Discussion Questions and Lab 7:
Networks, webs nodes and links

Answer the following questions based on Chapters 3 to 6 of the book *Linked* by Albert-László Barabási. To answer some of the questions you will have to modify and use some of the provided R code.

1. Describe the 1967 Stanley Milgram study and its findings. Did he discover that people are at most 6 "handshakes" away?
2. Play with the Kevin Bacon oracle here (Write down your observations)
3. What is a scale-free network?
4. What is a hub?
5. Explain how you would program a random network (the Erdos-Renyi type).
6. Explain how you would program a "small world" network (the Watts type). Explain the assumptions of such network.
7. Explain how you would program a growing network without preferential attachment. Explain the assumptions of such a network.
8. Explain how you would program a "preferential attachment" network (The Barabasi type). Explain the assumptions of such a network.
9. How would you expand the preferential attachment network to account for networks such as actors in movies or mathematicians writing papers?
10. Do a little research. What are the differences between power law, exponential and poisson distributions?

11. Draw a network with 100 nodes; some of the nodes should be hubs. Find the distance between some pairs of nodes. What happens to those distances if you remove nodes that are hubs and nodes that are not hubs?

12. The function staticrandom below produces a static random network. Run it, and draw histograms of number of connections.

13. The function growrandom below produces a growing random network. Run it, and draw histograms of number of connections.

14. This is an implementation of the small world network. It is unlikely to run in the lab computers. http://ccl.northwestern.edu/netlogo/models/SmallWorlds Play with it to better understand this type of network, and describe your observations.

15. This is an implementation of the preferential attachment network. It is unlikely to run in the lab computers at DePaul. http://ccl.northwestern.edu/netlogo/models/PreferentialAttachment Play with it to better understand this type of network, and describe your observations.

```
staticrandom=function(Nc, nlink){
   #static random
   srnd=matrix(ncol=nlink,nrow=Nc)
   for(i in 1:Nc) {
         for(j in 1:nlink) {
               srnd[i,j]=i
               #put it in a loop, because a node can not link to itself
               while(srnd[i,j]==i){
                     srnd[i,j]=trunc(runif(1,1,Nc+1))
               }
         }
   }
   return(srnd)
}

growrandom=function(Nc, nlink){
   #dynamic random
   drnd=matrix(ncol=nlink,nrow=Nc)
   #drnd[1,]=rep(1,nlink)
   for(i in 1:Nc){
         if (i>1){
               drnd[i,]=trunc(runif(nlink,1,i))
         }
   }
   return(drnd)
}

# hint: Write a function that calls one of the above
# functions and generates a histogram.  Here is some
# code to help.  Run it to see what it does, then try
# using it to write a function.

nnodes=5
linkseach=3

# Code for creating a histogram of static network link counts
  network= staticrandom(nnodes,linkseach)
  c = length(network[,1])
  b=sort(network)
  # define an array to hold the counts
  counts=array(dim=c)
  # Initialize the counts:
  for (i in 1:c) {counts[i]=linkseach}
  # Why did we start with "linkseach" rather than zero?
  # If we had started with zero, what would we be counting?
  # Try it and see how it is different:
  #for (i in 1:c) {counts[i]=0}
  # For the growing random network, the first node is special;
  # its starting node count is therefore different from the rest.
  for (i in 1:length(b)) {counts[b[i]] = counts[b[i]] + 1}
  c
  network
  counts
  # hist(counts)
  hist(counts,breaks=c((min(counts)-.5):(max(counts)+.5)))


# Then do the same thing for the growrandom function, changing as needed.
```