Lecture 3: Origins of Preferential Attachment

Matthew Johnson
matthew.johnson2@dur.ac.uk

Network Models

- Our exercise last time suggested that random graphs are not always a good model for real networks.
- Most networks we know evolved over time so, even if we are looking only at a static snapshot, we might expect this to be reflected in the definition of our model.

Preferential Attachment

- A growing network exhibits preferential attachment if new nodes are more likely to connect to existing nodes that are already well-connected.
- The model used in the exercise is sometimes known as the Barabási-Albert (BA) model. In this model, the network begins with m_0 nodes and then
  - at each time step a new node is created with $m \leq m_0$ links to existing nodes;
  - the probability that the new node links to an existing node v depends on the degree of v.

Note that the BA model leaves some details open. How are the original nodes connected? Are the links from a new node all added together or one by one? Do we allow parallel links?

A history of Prefential Attachment

The idea of Preferential Attachment emerged independently many times.

- György Pólya, Mathematician 1923
  Developed the urn model: an urn contains black and white balls, one is taken out and replaced with an additional ball of the same colour.
- George Udmy Yule, Statistician 1925
  Developed the Yule process to explain the numbers of species per genus of flowering plants
- Robert Gibrat, Economist 1931
  Used preferential attachment, calling it proportional growth to explain why large firms grow faster.
- George Kinsley Zipf, Economist 1941
  Used preferential attachment to explain the fat tailed distribution of wealth in society.

A history of Prefential Attachment continued

- Herbert Alexander Simon, Political Scientist 1955
  More fat tails: explained the distribution of city sizes, word frequencies or the number of papers published by scientists.
- Derek de Solla Price, Physicist 1968
  Explained citation statistics calling it cumulative advantage
- Robert Merton, Sociologist 1976
  Applied preferential attachment to sociology, coining the term Matthew effect

The Barabási-Albert network was proposed in 1999.