Problem on Complex Networks

- **1. Barabasi-Albert model** The simplest growing network model that has a power-law degree distribution is the Barabasi-Albert (BA) model. Starting with two nodes joined by a link
  - At every time step a single new node joins the network, so that at time t there will be exactly $N = 2 + t$ nodes.Every new node has initially $m = 1$ links.
  - Each new link attaches to an existing node of the network. The target node i is chosen with probability Π_i following the preferential attachment rule $\Pi_i = \frac{k_i}{\sum_j k_j}$, where k_i is the degree of the node i.

  a) What will be the time evolution of the average degree of the nodes in the mean-field approximation?
  b) What is the degree distribution of the network at large times in the mean-field approximation?
  c) Write the master-equation for the number of nodes with k links.
  e) Solving the master equation find the degree distribution of nodes at large times.

- **2. Growing network model with initial attractivness** $A > -1$ The simplest variation to the BA model is growing network model with initial attractiveness $A > -1$.
  Starting with two nodes joined by a link
  - At every time step a single new node joins the network, so that at time t there will be exactly $N = 2 + t$ nodes .Every new node has initially $m = 1$ links.
  - Each new link attaches to an existing node of the network. The target node i is chosen with probability Π_i following the preferential attachment rule with initial attractiveness $\Pi_i = \frac{(k_i+A)}{\sum_j (k_j+A)}$, where k_i is the degree of the node i.

  a) What will be the time evolution of the average degree of the nodes in the mean-field approximation?
  b) What is the degree distribution of the network at large times in the mean-field approximation?
  c) Write the master-equation for the number of nodes with k links.

- **3. Visualization of networks** Write a program in order to produce a network of $N = 1000$ nodes for a growing network model and visualize the network for example with Cytoscape .