Emergence of community structure in networks from local preferential attachment

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We present a new model for generating networks with community structure and show that it produces networks with stronger community structures than the basic triadic closure model. We address the issue of what local processes can cause community structure to emerge and be influenced.

The basic triadic closure model for generation of networks, shown by Bianconi et al to form networks with communities, has two features: a random growth step, where a node i is added to a network and is attached to another random node j in the network, and a proximity bias step, where, with a probability p, node i is attached to a random neighbor of j and to random node in the network otherwise. The proximity bias step is repeated m-1 times, and then the random growth step happens until the network has n nodes.

In our model, we modify this proximity bias step to include preferential attachment in three forms. First, we have global preferential attachment in the proximity bias. Instead of a random neighbor of node j, we instead select the random neighbor with probability directly proportional to their degree. We also have the local preferential attachment, where the selection probability is only proportional to the number of edges that attach to other neighbors of j. Finally, we include the neighbors of neighbors for selection in the proximity bias and selection probability calculation.

We ran the four models with n = 5000, m = 2, 3, 10, 20, and p from 0.05 to 1.00, generating 20 networks for each set of parameters. We found that the local preferential bias model produced networks with the strongest community structures, especially outperforming all three for m = 10 and 20. Meanwhile global preferential attachment and the widened radius models produced networks that have weaker community structure than the basic triadic closure model. The ability of these model to produces networks with stronger or weaker community structures than the basic model provides new insight into the emergence of communities.

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