Isolation statistics in temporal spatial networks

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Many kinds of complex networks such as transport, power, social and neuronal networks are spatial in character, that is, the nodes and perhaps also the links have a physical location. Geometry can structure the network in that the probability of a link between two nodes is related to their mutual distance. Longer links are typically more expensive to build, maintain, or operate (e.g., motorways) than shorter ones, yet offer fast information flow or transport through different parts of the network. Consequently, spatially embedded networks often exhibit interesting topological features such as clustering, modularity, or small worldness. Spatial structure is also particularly important in many multiplex and/or dynamic networks.
Here we focus on temporal and small world spatial networks and, unlike studies which are data or algorithmically driven, derive deep analytical results relating to the connectivity. We obtain statistics (all moments and the density) for the probability of isolated (i.e., disconnected) nodes in networks with local or small world connection models, static or with temporally uncorrelated or correlated links. Isolation statistics are vital for understanding bottlenecks in transporting people, resources or information throughout the network. The enabling approach leverages tools from stochastic geometry and statistical mechanics via the probability generating functional to extract spatial averages and Ising lattices to model time correlated links.
Consider spatial networks in which the nodes remain fixed, but for which the links break and reconnect, thus forming a temporal network. For example, this is a good model of a wireless ad-hoc network where nodes (devices) communicate directly with each other rather than a central router and where their locations may be considered random; examples include sensor and vehicular networks, the Internet of Things, or smartphone networks interconnected via Wi-Fi Direct. The link probability decreases with the distance between nodes. The communication channel exhibits rapid fading, so that some time later, the state of the system has the same distance-dependent link probabilities, independently or in a time correlated manner. The nodes remain fixed in space, at least on the rapid fading timescale. We are interested in how the link probability and temporal correlations affect the time required to distribute information packets throughout the network, limited by the isolated nodes.

[l] C.P. Dettmann and O. G, arxiv:1610.09884 (2016).
[2] C.P. Dettmann and O. Georgiou, Phys. Rev. E **93**, 032313 (2016).
[3] J.P. Coon, OG and CPD, IEEE Wire Comm Lett **4**, 629 (2015).