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Stochastic Modeling of Dynamic Networks with Growth and Removal

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Abstract

In this report, we simulate a dynamic network based on preferential attachment, where the network evolves over discrete time steps by either growing or shrinking. That is, by adding or removing a node. We study how different factors, such as the probability of adding a node, the number of interactions per new node, and the removal strategy (random vs. targeted), affect the overall robustness of the network. The main focus is on how these changes influence the size of the *largest connected component*, a common measure of structural cohesion. The results provide insight into how seemingly small changes in network dynamics can significantly affect resilience.

The simulations show that the network's robustness is strongly influenced by the number of edges per new node (m) and the probability of node addition (p_{add}). When m is small, the network is sparse and quickly fragments under both random and targeted removal. As m increases, the network becomes significantly more connected and robust.

For $p_{add} > 0.5$, the network grows, and the largest connected component (LCC) remains stable under random attacks. However, targeted removal of high-degree nodes leads to rapid fragmentation. The degree distribution approximately follows a power law under random removal, but simulations have confirmed that the pattern breaks down under targeted strategies or when the growth rate is too slow. The robustness curves and estimated power law exponents γ support the theoretical prediction that scale-free networks are resilient to random failures but vulnerable to targeted attacks.

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