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Cascading Failures and Recovery in Networks of Networks[1]

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Network science have been focused on the properties of a single isolated network that does not interact or depends on other networks. In reality, many real-networks, such as power grids, transportation and communication infrastructures interact and depend on other networks. I will present a framework for studying the vulnerability and the recovery of networks of interdependent networks. In interdependent networks, when nodes in one network fail, they cause dependent nodes in other networks to also fail. This is also the case when some nodes like certain locations play a role in two networks –multiplex. This may happen recursively and can lead to a cascade of failures and to a sudden fragmentation of the system. I will present analytical solutions for the critical threshold and the giant component of a network of n interdependent networks. I will show, that the general theory has many novel features that are not present in the classical network theory. When recovery of components is possible global spontaneous recovery of the networks and hysteresis phenomena occur and the theory suggests an optimal repairing strategy of system of systems. I will also show that interdependent networks embedded in space are significantly more vulnerable compared to non embedded networks. In particular, small localized attacks may lead to cascading failures and catastrophic consequences.Thus, analyzing data of real network of networks is highly required to understand the system vulnerability. References: [1] S. Buldyrev, R. Parshani, G. Paul, H.E. Stanley, S. Havlin, Nature, 465, 0893 (2010) [2] R. Parshani, S. Buldyrev, S. Havlin, PRL, 105, 048701 (2010) [3] R. Parshani, S.V. Buldyrev, S. Havlin, PNAS 108, 1007 (2011) [4] J. Gao, S. Buldyrev, H. E. Stanley, S. Havlin, Nature Physics, 8, 40 (2012). [5] A. Bashan et al, Nature Communications 3, 702 (2012) [6] A. Bashan et al, Nature Physics, 9, 667 (2013) [7] A Majdandzic et al, Nature Physics 10 (1), 34 (2014)

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