Diffusion and Contagion Processes on Temporal Networks

Dirk Brockmann

Humboldt University Berlin / Robert Koch-Institute Berlin, Germany
dirk.brockmann@hu-berlin.de

Complex Networks are frequently a suitable way to model structures on which dispersal-, diffusion-, spreading- and contagion processes evolve. Modeling systems with an underlying network structure range from social contact patterns in single populations in which nodes resemble individuals and links between pairs a propensity of interaction to larger scale mobility networks in which nodes represent locations and links the amount of traffic between them. Diffusion processes on networks have been investigated in numerous studies mostly focusing on static networks. Generically the goal of these studies is the understanding of what statistical or topological features impact the speed and other properties of dynamical processes. Recently, a lot of effort has been devoted to understanding dynamical processes on networks that change their connectivity over time as well. The focus on temporal networks is motivated by the fact that for example the spread of infectious diseases by direct physical contact occurs on contact patterns between individuals that change their physical proximity on a time scale comparable to the dynamical process. Compared to their static counterpart, dynamical processes on temporal networks are difficult to understand because mathematical / analytical treatments as well as numerical investigations are difficult. Studies often are based on computer simulations run on empirical temporal networks without a clear understanding what features of the temporal network impact the dynamical process. In comparison to static network analysis, no consensus exists what the appropriate reference models to which empirical or in-silico studies can be compared. It remains elusive how higher order structures impact dynamics, whether temporality in networks e.g. slows down a spreading process or enhances it, and if both effects are observed what are the conditions. In this context it is particularly interesting how clustering or community structures in temporal networks impacts diffusion or spreading phenomena because human contact patterns generically exhibit strong clustering and community structure.

I will present and discuss two models for temporal networks and diffusion / contagion processes on them. First, I will introduce the link activity model that generalizes the static Erdös Renyi network. The link activity model is characterized by a time scale and a global link density and serves as a reference model. I will then introduce the “flockworks” model, a two parameter model that is based on a link rewiring scheme and naturally leads to the emergence of group structures in the temporal network. Both networks are identical when time averaged such that the impact of temporality can be identified systematically. I will show that especially in the context of disease dynamics the “flockworks” model can exhibit substantially different behavior not only compared to the static system but also to the link activity model concerning for example value of the critical point and the impact of a disease in terms of the overall fraction of infected individuals.