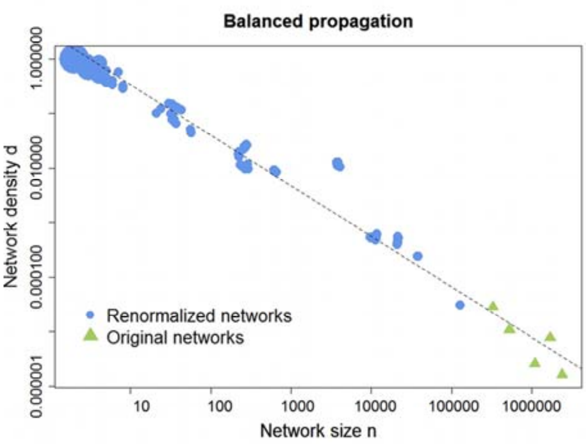
**Preserving properties under simplification of real-world networks**

The growing interest in exploring diverse real-world systems with networks reflects in increasing network sizes and complexity. Large networks become harder to understand and investigate, furthermore algorithms for their analysis proved to be temporally or spatially inappropriate. Natural solution to these problems lies in simplifying complex networks, which provide for better understanding, easier analysis and more efficient visualization. Methods for network simplification can be divided into two general classes, namely network sampling and coarse-graining. In the former, nodes or edges are randomly selected to form a sampled network (e.g. random node selection, node selection based on their degree, random walk, snowball sampling), whereas in the latter, nodes and edges are merged into supernodes and superedges based on their properties (e.g. cluster growing and box-tiling renormalization).

In our research, we analyze the simplification of several real-world networks under different above mentioned methods. We analyze fundamental network properties (e.g. assortativity, diameter, density, degree distribution, betweenness centrality, clustering, and community structure) and their modifications under simplification processes. We focus on finding correlations and similarities among network types and preserved properties. The results reveal the best method for preserving specific network property, the optimal size of simplified networks, and the most appropriate methods for simplifying specific type of networks. Moreover, the findings advance the comprehension of real-world networks and their internal structure, with several possible application. Adequate simplification of large networks without losing information about properties of original networks enables faster analysis and more efficient network visualization. Additionally, information about preserved properties under simplification can help to understand and predict dynamical processes on networks and their evolution, improve the accuracy of link prediction, and the quality of synthetic network generation.



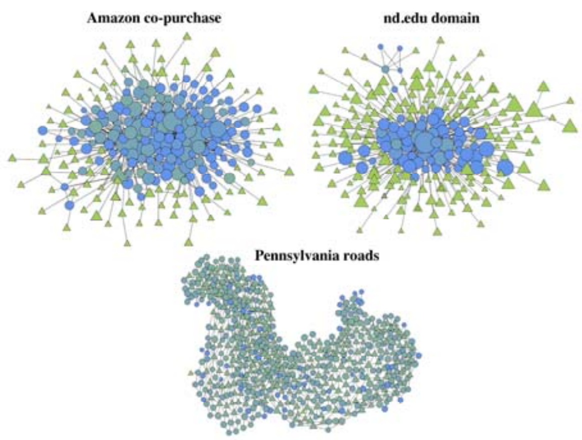




Figure 1: (left) Power-law relationship between network density and size of five real-world networks revealed with renormalization process based on balanced propagation community detection. Plot shows scaling of density over 10 simplification of each network. Green triangles correspond to original networks, whereas blue circle represent their renormalized varieties. (right) Density of network structure in renormalized varieties of three large real-world systems of different origin. Node symbols correspond to degree-corrected clustering coefficient that ranges between 0 and 1 – green triangles and blue circles, respectively – while symbol sizes are proportional to the number of nodes in the original network.