Information Transmission Focusing on Complex Networks Consisting of Oscillators

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***Abstract*— Complex networks have been the subject of great attention. In this study, we investigate synchronization phenomena in the complex networks using van der Pol oscillators and the performance of information transmission when the synchronization rate was taken into account in the number of transmitting packets.**

Keywords; Oscillator; Synchronization; Complex networks

I. INTRODUCTIO

Complex networks have attracted a lot of attention from various fields such as sociology, biology and physics. In the field of engineering, the performance of communication networks has been studied with a focus on complex networks [1],[2],[3]. Moreover the studies of synchronization between nodes in complex networks have identified some interesting phenomena [4],[5].

In this study, we first investigate the synchronization between nodes in complex networks, and then investigate the network performance by relating the synchronization to the efficiency of information transmission.

II. NETWORK MODEL

Figure 1 shows van der Pol oscillator. We use two network models in this study. Figure 2(a) shows Erdos-Renyi model (ER random) and Fig. 2(b) shows Barabasi-Albert model (BA scale-free). Table 1 shows each network properties. In this study, we set the average node degree to be close to 4.0 each network model. Further the network models composed of oscillators are used to calculate the synchronization rate between each node.

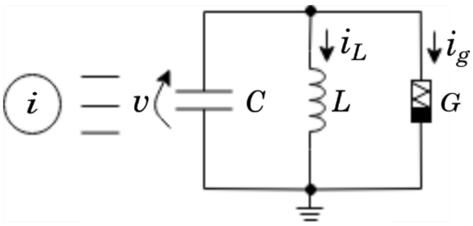
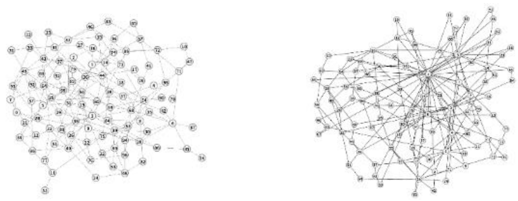


Figure 1: Oscillator.



(a) ER random. (b) BA scale-free.

Figure 2: Network models.

Table 1: Node number N, Average node degree d_{avg} and Maximum node degree d_{max} of two network models.

network	ER random	BA scale-free
N	100	100
d_{avg}	4.08	3.92
d_{max}	9.0	32.0

III. INFORMATION TRANSMISSION ALGORITHM

In this study, information is represented as packets. Packets are generated by the host nodes and transmit through the links one hop at a step until they reach the destinations. Also, each node in the network has a buffer B. Then, the packets transmission algorithm operates as follows:

1) Packets Generation

At each time step, hosts generate R packets.

2) Packets Transmission

The number of transmitting packets for node per step is S. At each time step, packets of each node are forwarded to their destinations by one step according to the shortest path routing algorithm.

3) Packets Dropped

If the total number of packets reaching one node is larger than buffer size B, transmitted packets are dropped.

4) Packets Released

Packets already arrived at their destinations are released from the buffer.

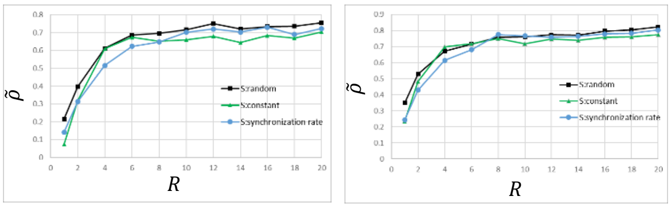
Further we consider two performance parameters to compare the packets transmission performance. The first, packet drop rate ρ, the second is arrival rate σ, and it is defined these equations for these parameters are as follows:

$$\rho = \frac{number\ of\ dropped\ packets\ in\ time\ step}{number\ of\ generated\ packets\ in\ time\ step}, \tag{1}$$

$$\sigma = \frac{number\ of\ arrival\ packets}{time\ step}. \tag{2}$$

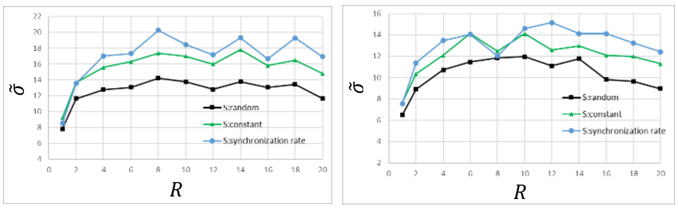
IV. RESULTS

In this study, the simulation parameters the buffer size for each node $B = 100$ and the number of transmitting packets S is set in three patterns. The first sets the S of each node randomly. The second sets the S of all nodes constant. The third is to set S based on the synchronization rate. Here, based on the synchronization rate means to increase the value of S when the synchronization rate between nodes is high, and to decrease the value of S when the synchronization rate is low. Further the total number of time steps $T = 2000$ and the relationship between the average drop rate $\tilde{\rho}$ and the number of generating packets R is shown in Figure 3 and the relationship between the average arrival rate $\tilde{\sigma}$ and the number of generating packets R is shown in Figure 4.



(a) ER random. (b)BA scale-free.

Figure 3: The relationship between the average drop rate $\tilde{\rho}$ and the number of generating packets R.



(a) ER random. (b)BA scale-free.

Figure 4: The relationship between the average arrival rate $\tilde{\sigma}$ and the number of generating packets R.

From Fig. 3, we see that $\tilde{\rho}$ is small when S is set based on the synchronization rate in the range of R from 2 to 6 in the both network models. Further $\tilde{\rho}$ is small when S is set to constant in the range of R from 8 to 20 in the ER random while $\tilde{\rho}$ is almost the same in the range of R from 8 to 20 in the BA scale-free. From Fig. 4, it is confirmed that $\tilde{\sigma}$ is large when S is set based on the synchronization rate and $\tilde{\sigma}$ is small when S is set to random in the both network models.

V. CONCLUSION

In this study, we calculated the synchronization rates between each node using network model composed of oscillators and investigated the performance of information transmission when the synchronization rate was taken into account in the number of transmitting packets S. As a result, it was confirmed that the average drop rate $\tilde{\rho}$ is the small when the number of generating packets R is small (the range of R from 2 to 6) in the both network models. Further it was confirmed that the average arrival rate $\tilde{\sigma}$ is large.

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