Cascading Overload Failures in Spatially-Embedded and Random Networks with Distributed Flows

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In complex information or infrastructure networks, even small localized disruptions can give rise to congestion, large-scale correlated failures, or cascades—a critical vulnerability of such networks. Here, we discuss cascades of overload failures for distributed flows in spatial and non-spatial random graphs, and empirical networks. Our recent results on load-based cascading failures in spatially-embedded random networks (applicable to power grids) underline both the conceptual and computational challenges and difficulties identifying critical nodes, lines, and regions to mitigate cascades. We observed that cascading failures are non-self-averaging in spatial graphs, hence predictability is poor and conventional mitigation strategies are largely ineffective. Among our main findings is that protecting all nodes (or edges) by the same additional capacity (tolerance) may actually lead to larger global failures. I.e., indiscriminately investing resources in the protection of nodes or links can actually make the network more vulnerable against cascading failures ("paying more can result in less", in terms of robustness).

References

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