Realistic models of personal networks

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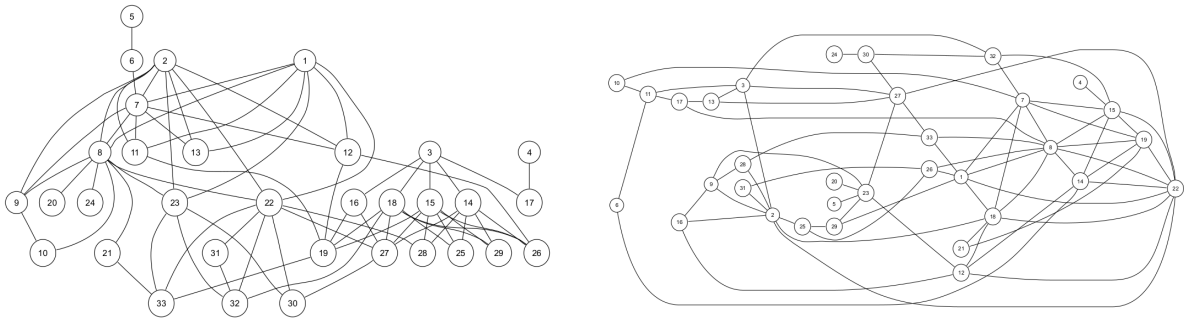
Context. To understand the structure of real-world networks, it is standard to use *null models*: random graphs with a set of given properties to which we can compare the structure of the real networks. By this means, we try to identify which are the **essential building blocks** of the network: motifs, properties that can explain the other characteristics of the graph.

Random graphs with a fixed number of nodes and edges (known as Erdős-Rényi graphs) have been largely used, but they lack realism to mimic real world networks. In the last decades, the configuration model [NP03], which generates a random graph with a given degree sequence, became a popular null model for its increased realism as it captures an essential element of real-world networks, namely the fact that their degree is highly heterogeneously distributed (see figure).



Real structure of the food web for the Chesapeake bay ecosystem (left) vs. one realization of its configuration model (right). Extracted from [BD11].

However, other properties such as the tendency of real-world networks to exhibit small dense patterns or larger scale communities escape this model. This is why a larger zoology of null models has been pursued for years [MKFV06, ODCdS$^+$15]. Unfortunately, more realistic **random models are hard to produce without bias**. For each case of interest, such as graphs with a fixed number of motifs [KN10], with given degree correlations [SP12], or with a fixed k-core sequence [VKBK21], inventive and complex processes have to be designed, and they are hardly generalizable to other null models.

In a recent paper [TK24], we have proposed a method which is unbiased and flexible, in the sense that it can be adapted to several types of properties. It is known as the *probabilistic k-swap method*. We want to adapt and use this method to investigate a variety of new realistic null models to account for the structure of networks in the context of social networks analysis.

Goal. The purpose of this internship is to adapt the probabilistic k-swap method to investigate a specific family of networks: personal networks. Personal or ego-networks are a special case of sociological network: they focus on an individual (*ego)* and gather the connections between the relationships of this person (or *alters*). It is assumed that the structure of personal networks relies on a few principles, in particular *homophily*, which is the fact that people with similarities (social background, educational level etc.) tend to connect. We aim to propose and create *null models* based on these sociological observations to understand the varieties of personal networks observed in practice.

Profile. This internship is directed at students with various backgrounds (complex networks, algorithmics, graph theory) but with a strong interest in **graph algorithms or theory** and their applications.

Location and environment. The intern will be part of the Complex Networks team of the LIP6 (SU-CNRS), located in Paris on Jussieu Campus (4 Place Jussieu). The internship will be supervised by Lionel Tabourier and Mehdi Naima.

Duration and remuneration. Up to 6 months internship - the remuneration of the internship is based on the standard rate of academic internship in France (4.35 euros/h, 35 h/week) with an additional compensation for food and transport.

References

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