IEMS 313
Spring 2016
Project Phase II
Due Wednesday, June 1, before midnight.

NOTE: All project files MUST be submitted electronically. Please combine all submitted files into a single zip (or similar) file.

This project must be done in the same groups from Phase I. You should not discuss your work with students outside your project group. However, you may do whatever research you feel necessary to understand and approach the problem. This includes any online resources as well as course materials, instructor and TA.

After you developed a heuristic for finding network structures and shipping plans in Phase I, the goal of this phase is to develop a Mathematical Programming model to compute a truly *optimal* network structure and shipping plan.

Your tasks:

1. Formulate a Mixed-Integer Linear Programming (MILP) model that finds the optimal network structure as it is defined in Phase I. There are several formulations for this problem, and you might want to try more than one. But only include the one that you decided to be the best.
2. Write a data-independent AMPL model for your formulation.
   As a starting point, download the AMPL files from Canvas provided for Phase II. This includes the beginning of the model file ("`network_design.mod`") in which the parameters are already declared. You will need to add variables declarations, (more parameters if you find that helpful), as well as the objective and constraints. The provided data file ("`network_design_small.dat`") corresponds to example in Phase I. It has the data for the base case; you will have to add the data for the different scenarios (write separate data files for the different scenarios). You can use the AMPL script "`network_design.run`" to run your model. The runfile sets a few CPLEX options, please use those. In particular, try to understand the CPLEX output.
   If you find that your formulation is too large for AMPL to handle, you need to look for an alternative.
3. Solve the three scenarios from Phase I for the small network.
4. Solve Scenarios 4-5 for the large network.

You need only submit one project report per group. Your project submission should consist of the following items:

1. A project report with
   a. a precise mathematical statement of your MILP model (i.e., parameter definitions, variable definitions, objective, constraints; be VERY careful with the indexing). This should be written in mathematical language, as you would find it in your text book, **not in AMPL code**.
   b. a detailed discussion of your model: What is the role of the different variables, the objective function, and the individual constraints? Why are they required, what is their interpretation?
   c. if you research formulations, cite your sources.
   d. the optimal network structure and shipment plan for the five scenarios from Phase I. Report the optimal solutions and compare them with the solutions that you obtained with your heuristic in Phase I. Make sure you present the result in the same table format as in Phase I (just listing values of variable will receive no credit). Include the optimal object value, and compare with the heuristic solutions you obtained in Phase I.
   e. For all your runs, report the time that CPLEX needs to solve the MILP, and the number of branch-and-bound iterations. Discuss what you observe.

2. All AMPL files (give them meaningful names):
   a. your model and data files
   b. one **single** AMPL script to run the model to produce **all** optimal solutions in your report. An AMPL script that does not run on my compute and produces all your answers will not receive much credit.
   c. a log file with the output from your entire AMPL script.

You will be graded based on the correctness and quality of your formulation, on the clarity of your description, and on the depth of your analysis and reflection.