Small world networks

Small-world networks are graphs/networks in which most nodes have many connections to a limited number of "neighbouring" nodes, but where a limited number of connections to "distant" nodes help to create a network with a relatively small average distance between all nodes. Small world networks can be created in various different ways, and can have very different properties otherwise:

1) Within a locally strongly connected network (like a ring with links to only the nearest neighbours), replace a number of links by links to arbitrary other nodes within the network. This is the Watts-Strogatz model.
2) A network is grown node by node. When adding a new node, the probability of connecting to an existing node is proportional to the number of existing connections to that node. Compare this to referencing to the top few Google results when creating a new web-page on a subject. This will create networks with a few strongly dominant nodes with a great many connections (hubs) and increasing numbers of nodes with fewer connections. In this way "scale-free" networks can be created (refer to e.g. the work of A.L. Barabasi).
3) And many more.

Small-world networks of various types are very common, in social networks, on all levels of the internet, in biological systems, etc. etc. For that reason small-world networks have become an important research area.

This assignment has two parts:

1) Create or find an algorithm that can create a range of small-world networks, based on one or more variables. The networks created must range from completely random to completely regular. Investigate the properties of such networks. Look at properties like diameter, clustering, maybe robustness to node and link deletions, etc. Search the literature to find what kind of properties can be of interest. E.g. for python there are various libraries that can be used for such an analysis.
2) Create a SIR (Susceptible, Infected, Recovered/Resistant) model for an infectious disease on such a network. Investigate the effect of vaccinations on the spread of such a disease in a social network by randomly marking a number of nodes as 'R' at the start of the simulation.

For this assignment you may make use of code found elsewhere (if and only if properly referenced), but you have to do the experiments, the analysis and provide the explanations.

Suggested reading:

http://en.wikipedia.org/wiki/Small-world_network

http://en.wikipedia.org/wiki/Clustering_coefficient

http://en.wikipedia.org/wiki/Scale-free_network

http://en.wikipedia.org/wiki/Watts_and_Strogatz_model

http://projects.skewed.de/graph-tool/

http://igraph.sourceforge.net/