Microscopic modelling of congestion in transportation networks

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Complex networks have become the natural substrate for modeling interactions between elements in complex systems. Here, we focus on transportation networks, in particular in the problem of congestion. It has been shown that when packets' traffic is small, transportation networks behave efficiently and performance measures are easy to model or compute. However, if the traffic is large, due to physical restrictions, the system is not able to deal with it and becomes congested. Under this situation, travel time and the amount of packets "in route" diverge. Up to now, only rough estimations of these quantities can be given. The phenomenon is equivalent to a phase transition in physics and its modeling is challenging. We propose a simple mechanistic and yet analytically tractable model, that we call *Microscopic Congestion Model* (MCM), that fully predicts important measures of the system such as the congestion order parameter [1]. We validated the MCM on several synthetic networks and with different routing strategies, showing that it accurately predicts local and global variables of the system before, while and after the congestion phenomena. Figure 1 shows preliminary results in a homogeneous random network of 300 nodes.

[1] R. Guimerà et al. Phys. Rev. Lett., 89(24):248701 (2002).

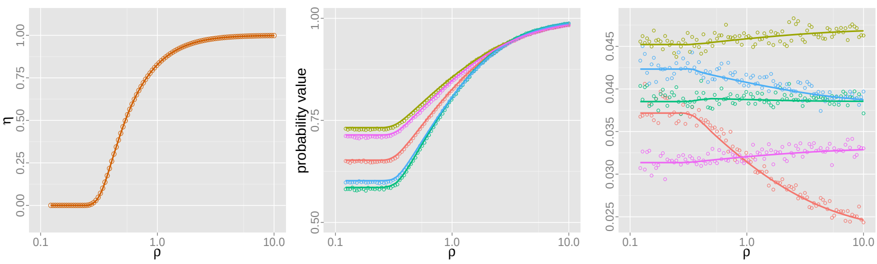

Figure 1: Validation of the MCM for the (left) congestion order parameter η, (middle) the probability a packet has reach it destination node, and (right) the probability a packet is redirected to a particular neighbour. Solid line corresponds to MCM predictions and points to Monte-Carlo simulations.