# Homework #5: Graph Partitioning

*Fall 2018*

**120 points (note 20 points for extra credit question below)**

Due: 11:59pm, 11/27/2018

## A. Problem

Please use python 2.7 in this assignment

In this assignment, you will implement the Girvan-Newman (GN) algorithm in Python (gn.py) for computing the betweenness of edges in a graph. Here, we consider the betweenness of an edge e as the sum of the fraction of shortest paths between nodes x and y that pass through e, over all pairs of nodes in the graph. The algorithm takes as the input a graph and outputs the betweeness for each edge in the graph. You may assume that the input graph is connected.

We cannot use any specific libraries except the basic libraries python itself has.

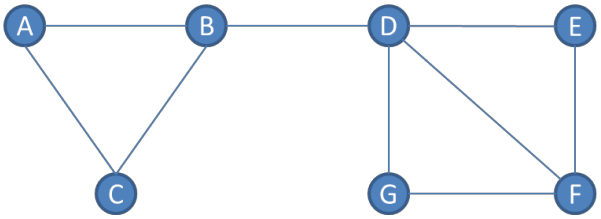
Recall that the GN algorithm works as follows.

- **[Step A]** for each node X in the graph G,
  1. Run BFS, starting at the node X; form a DAG graph G' that contains edges between different levels of BFS.
  2. For each node Y in the graph, compute the number of shortest paths from X to Y. Recall that this is done by a top-down traversal of G'.
  3. Based on the results in step 2, for each edge e in G', compute the sum of the fraction of shortest paths from X that pass through e. Recall that this is done by a bottom-up traversal of G'.

- **[Step B]** for each edge e in the graph G,
  1. Sum up the fractions obtained in Step A for e.
  2. Divide the sum by 2 to give the betweeneness of e.

### A. Input format

The input graph will be provided in a JSON file where each line represents an edge in the graph. For example, the input for the graph below is as follows.




["a","b"]
["a","c"]
["b","c"]

["b","d"]
…

## B. Output format

You should print the betweenness of edges to output.txt in a format as follows.
(a, b), 5.0
(a, c), 1.0
(b, c), 5.0
(b, d), 12.0
(d, e), 4.5
(d, f), 4.0
(d, g), 4.5
(e, f), 1.5
(f, g), 1.5

## C. Execution format

python gn.py input-file output-file

## D. Submission

- Submit the code gn.py

**Extra credit: (20 points)** But note that the maximum point of all homework remains to be 500.

- Implement a program in Spark that computes the edge betweenness in parallel. You can utilize your implementation of the GN algorithm above. Name your script gn-spark.py.
    - Execution format: spark-submit gn-spark.py input-file output-file
- Write a document that explains how your program computes the betweenness scores in parallel.
- Submit the code and the document.
- The library we need here is pyspark.
- Do not use Dataframe here.