Tutorial #4: Decision Aid Methodology
8th May, 2012

The purpose of this tutorial is to familiarize you with GLPK, a free and open source software used for solving large scale linear programming, mixed programming and other related problems. To get started, please visit the link: http://gnuwin32.sourceforge.net/packages/glpk.htm and download the software.

GLPK is a library of functions written in ANSI C, but includes a standard LP and IP solver, glpsol, built from these routines and a modeling language, GMPL (or GNU MathProg). This tutorial covers using glpsol to solve simple MIPs. Please note that you will need to use a command prompt to run glpsol on your model file, since GPLK does not provide a graphical user interface. The command prompt should indicate the current directory. You can do this by copying the model file and the data file for the given problem to the same folder that contains glpsol.exe (or vice versa) and then use the command prompt, to get to the directory that contains these files.

To run the program in the command prompt, issue the following command:

glpsol --model model_filename.txt –data data_filename.txt –output output_filename.txt

Here, model_filename.txt is the input GNU MathProg file containing the model.

The file data_filename.txt is the input file containing the input data for the problem.

The file output_filename.txt is the output file containing the results generated after running the model.

For more help regarding the various options for glpsol, issue the command

glpsol --help

Now please read through the sample question below, for a better understanding of the formulation and implemention of an LP/IP using glpsol.

Question 1: Network Flow Problem

You are the supply chain expert of a garment manufacturing company in USA. The company has 5 demand regions to cater to, all with different demands. Each region has to be served through a warehouse facility. The links connecting the warehouse facilities to the demand regions have fixed operating capacities and if operated, must be used to capacity. The company has warehouses at 3 different locations: New York (NY), Los Angeles (LA) and Dallax (TX), each warehouse with a different storage capacity.

The data for the problem is given as below:

Distance matrix

	New York	**Los Angeles**	**Dallas**
Demand Region A	10	7	7
Demand Region B	5	8	5
Demand Region C	7	6	8
Demand Region D	4	8	5
Demand Region E	8	3	7

Link Capacities

	New York	**Los Angeles**	**Dallas**
Demand Region A	4	6	4
Demand Region B	5	8	3
Demand Region C	7	5	5
Demand Region D	6	1	5
Demand Region E	8	7	15

Warehouse Storage Capacities

Warehouse	**Capacity**
New York	30
Los Angeles	20
Dallas	15

Demands

Region	**Demand**
A	10
B	8
C	12
D	6
E	15

- The problem is to determine which links should the company operate, such that the total travel distance is minimized.

  The complete model file (Network_Flow_Model.txt) and data file (Network_Flow_Data.txt) for this problem have been provided to you. Go through the files carefully and try to see if you understand the formulation.

Try running the files using glpsol solver by issuing the following command in the command prompt:

glpsol --model Network_Flow_Model.txt –data Network_Flow_Data.txt –output Network_Flow_Output.txt

- Now try to insert an extra constraint in the model for the case when each demand region must be served by at least two warehouse facilities and try to see how the optimal solution changes.

Question 2: Knapsack Problem

Antonin has just finished his final semester at EPFL and is visiting home in Athens, Greece. He wishes to buy several small presents for his friends in Greece who he will be seeing after a really long time. Each present has a fixed purchase cost and a certain dimensionless value attached to it. Antonin has a budget of 1200 CHF to spend on these gifts.

He visits a sports store in Lausanne Flon and has several options to choose from. The sports items, the corresponding prices and the values attached to each item are as given in the table below:

Item	Cost (CHF)	Value
Ski Gears	400	12
Hiking Shoes	200	8
Basketball	150	9
Snow Jacket	450	10
Hockey Stick	300	10
Baseball bat	300	12
Gloves	100	6

Now use glpsol solver to answer the following questions:

- Which items should Antonin purchase in order to maximize the total value of all purchased items such that his spending budget is respected ?

- How will the optimal solution change if Antonin wishes to buy only a present each for his 4 best friends Mike, Ed, Thomas and Justin ?

Note: The model file (Knapsack_Model.txt) and data file (Knapsack_Data.txt) have been provided to you. To answer the above questions, go through the files carefully and try to complete the missing lines of code in the file “Knapsack_Model.txt” based on your understanding of the formulation and description of variables provided.

Question 3: Sensitivity Analysis

You have 5 food items to choose from. Being a highly health conscious individual you want minimize the calorie intake, while satisfying the necessary vitamin requirements for healthy life. The data is as given below:

Food Item	1	2	3	4	5
Calories	40	26	30	47	35
Vitamin A	11	9	9	17	12
Vitamin B	8	15	18	12	19
Vitamin C	12	7	8	8	16

Food	Minimum Requirement
Vitamin A	800
Vitamin B	800
Vitamin C	600

Use MATHPROG to answer the following:

a. Determine the combination of food items that must be consumed in order to minimize the calorie intake while meeting the vitamin intake requirements. The model file (Sensitivity_Analysis_Model.txt) and data file (Sensitivity_Analysis_Data.txt) have been provided to you.

b. Find all the dual variable and reduced cost values .

c. If the calorie content of each unit of food item 1 is reduced from 40 to 20, would this affect your optimal diet? Explain why or why not.

d. How would the optimal solution change if the Vitamin C content of food item 3 is increased from 8 to 12 units? Explain the result.

Note: This tutorial is designed and prepared by Nitish Umang for the "Decision Aid Methodology" course for Spring 2012 session.