The Study of Cascading Failure in Complex Systems

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The disturbance of large interconnected infrastructure is very often caused by cascading failures of loaded system components. For instance, large blackouts of electric power system are caused by cascading failures of overloaded components. The CASCADE model of cascading failures of a system with many identical components randomly loaded is used to study the propagation of failures in both a single system and in coupled systems. Considering a single system (electric power grid for instance), an initial disturbance causes some components to fail by surpassing their loading limit. Failed components interact with other components by transferring a fixed amount of load to them that increases the probability of further failures. As components fail, failure of other components becomes probable. This model has been implemented in a C++ cellular automaton code. The original CASCADE model studied in a single system gave results similar to the more detailed ORNL-Pserc-Alaska (OPA) model for blackouts dynamics, but it shows some clear discrepancies. It captured only few of the features of the OPA model. By adding truncation and randomization of outages to the model, it gives results more similar to that of the OPA model. After comparing the features of the CASCADE model to that of the OPA model in a single system, we have extended the model to coupled systems. Even though many infrastructures can be modeled individually, in reality they interact with each other in more complex ways. These interactions can lead to a decrease or increase of the risk of failures in those individual systems when coupled, depending on the sign of the coupling coefficient δ. The CASCADE model is modified to study the impact and to investigate on the interdependencies between those complex infrastructures, in particular a coupled system.

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