CSE6010 HW3 Version2 Report Part1

Literature Review

Papers on how to create scale-free network?

1. In Albert, Jeong [1]'s paper, they think the scale-free model has new features in conformity with the real world. First of all, real world networks continuously expand by the addition of new vertices that are connected to the vertices already present in the system. Second, there is higher probability to be linked to a vertex that already has a large number of connections. The scale-free model incorporating these two ingredients is defined in two steps:

(1) Growth: Starting with a small number (N) of vertices, at every timesteps we add a new vertex with m (<=N) edges (that will be connected to the vertices already present in the system).

(2) Preferential attachment: When choosing the vertices to which the new vertex connects, we assume that the probability P that a new vertex will be connected to vertex i depends on the connectivity Ki of that vertex, such that

$$P(k_i) = k_i / \sum_j K_j$$

(3) After t timesteps the model leads to a random network with N = t + N vertices and mt edges.

2. In Schneeberger, Ferguson, Johnson[2]'s paper, they give detail information on how to create the scale-free network. One can construct a scale-free network (like with a random graph) by starting with a few unconnected nodes and adding new nodes with n edges (connections) per node. Edges are added "at random" to existent nodes, but with a probability weighted in favor of those nodes, which already have many edges. This is called preferential attachment and, in mathematical terms, the probability p (Ki) that a new node will be connected to node i is a function of the number of edges this node already has divided by the total number of edges in the system. Numerical simulations as well as analytical calculations have shown that this method of construction leads to a scale-invariant network whose degree distribution follows a power law. In effect, scale invariance means that as one changes the "scale" (ie, the cutoff degree of the nodes, which is used to exclude them from an analysis), the pattern observed, in this case the rate of decay of the degree distribution remains unchanged.

Papers about identifying real-world application of scale-free networks

1. Scale-free model has its application in the World Wide Web, Albert, Jeong [1] believe this model captures in a minimalist way the main ingredients that are responsible for the development of the scale free state observed for the www. They also bring up that Growth and preferential attachment are mechanisms common to a

number of complex systems, including business networks, social networks (describing individuals or organizations), and transportation networks.

Q&A
Specifying what the nodes and links represent: nodes represent the websites, links represent the links between websites.
What kinds of questions a graph analysis might answer: how nodes are connected, how to tell the importance of a certain website.

2. Dezso and Barabasi[3] ‘s paper talks about the application of scale-free networks to halting virus. They conclude that the vanishing epidemic threshold for viruses spreading on scale-free networks indicates that traditional methods, aiming to decrease a virus’ spreading rate cannot succeed in eradicating an epidemic. They demonstrate that policies that discriminate between the nodes, curing mostly the highly connected nodes, can restore a finite epidemic threshold and potentially eradicate a virus. They find that the more biased a policy is towards the hubs, the more chance it has to bring the epidemic threshold above the virus’ spreading rate. Furthermore, such biased policies are more cost effective, requiring fewer cures to eradicate the virus.

Q&A
Specifying what the nodes and links represent: nodes represent the patients that suffer from epidemics, links represent the people they met since one got infected.
What kinds of questions a graph analysis might answer: what is the epidemic threshold? If we only cure the highly connected nodes, what’s going to happen.

References

[1] Barabási, Albert-László, Réka Albert, and Hawoong Jeong. "Scale-free characteristics of random networks: the topology of the world-wide web."Physica A: Statistical Mechanics and its Applications 281.1 (2000): 69-77.
[2] Schneeberger, Anne, et al. "Scale-free networks and sexually transmitted diseases: a description of observed patterns of sexual contacts in Britain and Zimbabwe." Sexually transmitted diseases 31.6 (2004): 380-387.
[3] Dezső, Zoltán, and Albert-László Barabási. "Halting viruses in scale-free networks." Physical Review E 65.5 (2002): 055103.