# CSE450/598 PROJECT, Wednesday, 04/03/2013, Due: Monday, 04/22/2013

In this programming assignment, you will implement specified algorithms for computing a maximum flow in a flow network. You program should read in the flow network from an ASCII file named input.txt and write the output to an ASCII file named output.txt. The first line of input.txt contains two integers $nV$ and $nE$, which are the number of vertices and number of weighted edges in the flow network $G$ (a directed graph). The second line of input.txt contains three integers $s$, $t$, and $k$, where $s$ and $t$ denote the source node and the destination node, and $k$ is a positive integer (for checking your program). The next $nE$ lines each contain three integers $u$, $v$, and capacity, where $u$ and $v$ are the start and end vertices of the corresponding edge and capacity is the capacity of that edge. The vertices are numbered from 1 to $nV$. The edges are numbered from 1 to $nE$. For example, the following input file specifies a flow network with 4 vertices and 5 edges.

```
4 5
1 4 3
1 2 4
1 3 1
2 3 5
2 4 1
3 4 4
```

For this example, the source node is 1, the destination node is 4, and $k = 3$. The edge from 1 to 2 has capacity 4. The edge from 1 to 3 has capacity 1. The edge from 2 to 3 has capacity 5. The edge from 2 to 4 has capacity 1. The edge from 3 to 4 has capacity 4.

On reading the input, your program should do the following.

- Initialize your chosen data structure for the graph (your choices will be between adjacency list and adjacency matrix) with dynamic memory allocation.

- Compute the maximum flow using an augmenting path algorithm, where you compute a shortest path (in hops) in the residual graph as the augmenting path.

- Output the augmenting path computed during the $k$th iteration of your algorithm. Output the maximum flow computed. Here you need to output the value of the maximum flow, as well as the positive flows on the edges. For a positive flow $f(x, y)$ on edge $(x, y)$, there should be a corresponding line in the form of $x\ y\ f(x, y)$.

- Output the corresponding min-cut and its capacity. Here you need to output the capacity of the min-cut, as well as the cut itself.

For the sample input, your program should generate the following output.

```
The augmenting path at iteration 3 is
1 2 3 4


Flow value=5
The max-flow is
1 2 4
1 3 1
2 3 3
2 4 1
3 4 4


Min-cut capacity=5
The min-cut is
1
2, 3, 4
```

Grading policies: You should use the programming language C++. Your program should be working on general.asu.edu, as it will be graded there. You will need to submit it electronically at the class web-site.

(10 pts) You should have a module that constructs the residual graph. The input to this module will be the flow graph and the current flow. The output of this module will be the residual graph.

(10 pts) You should have a module that computes the augmenting path. The input to this module is the residual graph. The output of this module is the augmenting path.

(10 pts) You should have a module that updates the flow. The input to this module is the augmenting path, together with the current flow and the flow network. The output of this module is the updated flow.

(10 pts) You should have a module that computes a min-cut when there is no augmenting path for the current flow.

(10 pts) You should have a module for input and output. You also need to have a driver for the overall program, and provides a Makefile.

**Extra Credit Work**

You can earn up to an extra 30 pts on this project by doing the following.

(15 pts) Write a report to carefully describe the algorithms you implemented and analyze their worst-case time complexities. In particular, you need to state why you are choosing the data structures in terms of improving worst-case time complexities. Why are the data structures you used are better than other options?

(15 pts) Implement another variant of the max-flow algorithm, where the augmenting path is the widest path in the residual graph. Compare the two algorithms with randomly generated test cases, and compare the performance, in terms of (1) the number of augmenting paths needed, and (2) the running time.

**Please note that you have to typeset your report using either LATEX or Microsoft Word. Hand-written report will not be graded. You need to submit a single electronic file at the digital drop box. You should name your file using the format CSE450-P-LastName-FirstName or CSE598-P-LastName-FirstName.**