Robustness of a Network of Networks\textsuperscript{1} JIANXI GAO\textsuperscript{2}, Boston University, SERGEY V. BULDYREV\textsuperscript{3}, Department of Physics, Yeshiva University, H. EUGENE STANLEY, Boston University, SHLOMO HAVLIN\textsuperscript{4}, Department of Physics, Bar-Ilan University, Israel — Network research has been focused on studying the properties of a single isolated network, which rarely exists. We develop a general analytical framework for studying percolation of \( n \) interdependent networks. We illustrate our analytical solutions for three examples: (i) For any tree of \( n \) fully dependent Erdős-Rényi (ER) networks, each of average degree \( \bar{k} \), we find that the giant component \( P_\infty = p[1 - \exp(-\bar{k}P_\infty)]^n \) where \( 1 - p \) is the initial fraction of removed nodes. This general result coincides for \( n = 1 \) with the known second-order phase transition for a single network. For any \( n > 1 \) cascading failures occur and the percolation becomes an abrupt first-order transition. (ii) For a starlike network of \( n \) partially interdependent ER networks, \( P_\infty \) depends also on the topology—in contrast to case (i). (iii) For a looplike network formed by \( n \) partially dependent ER networks, \( P_\infty \) is independent of \( n \).

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