Vulnerability and Co-susceptibility Determine Large Network Cascades

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In a network, a local disturbance can propagate and eventually cause a substantial part of the system to fail, in cascade events that are easy to conceptualize but extraordinarily difficult to predict. Here, we first develop a statistical framework that can predict cascade size distributions by incorporating two ingredients only: the vulnerability of individual components and the co-susceptibility of groups of components (i.e., their tendency to fail together). Using the North American power grid as a complex system per excellence, we show that correlations between component failures define structured and often surprisingly large groups of co-susceptible components. We then identify, quantify, and analyze the set of network components that are vulnerable to cascading failures across multiple conditions in which the system operates. We show that the vulnerable set consists of a small but topologically central portion of the network and that large cascades are disproportionately more likely to be triggered by initial failures close to this set. Aside from their implications for blackout studies, these results provide insights and a new modeling framework for understanding cascades in financial systems, food webs, and complex networks in general.

References

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