Title: Modeling Wireless Multi-hop Network Resilience Using Graph Theory

Doctoral Research Seminar Presentation by

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Abstract: Wireless ad hoc multi-hop networks are increasingly being utilized for various applications, such as industrial sensor networks, Internet-of-Things (IoT) networks, Vehicular Mobile Ad-Hoc Networks (VANETs), tactical military networks as well as traditional mobile ad-hoc networks (MANETs), all of which typically operate in highly resource-constrained environments. Such networks are typically self-organizing, dynamic, and share spectrum with other similar (or dissimilar) wireless networks. The nodes comprising these networks are often mobile, lightweight and power constrained. These characteristics make these networks susceptible to node and link failure. In order to analyze and quantify how such failures can impact overall network resilience, we model this network using graph theory concepts. We define resilience as the ability of the network to stay connected under adverse conditions that may lead to node and link removal. Resilience can be quantified by modeling the network as a geometric random graph, where edges represent wireless links and vertices represent network nodes. Link resilience is measured using the graph theoretic concept of *edge-connectivity*, which quantifies the degree of resistance a network has to link failure. A traditional ad hoc network model where all nodes share a single channel and use some form of carrier sense multiple access technique is assumed. We also assume that other similar networks coexist both spatially as well as spectrally, and that nodes belonging to these other networks are interference sources. Channel interference across the network results in link degradation and eventually link removal, thus decreasing edge-connectivity. In order to make the network more resilient to link removal, we propose a frequency division-based channel allocation approach using the concept of graph coloring. The spectral diversity introduced by this approach decreases the susceptibility of the network to link removal, thus maintaining a high level of edge-connectivity. Similarly, node resilience is measured using *vertex-connectivity*, which quantifies the resistance a network has to node failure. First, a random node removal model is analyzed and demonstrated, where a decrease in node density results in a decrease in the network's vertex-connectivity. We then analyze how focused node removal, which prioritizes nodes to be removed (or attacked) based on their relative importance in the network, impacts the network's vertex-connectivity. We finally compare the resilience of networks under both focused and random node removal and discuss how vertex connectivity can be improved.