Assortative and preferential attachment lead to core-peripheriy networks

Keywords: Network analysis, network evolution, core-periphery, homophily, preferential attachment

Extended Abstract

Core-periphery structures are, along with communities, one of the most common mesoscale arrangements found in empirical networks. In core-peripheries, a group of nodes called the *core* dominates connections, whereas a second group known as the *periphery* remains largely unconnected to itself, and mostly to the core [1]. Despite their ubiquity, most research has focused only on the detection of core-peripheries, whereas the mechanisms that produce them are largely unknown [2], particularly in cases where the core and periphery groups correspond to known partitions.

We show that core-peripheries emerge on networks that evolve through combinations of preferential and assortative attachment -or homophily in social networks-. This result applies to both growing and rewiring network evolution dynamics. We first develop and implement evolution algorithms for networks with two groups *a* and *b* (of fraction sizes n_a and $1\text{-}n_a$), whose connections are governed by two assortative mixing parameters s_a, s_b, as well as a parameter *c* that balances between preferential attachment and random rewiring.

The combined results from simulations and mean-field analyses reveal that preferential and assortative attachment can interact in non-trivial ways that yield core-periphery structures. Both growing and rewiring models differ in the qualitative type of CP structures they generate. Growing mechanisms typically produce layered networks, with a periphery being as likely to connect to the core than to itself, while in rewiring we find a strict "hub-and-spoke" where most connections are located in the core and the periphery remains largely disconnected [3]. In the presence of both high preferential attachment and highly-assortative groups, we find that network evolution processes can lead to scenarios where both groups can become the core, with the other group becoming disconnected form itself despite being highly assortative.

We validate our results by analyzing five empirical networks -*APS* and *Cit-geo* for the growth model; *Boards* [4], *Twitter* and *Airport* for the rewiring model-, where we fit our model parameters via a maximum-likelihood method from temporal network statistics, and estimate the effect of the main parameters on observed network structures. In many empirical networks we find a disassortative periphery and an assortative core, which has implications on the newtork structure. For example, in the *Twitter* dataset we find that heterophilous retweeting by users in the periphery exposes even more peripheral users to the core, in a way that cumulatively amplifies their information from the core. Using the *Boards* dataset, we showcase the potential of our model by displaying the effect of parameter interventions on the networks' core-peripheriness.

Our research provides an explanation for the emergence of core-periphery structures in networks via the combination of two well-known network evolution mechanisms. These insights have applications in social media, transportation networks, and others. For example,

the existence of privileged and elite social groups can be understood as an emergent phenomena caused by seemingly unrelated mechanisms.

References

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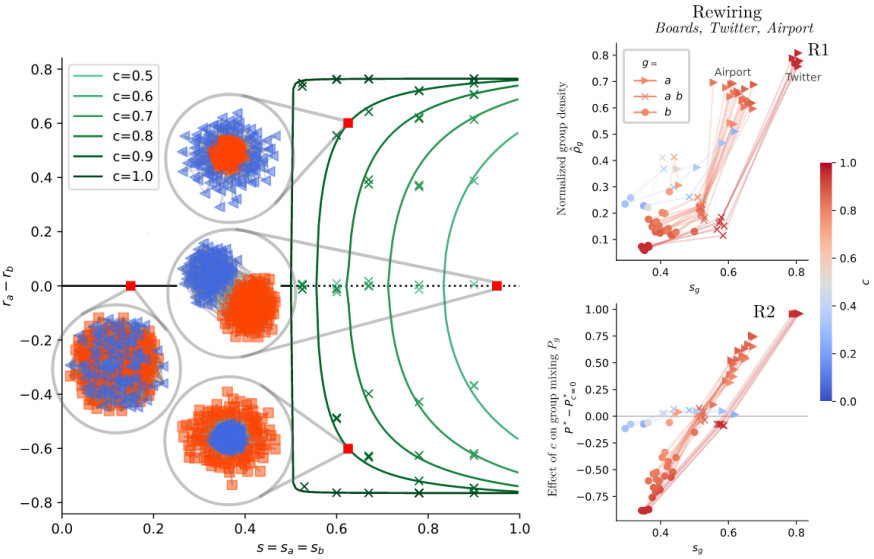

Fig *ction of homophily and fitted simul* ad to bifurcatio riness [1], r_a-r_b, helps) is a core. The dotte ets: visual representat nts. ***(Right)*** *Empirica impact of preferenti* here each line r is are homophily values, we define *s ction of estimated g with an assorta* lbutions within/between groups at fixed points, and $P^* - P^*_{c=0}$ depicts the difference with and without preferential attachment (*c=0*). Positive (negative) values imply a loss (gain) of links on the entries of the group mixing matrix of link distributions. For the Airport and Twitter dataset estimated parameters cluster together.