Scale-freeness and growth stability of realistic network models

Networks are found everywhere across a huge number of fields of research, from interactions between proteins in a cell to the structure of the world wide web, all of these networks are the results of some network generative model. The nature of such a model is of both scientific and practical interest. Our focus are the ‘scale-free’ networks that have degree distributions that are modelled by a power law. These are associated with networks generated by the popular Barabasi-Albert preferential attachment model, whereby new nodes are more likely to connect to nodes already in the network with higher degrees. This is analogous to many mechanisms in real life such as how people gain followers on social media apps.

This scale-free property is nice as it allows us to describe the structure of a network with regards to its degrees using only one parameter, the exponent of the power law. However, looking at the degree distribution of real networks and networks generated by the Barabasi -Albert model, it becomes clear that while the power law seems to hold for the bulk of the data, it is usually inadequate for the set of full degrees. This is particularly evident in the right tail, and to a lesser extent the left tail. While several papers have investigated using different models for the degree distribution, methods from extreme value theory remain underutilised. Presenting an opportunity to quantify the scale-freeness using a more realistic model.

This project aims to find a suitable model for the degree distribution using methods from extreme value theory, such as mixture models with a discretised version of the Generalised Pareto distribution for the right tail, and power laws for the rest of the degrees. This can then be used to quantify the scale-freeness of a network through numerical measures as well as investigating how the parameters of the model change as real networks grow over time. Further, we intend to use this information to aid in the modification and/or extension of the Barabasi-Albert model to more accurately describe how realistic networks grow. With the aim of studying the theoretical properties of the largest degrees and scale-freeness of networks as they grow under the new model.