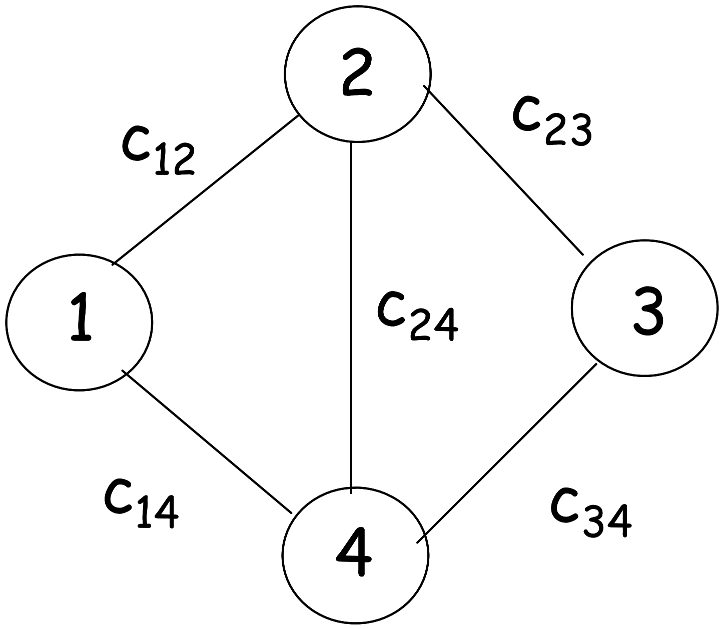
Homework 3 (Due Dec. 19, turn in at class time – 12:40 pm - and in hardcopies)

1. (80 %) We have the following network



With 4 nodes 1,2,3, and 4, and 5 links (1,2),(2,3),(2,4),(1,4), and (3,4). Let $C = (c_{ij})$ denote the capacity matrix:

$$C = \begin{bmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 1 & 2 \\ 0 & 1 & 0 & 1 \\ 1 & 2 & 1 & 0 \end{bmatrix}$$

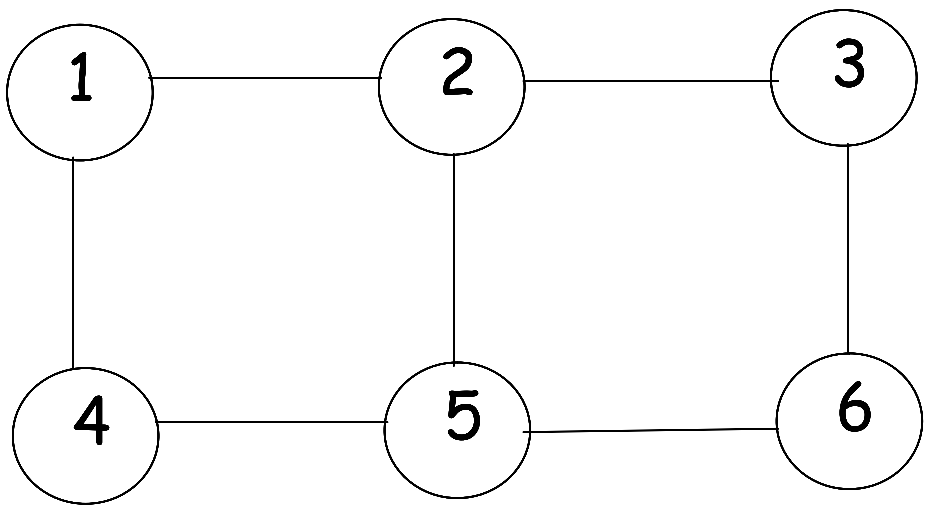
Let $T = (T_{ij})$ denote the demand matrix:

$$T = \begin{bmatrix} 0 & 1/2 & 1/2 & 1/2 \\ 1/2 & 0 & 1/2 & 1/4 \\ 1/4 & 1/2 & 0 & 1/2 \\ 1/2 & 1/2 & 3/4 & 0 \end{bmatrix}$$

The goal is to map the traffic to network links so as to minimize the maximum of the loads (denoted by α) on each link where load on a link is defined as the ratio of carried traffic to the capacity of the link.

a) Find the load on each link with pure IP routing with all link costs set to 1 without equal cost multipath (no even splitting when path costs are equal)
b) Repeat part a) with even splitting in the case of equal cost paths
c) Use trial and error or enumeration to find the link costs in such a way that α is minimized. Also write down the load on each link with your best possible link weight selection.
d) All above methods use pure IP destination-based routing. Now assume MPLS explicit routing in place and use the off-line formulation to find the optimal mapping (MPLS and traffic engineering viewgraphs, page 54). Hint. Use linprog of MATLAB or any other lp solver that you can find. Provide your lp code for this part of the problem as well.

2. (Bonus 20 %) Repeat 1. for the following network



where all the demands are one, all the links having symmetrical capacities, but the five links above (1,2),(2,3),(1,4),(2,5), and (3,6) to have 2 times more capacity than the other 2 links (4,5) and (5,6) which have a capacity of one.