Applications of Linear Programming

1 The Diet Problem

Find the cheapest combination of foods that will satisfy all your nutritional requirements.

- Can be accessed interactively from the NEOS Server at: `http://www-neos.mcs.anl.gov/CaseStudies/dietpy/WebForms/`
- For the results of an experiment with this, see the next sheet.
- Practical considerations — what about taste, variety?

2 Portfolio Optimization

Minimize the risk in your investment portfolio subject to achieving a certain return. Can also be accessed from the NEOS Server:

`http://www.mcs.anl.gov/otc/Guide/CaseStudies/port`

Many investment companies are now using optimization and linear programming extensively to decide how to allocate assets. The increase in the speed of computers has enabled the solution of far larger problems, taking some of the guesswork out of the allocation of assets.

http://www-fp.mcs.anl.gov/otc/Guide/CaseStudies/diet/

Your Input

You selected 19 foods to consider for your diet.

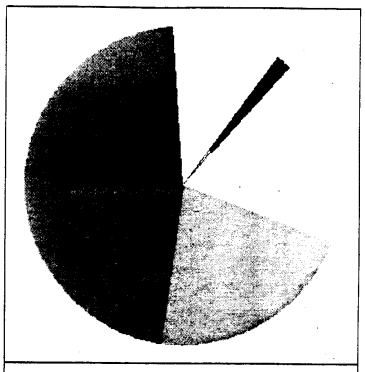
The Optimized Menu

The cost of this *optimal* diet is $2.03 per day.

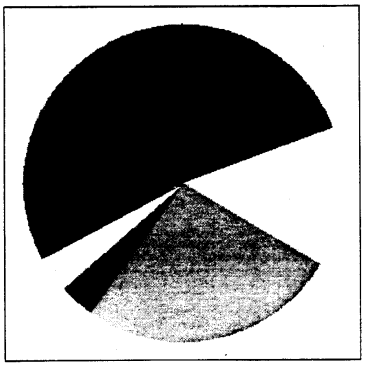
The Solution and Cost Breakdown by Food

Food	Servings	Cost ($)
White Bread	3.81	0.23
Cheddar Cheese	1.51	0.38
Chocolate Chip Cookies	6.78	0.20
Scrambled Eggs	1.01	0.11
Lettuce,Iceberg,Raw	10.00	0.20
Potatoes, Baked	3.23	0.19
Skim Milk	1.64	0.21
Spaghetti W/ Sauce	0.64	0.50

What foods contribute to nutrient 'Total_Fat'



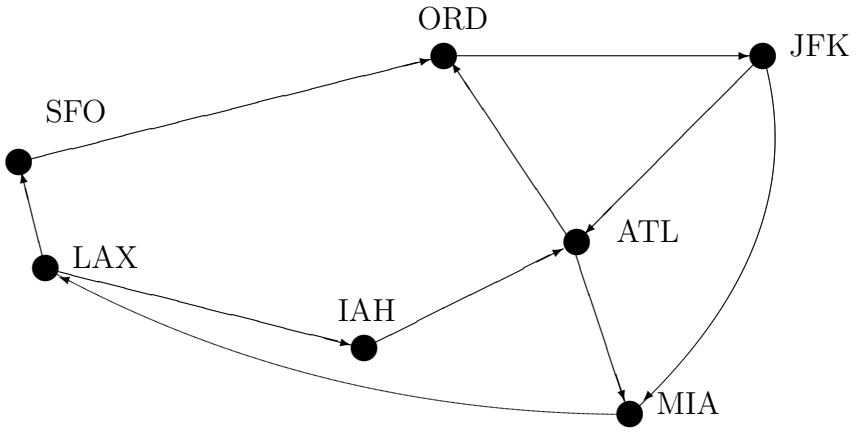
White Bread	3.81 g
Cheddar Cheese	14.08 g
Chocolate Chip Cookies	30.51 g
Scrambled Eggs	7.39 g
Lettuce,Iceberg,Raw	0.00 g
Potatoes, Baked	0.65 g
Skim Milk	0.66 g
Spaghetti W/ Sauce	7.91 g
Total	65.00 g



What foods contribute to nutrient 'Calcium'

White Bread	99.81 mg
Cheddar Cheese	385.88 mg
Chocolate Chip Cookies	42.03 mg
Scrambled Eggs	43.10 mg
Lettuce,Iceberg,Raw	38.00 mg
Potatoes, Baked	73.40 mg
Skim Milk	496.09 mg
Spaghetti W/ Sauce	51.59 mg
Total	1150.71 mg

3 Crew scheduling



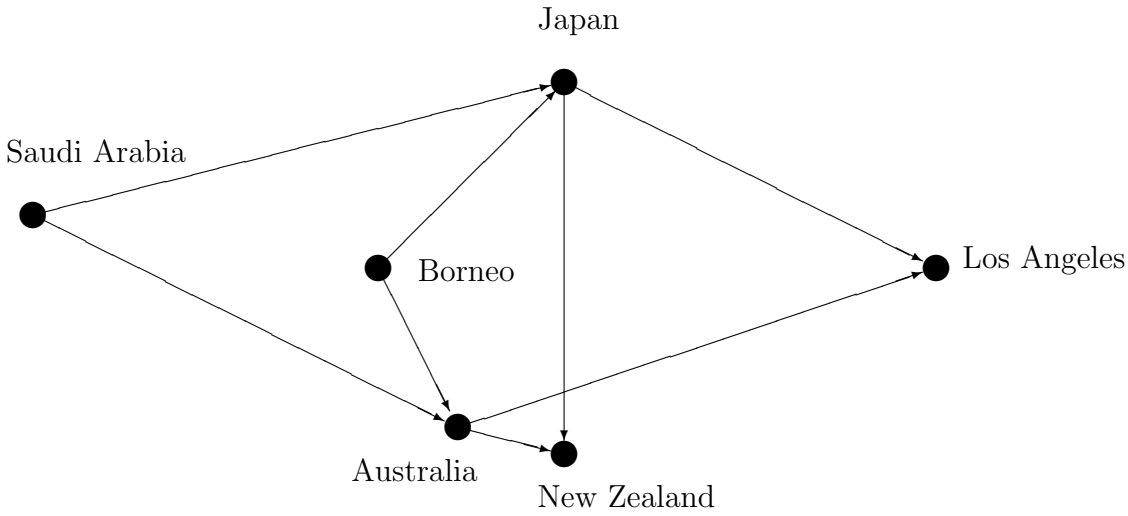
An airline has to assign crews to its flights.

- Make sure that each flight is covered.
- Meet regulations, eg, each pilot can only fly a certain amount each day.
- Minimize costs, eg: accommodation for crews staying overnight out of town, crews deadheading.
- Would like a *robust* schedule.

The airlines run on small profit margins, so saving a few percent through good scheduling can make an enormous difference in terms of profitability.

They also use linear programming for *yield management*.

4 Manufacturing and transportation



For example, an **oil company** has oil fields in Saudi Arabia and Borneo, refineries in Japan and Australia, and customers in the US and New Zealand.

The fields produce different qualities of oil, which is **refined** and combined into different grades of gasoline. What raw oil should be **shipped** to which refinery? How much of each type of gasoline should each refinery produce?

5 Telecommunications

Call routing: Many telephone calls from New York to Los Angeles, from Houston to Atlanta, etc. How should these calls be routed through the telephone network?

Network design: If we need to build extra capacity, which links should we concentrate on? Should we build new switching stations?

Internet traffic: For example, there was a great deal of construction of new networks for carrying internet traffic a few years ago.

6 Traveling Salesman Problem

Given a set of cities, find the shortest route that visits each city exactly once and returns to the home city.

Applications include:

- **Vehicle routing** — eg, how do we route school buses to pick up children, how do Federal Express and UPS assign packages to trucks?
- **VLSI chip** board manufacturing: holes need to be drilled on the board. How do we route the drill to visit all these holes so it takes the shortest possible route?

Website:

`http://www.tsp.gatech.edu/`

Largest problem solved to date has more than 24000 cities.

All 13509 cities in the continental USA with populations at least 500 in 1998, solved by Cook et al: