# Node mixing in networks, graphlet degree distributions

You are given different networks in Pajek format (edge list and LNA formats are also available).

- Zachary karate club network (small)
- Lusseau bottlenose dolphins network (small)
- Java class dependency network (smallish)
- Map of Darknet from Tor network (smallish)
- iMDB actors collaboration network (medium)
- Gnutella peer-to-peer sharing network (medium)
- Part of Facebook social network (medium)
- Part of Internet overlay map (medium)

## I. Degree assortative and disassortative networks

1. **(code)** Implement Newman's node degree mixing coefficient $r$ as sample Pearson correlation coefficient between the linked nodes' degrees $k$ and $k'$.

   $$r(k,k') = \frac{\sum_i (k_i - \langle k \rangle)(k'_i - \langle k' \rangle)}{\sigma_k \sigma_{k'}}$$

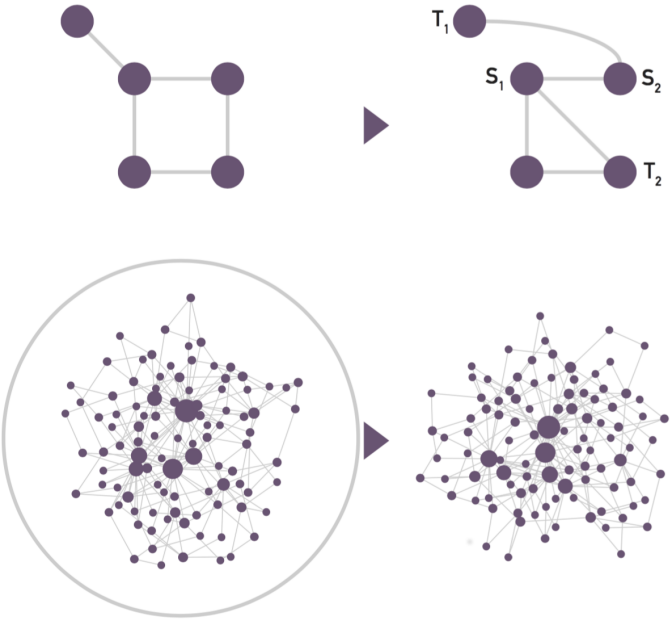
   Treat all networks as undirected graphs and compute their undirected degree mixing coefficient $r$. Are the networks assortative $r > 0$, disassortative $r < 0$ or neutral $r \approx 0$?

2. **(code)** For undirected networks, generate corresponding Erdös-Rényi random graphs and compute their undirected degree mixing coefficient $r$. Are random graphs assortative $r > 0$, disassortative $r < 0$ or neutral $r \approx 0$?

3. **(code)** For directed networks, compute all four directed degree mixing coefficients $r_{(in,in)}$, $r_{(in,out)}$, $r_{(out,in)}$ and $r_{(out,out)}$. Are the networks assortative $r_\cdot > 0$, disassortative $r_\cdot < 0$ or neutral $r_\cdot \approx 0$?

## II. Structurally disassortative networks by degree

1. **(answer)** Consider network randomization by degree-preserving link rewiring. What is the expected undirected degree mixing coefficient $r'$ after rewiring if you allow for multiple links between the nodes? What about if you restrict the process to generate only simple graphs?




2. **(code)** Apply link rewiring restricted to simple graph to degree disassortative networks and compute their degree mixing coefficient $r'$ after rewiring. Are the networks indeed degree disassortative $r' \approx 0$ or (partly) structurally disassortative $r' < 0$?

## III. Node mixing by *not* degree

**(code)** Study node mixing in networks by some property *other* than node degree. This can be either some structural property of nodes (e.g. node clustering coefficient $C$ or corrected clustering coefficient $C^{\mu}$) or external information associated with each node (e.g. traffic loads in Slovenian highways network).

## IV. Graphlet degree distributions

**(code)** Consider the orca algorithm by Hočevar and Demšar for computing graphlet orbit degrees $k^i$ for graphlets with up to $4$ nodes, $i \in \{0, \ldots, 14\}$. Compute graphlet orbit degrees $k^i$ and plot graphlet degree distributions $p_k^i$ for larger networks above.