Comparison of defense strategies for cascade breakdown on SF networks with degree correlations

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March 2005

Keywords: Cascade failure, SF network, degree correlation

Cascade failure is possible to occur on the networks where each node frequently communicates mutually such as electrical power grids and Internet routers. As the examples, there are the large-scale blackout in the western United States in 1996 and the congestion phenomenon of the packet translation on the Internet. On such networks, an initial small failure of nodes and edges change the loads of others. Therefore the subsequent failure occur when the load to the nodes and to the links exceed the capacity. Consequently the failure propagates on the networks.

On the other hand, it has been described that the actual networks have a common structural feature, which is power-law distribution of the number of nodes to the degree (the number of links connected to a node), e.g. electrical power grid, Internet, and so on. The networks with such structure are called scale-free (SF) networks. In addition, degree correlation (the average degree of the nearest neighbors of a node to the degree of that) has been noticed as another structural feature of SF networks. Networks with positive degree correlation have high frequencies of connections between the nodes with high-degree and corresponds to social networks such as the E-mail networks. On the other hand, those with negative one have high frequencies of connections between the nodes with high-degree and those with low-degree and corresponds to technological and biological networks such as electrical power grid, Internet, protein interaction network, and so on.

Recently, the damage scale of cascade failure on uncorrelated SF network models has been analized with computer simulation. Moreover, "A defense strategy by intentional removals of nodes" has been proposed as an attempt to suppress the damage. The conventional strategy cuts off many peripheral low-degree nodes from a network.

In this paper, I experiment cascade failure on the network model possible to adjust degree correlation and investigate the influence of degree correlation to the damage scale. In addition, I propose defense strategies of "rewiring of failure edges" to keep the connectivity, and investigate the relations between degree correlation and the effects of defense strategies. The proposed defense strategies are the rewiring methods between nearest neighbors of damaged nodes based on the degree and the load.

The results of the simulation experiments are shown as follows.

1. Degree correlation influences the damage scale although the scale depends on models.
2. The defense effect is improved in the case using the proposed strategies more than using the conventional one. In particular, the proposed strategy of connecting the bridge nodes is more efficient than others.

Furthermore the proposed and conventional strategies have the following feature: the proposed ones need the local link structure of networks, whereas the conventional one needs the global one to cut off peripheral nodes. Therefore the proposed strategies are more practical than the conventional one because it is difficult to grasp the whole structure of actual networks.