth road, near so as to avoid the congestion crossing, though not the shortest path, but much more smoothly than continued plugging in the intersection. Second, previous studies of some scholars usually assume that each node packet processing capacity is constant or is directly

proportional to the degree of the and node, however, in practical application, due to the capacity of each node in the network and communication ability is not infinite, but limited, and because of different nodes makes it have different capacity and communication capacity, resulting in a difference. And all of these will become the important cause of network congestion. From the self-organization mechanism of the communication system to consider, if a router in the network in the important position, is the information flows through the router, the router bear the task is big, you can make it larger packet transmission and processing ability, so as to improve the condition of congestion in the network traffic flow. Therefore, in here, $C_i = \max(k_i, 10)$ assume that node can handle packet ability for each time step: k_i for the node degrees.

3.2. Dynamic Process

Dynamic process and the traditional basically adopted by the routing strategy based on local information mentioned in the same:

(1) adding new packets. Assumes that the network starting from zero load, each time step to produce R a packet, and randomly selected source node and destination node. New packet will be added to the end of a queue of nodes, the nodes of the queue, and have it produce packets and from other node transmit packets, for the sake of simplicity, assume that each node queue buffer for infinity.

(2) search the target node. To send packets to the target node, each node in as the packet is passed, within the scope of the neighborhood search first whether to have the target node, if you have, the packets delivered directly to the destination node; Otherwise, will be carried out in accordance with the type (1) the probability of transmission, repeat this process, until you find the target node.

(3) transfer packets. Packet delivery to the middle of the relay node, until you reach the destination node, the packet will disappear in the network. As said before, it is assumed that a node in the network in the important position, so in the process of network transmission, it will correspondingly handling more traffic flow, therefore, in order to solve the problem of traffic congestion in the network, we can update the transmission and the ability to handle packet. Therefore, in the new improved model, the processing capacity of each node can be set to different values, if the nodes in a network of degree is bigger, busier, is given to its larger packet processing capacity, let it is equal to the degree of node; And smaller if the nodes in the network degree, given constant to its packet processing capacity, in this way, and more in line with the actual condition, and to some extent alleviate the network congestion situation.

4. Simulation Results and Analysis

In order to verify the validity and superiority of the routing strategy, we in the Matlab simulation test platform, and compares the routing strategy based on local information. This section of BA scale-free network information transmission, numerical study on the selection of parameters in the simulation process of the following: network scale selection for N = 1000, in the process of network transmission, packet randomly select a node as the source node, randomly select another node at the same time as the target node. Number of nodes in the network time increase in the process of growth for m = 5, the biggest processing capacity of each node as the adjustable parameter alpha - 2, 1, 0, 1 of these four conditions are studied.

Figure 1 shows the adjustable parameter under the condition of different value, the rate of the network packet R with the corresponding relations between the order parameter eta. From Figure 1, we can clearly see that for different alpha values, when the Rc < R, corresponding eta to 0; When Rc > R, eta suddenly jump. It also and the conclusion of literature [14] is the same. That as long as the network packet generation rate R is less than the critical packet generation rate, the entire network will be in a smooth condition; Once the packet generation rate R than the phase change of the critical value, the entire system can appear congestion, and, along with the rising of the packet generation rate, the passage of time, the congestion will be more and more serious, and these are shown in Figure 1 is reflected by the same. By Figure 1, you can see, at the same time, different alpha values corresponding to different threshold also Rc, this shows that the network transmission capacity of the Rc and routing the adjustable parameter. From solid curve can be seen in Figure 1, when the alpha = - 1, network transmission ability, the biggest can reach 135. We'll contrast Figure 1 respectively corresponding to the hollow and solid of the two curves, can see clearly in this paper, the proposed strategy is superior to the routing strategy based on local information.

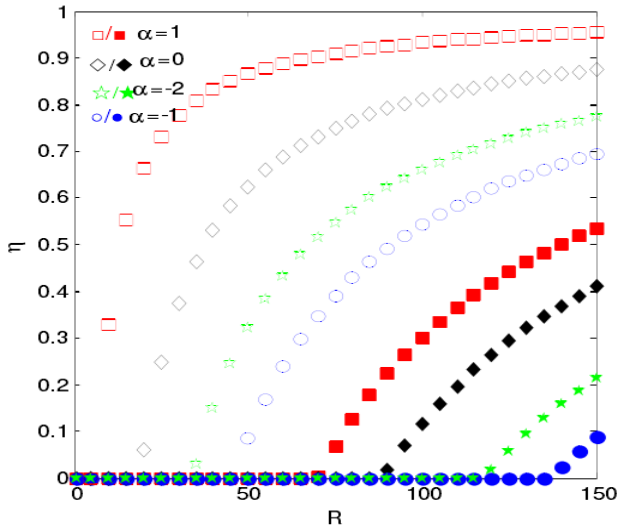

Figure 1. The Rate of the Network Packet R with the Corresponding Relations between the Order Parameter η

In addition, we also do the further research, studies the network Load < Load > relationship with the packet generation rate R. From Figure 2 can be concluded that when the alpha = 1, minimum network load, this can also, at the same time, under the same packet generation rate, alpha = 1 when the stranded in the number of packet networks is the smallest, and the number of packets sent to the destination is also the most. Respectively comparing corresponding hollow curve and solid curve in Figure 4.2, you can see in this paper, the network load of the proposed strategy is lower than the traditional local routing strategy. At the same time can be seen from the Figure 3, when the alpha = - 1, reached the maximum network throughput, this is because the uniform distribution in each node in the network load, and won't be crowded in the degree of node, thus effectively inhibit the network congestion. Therefore, this article proposed routing strategy, can effectively improve the communication ability of the network,

reduce the network load, and in the alpha = - 1, packets can be evenly so as to make the network communication ability.

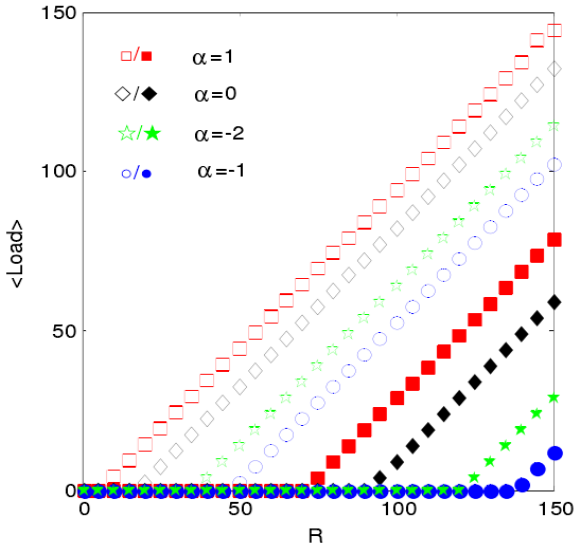

Figure 2. Network Load < Load > Relationship with the Packet Generation Rate R

On the other hand, the packets transmitted from source node to destination node average transmission time < T > can from another Angle to indicate that the network communication ability, it also reflects the transmitted packets needed time overhead. Figure 4 shows free state, the average transmission time < T > the relationship between the rate of packet R. Solid curves are compared in Figure 4, respectively, and the hollow curve, you can see, in this paper, the proposed strategy is only slightly increased the packet transmission time, not dramatically increase the packet transmission time. Can be seen from the Figure 4, when the alpha = 1, the network shortest packet transmission time, this is because, when the alpha > 0, preferred degree relatively large transmission nodes, is conducive to the transfer of information along the shortest path, which can shorten the time, on the contrary, when the alpha < 0, small node connection preference degree, increases the packet transmission path, thus transmission time. And this article proposed strategies to a certain extent, avoid the stronger and wait longer nodes, so the transmission time increased slightly.

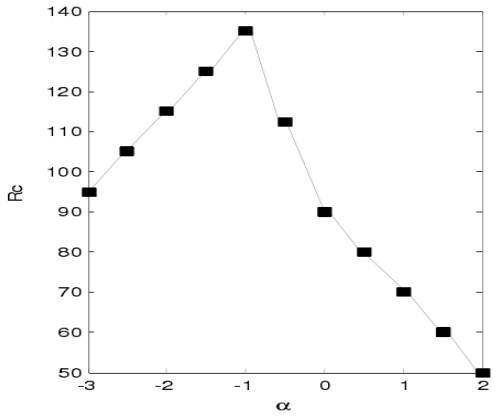

Figure 3. The Adjustable Coefficient Alpha's Relationship with the Rc

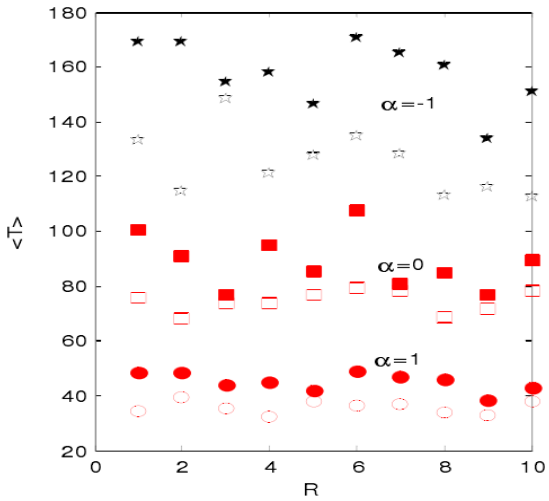

Figure 4. Packets, the Rate of R and the Average Length of the Relationship Between the < T >

In addition, we studied the degree of node k and the average number of packets per node n (k), the relationship between the average number of packets refers to with the same number of packets on the degree of node summation and then averaged. Can be seen from the Figure 5, the average is directly proportional to the number of packets and its degree of approximation, and because of the ability $C_i = \max(k_i, 10)$ for a node delivery packet, can regard as is directly proportional to the similar degree, so we can get the number of packets on each node and node delivery ability of approximation is proportional to the conclusion, this makes the network packet distribution is relatively uniform, which can better reduce network congestion.

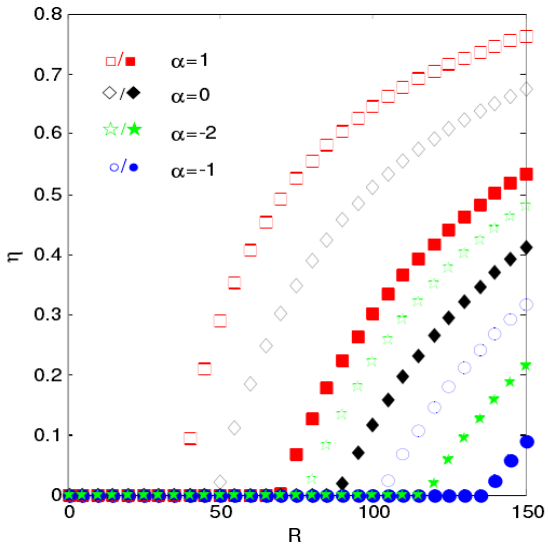

Figure 5. Different Network Topology Structure on the Influence of Network Traffic

5. Conclusion

To solve the problem of traffic congestion in the mass communication network, this section is based on the static network topology and node of the current traffic flow information (for example, the node buffer queue length and the node's packet processing capacity) put forward a new local routing strategy. Through the simulation experiment study found that there is a optimal can adjust the control parameters, namely the alpha = - 1, can maximize the network throughput and network load to a minimum. Similar to the results in [14], this chapter puts forward the routing algorithm is also based on the local routing information and has a broad application prospect in practice, for the future network routing algorithm has a certain guiding significance. In addition, this paper also studied the nodes in the average number of packets and the relationship between the node degrees and different network topology structure on the influence of network traffic.

References

[1] R. Pastor-Satorras R, Vázquez A, Vespignani A. Dynamical and correlation properties of theInternet[J]. Physical review letters, 2001, 87(25): 258701.
[2] Guimera R, Mossa S, Turtschi A, et al. The worldwide air transportation network: Anomalous centrality, community structure, and cities' global roles[J]. Proceedings of the National Academy of Sciences, 2005, 102(22): 7794-7799.
[3] Newman M E J. The structure of scientific collaboration networks[J]. Proceedings of the National Academy of Sciences, 2001, 98(2): 404-409.
[4] Yook S H, Jeong H, Barabási A L,et al, Weighted evolving networks[J],Physical Review Letter, 2001,86(25):5835-5838
[5] Watts D J, Strogatz S H, Collective dynamics of 'small-world' networks[J], Nature，1998,393(6684), 440-442
[6] Barabási A L, Albert R, Emergence of Scaling in Random Networks[J], Science,1999,286(5439):509-512
[7] Chen S, Huang W, Cattani C, et al, Traffic Dynamics on Complex Networks: A Survey[J],Mathematical Problems in Engineering, 2011,2012
[8] Erdos P , Renyl A, On the evolution of the random graphs[J], Nature，1990,5:17-60
[9] Ohira T, Sawatari R, Phase transition in a computer network traffic model [J], Physical Review E,1998, 58(1): 193-195

[10] Kleingberg J, The small-world phenomenon: an algorithmic perspective[C], Proceedings of thethirty-second annual ACM Symposium on Theory of Computing, New York, 2000:163-170
[11] Xiao Xu, Weizhe Zhang, Hongli Zhang, Binxing Fang. "Exploring web partition in DHT- based distributed web crawling". IEICE Transactions on Information and Systems, E93-D(11):2907-2921, 2010. http://dx.doi.org//10.1587/transinf.E93.D.2907
[12] Arenas A, Cabrales A, Diaz-Guilera A, et al, Search and congestion in complex networks[J],Statistical Mechanics of Complex Networks, 2003, 625: 175-194
[13] Moreno Y, Pastor-Satorras R, Vazquez A, et al, Critical load and congestion instabilities inscale-free networks [J], Europhysics Letters, 2003,62(2):292-298
[14] Janaki T M, Gupte N, Connectivity strategies to enhance the capacity of weight-bearing networks[J], Physical Review E,2003, 67(2): 021503
[15] Arenas A, Diaz-Guilera A, Guimera R, Communication in networks with hierarchical A. F. Abdelnour and I. W. Selesnick.，Nearly symmetric orthogonal wavelet bases, Proc. IEEE Int. Conf. Acoust.,peech, Signal Processing (ICASSP), May 2001.

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