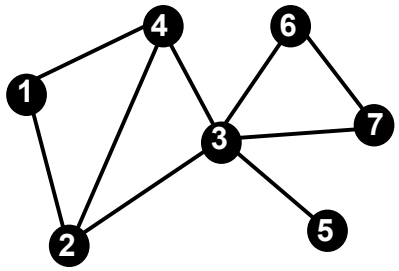
SME0130 Complex Networks

Exercises I

Send the solutions to: **projetosicmc@gmail.com**

1. Consider the follwing network.



Manually calculate the following measures:
a) Degree distribution,
b) Local clustering coefficient,
c) Transitivity,
d) Distance matrix,
e) Entropy of the degree distribution,
f) Second moment of the degree distribution.

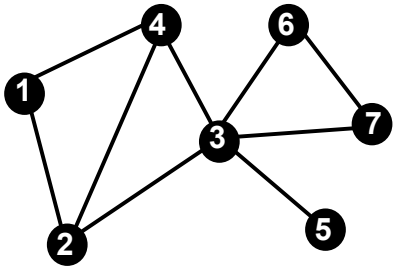
Implement a computer program to construct this graph by using Networkx. Calculate the measures again by using your computer and compare the results.

2 - Implement a program to read a directed and weighted network and transform it in an unweighted and undirected network. Consider the network of the characters of Les Miserables[1] and the Florida ecosystem wet[2]. Draw the network of the characters on the novel Les Miserables, both weighted and unweighted version.

3 - Implement a routine to perform a random walk in a network. Consider the unweighted version of the Les Miserable networks. Does the number of visits to each node correlated with the degree of each node?

[1] `http://www-personal.umich.edu/~mejn/netdata/lesmis.zip`
[2] `http://networkrepository.com/eco-foodweb-baywet.php`

4 - Consider the following network.



a) The transition probability matrix is defined as $P_{ij} = A_{ij}/k_i$. Implement a routine to calculate the powers of the probability matrix. What does it happen when $\lim_{n\to\infty} P^n$? That is, you can verify how the elements of the matrix P^n changes as n increases.

b) Calculate the matrix of distances D for the Les Miserables network. Calculate A^n. For $n = 3$, put the values of A^3 and D in a scatterplot. That is, each point in the scatterplot will be $((A_{ij})^3, D_{ij})$, for $i, j = 1, \ldots, N$.

c) Verify how the Pearson correlation between D and P^n varies with n. More specifically, construct a scatterplot for $n = 1, 2, ...$ and calculate the correlation for each case. Then, plot the correlation in function of n.

5 - Calculate the cumulative distribution of the power law degree distribution ($P(X \leq x)$, where X is the random variable representing the network measure). How is the coefficient of this distribution related to the power law degree distribution?

6 - Determine the cumulative distribution of the degree distribution of the following networks. Are some networks scale-free? Use only the largest component.
a) E-road network (`http://konect.cc/networks/subelj_euroroad`),
b) Facebook user-user friendships (`http://snap.stanford.edu/data/egonets-Facebook.html`)
c) A coauthorship network among scientists working on network science, from 2006.
(`http://www-personal.umich.edu/~mejn/netdata/netscience.zip`),
d) Hamsterster friendships
(`http://konect.uni-koblenz.de/networks/petster-friendships-hamster`).

7 - Compare the average clustering coefficient (equation **??**) and the transitivity (equation **??**) of the following networks.
a) E-road network (`http://konect.cc/networks/subelj_euroroad`),
b) Facebook user-user friendships (`http://konect.uni-koblenz.de/networks/ego-facebook`)
c) Collaboration of authors of scientific papers from the arXiv's Astrophysics
(http://konect.uni-koblenz.de/networks/ca-AstroPh),
d) Hamsterster friendships (`http://konect.uni-koblenz.de/networks/petster-friendships-hamster`)
Why do C and C_L diverge in some networks?

8 - Calculate the distribution of the shortest path of the following networks:
a) E-road network (`http://konect.cc/networks/subelj_euroroad`),

b) Facebook user-user friendships (`http://konect.uni-koblenz.de/networks/ego-facebook`)
c) Collaboration of authors of scientific papers from the arXiv's Astrophysics
(`http://konect.uni-koblenz.de/networks/ca-AstroPh`),
d) Hamsterster friendships (`http://konect.uni-koblenz.de/networks/petster-friendships-hamster`)
Compare the distributions and relate then with the scale-free nature of the networks.

9 - Construct a table where each row represents the measures of a network. Consider the following networks.
a) E-road network (http://konect.uni-koblenz.de/networks/subelj_euroroad),
b) Facebook user-user friendships (http://konect.uni-koblenz.de/networks/ego-facebook)
c) Collaboration of authors of scientific papers from the arXiv's Astrophysics
(http://konect.uni-koblenz.de/networks/ca-AstroPh),
d) Hamsterster friendships (http://konect.uni-koblenz.de/networks/petster-friendships-hamster).
And the following measures: (i) number of nodes, (ii) average degree, (iii) second moment of the degree distribution, (iv) average clustering coefficient, (v) transitivity, (vi) average shortest path length, (vii) diameter.
Compare these networks in terms of the measures.

10. Consider the OSMnx package. Show the networks of the following cities: (i) London, (ii) Paris, and (iii) Berlin. Determine the degree distribution of these cities and calculate the following measures:
a) Complexity measure,
b) Average shortest path length,
c) Clustering coefficient.
What can you say about the structure of these networks? Which one is more complex? If you want to find a place in one of these cities, which one should be the easiest to navigate?