ABSTRACT

Understanding the graphical structure of the electric power system is important in assessing reliability, robustness, and the risk of failure of operations of this critical infrastructure network. Statistical graph models of complex networks yield much insight into the underlying processes that are supported by the network. Such generative graph models are also capable of generating synthetic graphs representative of the real network. This is particularly important since the smaller number of traditionally available test systems, such as the IEEE bus systems, have been largely deemed to be insufficient for supporting large simulation studies and commercial-grade algorithm development. Thus, there is a need for statistical generative models of electric power network that capture both topological and electrical properties of the network and are scalable.

Generating synthetic network graphs that capture key topological and electrical characteristics of real-world electric power systems is important in aiding widespread and accurate analysis of these systems. Classical statistical models of graphs, such as small-world networks or Erdos-Renyi graphs, are unable to generate synthetic graphs that accurately represent the topology of real electric power networks -- networks characterized by highly dense local connectivity and clustering and sparse long-haul links.

This thesis presents a parametrized model that captures the above-mentioned unique topological properties of electrical power networks. Specifically, a new Cluster-and-Connect algorithm is introduced to generate synthetic graphs using these parameters. Using a uniform set of metrics proposed in the literature, the accuracy of the proposed model is evaluated by comparing the synthetic models generated for specific real electric network graphs. In addition to topological properties, the electrical properties are captured
via line impedances that have been shown to be modeled reliably by well-studied heavily tailed distributions. The details of the research, results obtained and conclusions drawn are presented in this document.