

Title:

Percolation Theory and Scaling Laws for Wireless Networks.

Abstract:

A central paradigm in the successful development of communication protocols in the Internet is the separation of the different tasks performed by a communication network, such as connectivity, channel multiple access, routing, which are each carried out at a different layer of the protocol stack. In this layered model, lower layers are abstracted to the upper ones: for example, end-to-end paths are routed on a network that is first assumed to be fully connected. This brings simplicity and operational efficiency, but may come at the cost of over-simplification and resource inefficiency. Such is the case for wireless multi-hop networks, whose nodes can only connect to nodes in their neighbourhood, but have nevertheless to transfer information globally, over long distances. Abstractions between layers of the protocol stack lead to loose upper and lower bounds on scaling laws of some key network properties.

The solution to bridge this gap is brought by percolation theory, as we review for two key properties, network connectivity and rate capacity (or throughput). On a Poisson Boolean model extended to account for interferences, we first establish the existence of a percolation threshold as a function of the node spatial density and of a parameter accounting for noise and interference level in the wireless channel, and characterize some of its properties. Next, we show that the achievable bit rate per source–destination pair in a wireless network of n randomly located nodes scales as $1/\sqrt{n}$, by leveraging on the underlying percolation model. This result is tight, contrary to scaling laws requiring full connectivity of the network (joint work with Olivier Dousse, François Baccelli, Massimo Franceschetti, David Tse, Nicolas Macris, Ronald Meester).