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Flows, first passage percolation and random disorder in networks

Consider a connected network and suppose each edge in the network has a random positive weight. Understanding the structure and weight of the shortest path between nodes in the network is one of the most fundamental problems studied in modern probability theory and goes under the name *first passage percolation*. It arises as a fundamental building block in many interacting particle system models. In the modern context these problems take on an additional significance with the minimal weight measuring the cost of sending information while the number of edges on the optimal path (hopcount) representing the actual time for messages to get between vertices in the network.

The aim of this talk is to describe a heuristic based on continuous time branching processes which gives very easily, a wide array of asymptotic results for random network models in terms of the Malthusian rate of growth and the stable age distribution of associated branching process. These techniques allow us to solve not only first passage percolation problems rigorously but also understand functionals such as the degree distribution of shortest path trees, congestion across edges as well as asymptotics for “betweenness centrality” a concept of crucial interest in social networks, in terms of Cox processes and extreme value distributions. These techniques also allow one to exactly solve models of “weak disorder” in the context of the stochastic mean field model of distance.