Proposition de stage de M2
Localisation: Centre de Physique Théorique, Marseille
Directeurs de stage: Alain Barrat and Márton Karsai
(alain.barrat@cpt.univ-mrs.fr, karsaim@ceu.edu)

Temporal network backbones

Abstract:
In many data sets, crucial information on the structure and temporality of a system coexists with noise and non-essential elements. In networked systems for instance, some edges might be non-essential or exist only by chance. Filtering them out and extracting a set of relevant connections, the "network backbone", is a non-trivial task. To solve this problem for static networks, a number of methods have been proposed already [1,2]. However, the case of temporal networks, in which an edge between two nodes is replaced by a set of events with the time at which they occur (e.g., communication events between two persons), has however only recently been tackled [3]. In [3], a method was indeed proposed to extract significant ties in a temporal network, using a temporal null model as reference: a significance level with respect to the null model is assigned to each tie, and, by varying the required significance, one can filter out the non-significant ties, keeping only the significant ones.

These ties are however whole timelines of events between two nodes, while methods to extract a backbone made of "significant events" are still lacking. The goal of this internship is to define and investigate new such filtering techniques for temporal networks, using several empirical data sets as case studies. The idea is to define suitable null models so that a significance level can be assigned to each event between two nodes, and to use this significance to define a backbone of significant events in a temporal network. Once a systematic method is defined, the backbone and its properties will be analyzed in detail, as a function of the level of filtering, for instance by:

- measuring the size of the largest connected component and total weight carried by the significant events in the aggregated network;
- measuring the fraction of pairs of nodes that are connected via time respecting paths in the backbone (i.e., can send a message to each other in a causally possible way);
- investigating the properties of spreading processes along the backbone (using simple toy models of spreading processes);

In addition, we will investigate whether a representation of the network considering only the backbone and additional random events can be close enough to the original network to be used in numerical simulations of spreading processes instead of the real original data. This could provide a way to represent complex data in a simpler way.

Required profile: physicist trained in complex systems with good numerical (coding) skills, preferentially in python.

References

[1] Extracting the multiscale backbone of complex weighted networks. Proc. Natl. Acad. Sci. USA 106, 6483–6488 (2009), http://www.pnas.org/content/106/16/6483.short
[2] Irreducible network backbones: unbiased graph filtering via maximum entropy. https://arxiv.org/pdf/1706.00230.pdf
[3] The structured backbone of temporal social ties, Nature Communications **10**:220 (2019), https://arxiv.org/abs/1804.08828