Dynamic properties of packet transportation for topological structure of networks

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As progressing the infrastructure of computer networks, the Internet is very important tool in our life. It makes new types of network service called "social software" in Weblog, P2P technology, etc. Those services will open a revolution from the old communicating way like mailing list, chat, groupware, to a new type of network community called "knowledge community". On the other hand, Grid computing that called the one of informational "social ware" is developed for scientific technology and business in recent years. However, there exist serious problems for huge number of packets flow with increasing hosts. We must resolve the packet congestion, and to develop a new method for the routing.

The conventional network analysis, in order to investigate dynamic behavior of packet transit, has two approaches. One is for topological structure of networks, another packet dynamics based on independent poission arrivals. We have usually applied a random graph or a lattice graph, however, as pointed out by Faloutsos et al, the router network has a different structure characterized by power law degree distribution. Moreover, for the packet dynamics, Takayasu et al. has found the phase transition between free flow and congestion states in mutually depended flows.

Thus, we focus on the networks with a power law degree distribution called scale-free(SF) networks. In the Internet, SF structure is appeared not only in router networks, but also in AS network that is classified upper level of router networks. Furthermore, many complex networks in nature and social relationship, such as a power grid, a protein, a metabolism reaction, the dependency of a software component, electronic circuit, have such SF structures. Recent studies in packet transportation also gives much attention to the SF structure. Therefore, we investigate the dynamic property of packet transportation on SF structures in large networks. We make a simulator that have topological structure are extracted real data of power grid, and AS network.

Simulation results show that the network congestion is influenced by the topological network structures. In the congestion phase, the topology of power grid has many packets on network than AS network, because the mean path length in power grid is longer than AS network. Moreover, the packets are concentrated on the queue of a few hubs with high degrees, according to the power exponent of correlation functions in AS network.

Finally, we found that "betweenness centrality", which was used in social networks, is very important factor for packet transportation. Our result has shown the mean queue length are longer as higher betweenness followed by a power law distribution.