Criticality in finite dynamical networks

THIMO ROHLF, Santa Fe Institute, NATALI GULBAHCE, CHRISTOF TEUSCHER, Los Alamos National Laboratory — It has been shown analytically and experimentally that both random boolean and random threshold networks show a transition from ordered to chaotic dynamics at a critical average connectivity $K_c$ in the thermodynamical limit [1]. By looking at the statistical distributions of damage spreading (damage sizes), we go beyond this extensively studied mean-field approximation. We study the scaling properties of damage size distributions as a function of system size $N$ and initial perturbation size $d(t = 0)$. We present numerical evidence that another characteristic point, $K_d$, exists for finite system sizes, where the expectation value of damage spreading in the network is independent of the system size $N$. Further, the probability to obtain critical networks is investigated for a given system size and average connectivity $k$. Our results suggest that, for finite size dynamical networks, phase space structure is very complex and may not exhibit a sharp order-disorder transition. Finally, we discuss the implications of our findings for evolutionary processes and learning applied to networks which solve specific computational tasks. [1] Derrida, B. and Pomeau, Y. (1986), Europhys. Lett., 1, 45-49

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