RIGA TECHNICAL UNIVERSITY

FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

INSTITUTE OF APPLIED COMPUTER SYSTEMS

Introduction to Operations Research
Assignment 5
Writing an OPL Program Using CPLEX

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➢ Question 1 – Transportation Problem

In this transportation problem, there is a company that produces vegetables. This company operates three production sites and four warehouses across the USA.

The main goal of this transportation problem is to reduce shipping costs between the production sites and the warehouses.

The costs for a delivery truckload, based on the production site and warehouse, are shown in the table below. We can also see each production site's output and each warehouse's allocation.

	Warehouse				
Cannery	*Sacramento*	*Salt Lake*	*Rapid City*	*Albuquerque*	***Supply***
Bellingham	$464	$513	$654	$867	*75*
Eugene	$352	$416	$690	$791	*125*
Albert Lea	$995	$682	$388	$685	*100*
Demand	*80*	*65*	*70*	*85*	

In addition, we can see that the overall allocation across all warehouses and all outputs from production locations are 300 truckloads.

➢ Answer 1 – Transportation Problem

- Let's write an OPL program for this Transportation Problem!

1. Decision Variables

x_{11}: from Bellingham to Sacramento	x_{21}: from Eugene to Sacramento	x_{31}: from Albert Lea to Sacramento
x_{12}: from Bellingham to Salt Lake	x_{22}: from Eugene to Salt Lake	x_{32}: from Albert Lea to Salt Lake
x_{13}: from Bellingham to Rapid City	x_{23}: from Eugene to Rapid City	x_{33}: from Albert Lea to Rapid City
x_{14}: from Bellingham to Albuquerque	x_{24}: from Eugene to Albuquerque	x_{34}: from Albert Lea to Albuquerque

2. Constraints

Supply	Demand
$x_{11} + x_{12} + x_{13} + x_{14} = 75$	$x_{11} + x_{21} + x_{31} = 80$
$x_{21} + x_{22} + x_{23} + x_{24} = 125$	$x_{12} + x_{22} + x_{32} = 65$
$x_{31} + x_{32} + x_{33} + x_{34} = 100$	$x_{13} + x_{23} + x_{33} = 70$
	$x_{14} + x_{24} + x_{34} = 85$

3. Objective Function

Minimize:

$$Z = 464x_{11} + 513x_{12} + 654x_{13} + 867x_{14} + 352x_{21} + 416x_{22} + 690x_{23} + 791x_{24} + 995x_{31} + 682x_{32} + 388x_{33} + 685x_{34}$$

4. OPL Program

➢ Code

```
/*********************************************
 * OPL 22.1.1.0 Model
 * Author: Emir
 * Creation Date: 23 Mar 2023 at 17:01:01
 *********************************************/

dvar int+ x11;
dvar int+ x12;
dvar int+ x13;
dvar int+ x14;
dvar int+ x21;
dvar int+ x22;
dvar int+ x23;
dvar int+ x24;
dvar int+ x31;
dvar int+ x32;
dvar int+ x33;
dvar int+ x34;

minimize
    464 * x11 + 513 * x12 + 654 * x13 + 867 * x14 + 352 * x21 + 416 * x22 + 690 * x23 + 791 * x24 + 995 * x31 + 682 * x32 + 388 * x33 + 685 * x34;

subject to {
    x11 + x12 + x13 + x14 == 75;
    x21 + x22 + x23 + x24 == 125;
    x31 + x32 + x33 + x34 == 100;
    x11 + x21 + x31 == 80;
    x12 + x22 + x32 == 65;
    x13 + x23 + x33 == 70;
    x14 + x24 + x34 == 85;
}
```

➢ Result

Solution with objective 152,535

Name	Value
Decision variables (12)	
x11	0
x12	20
x13	0
x14	55
x21	80
x22	45
x23	0
x24	0
x31	0
x32	0
x33	70
x34	30

✓ To minimize the shipping costs, the company should carry

- 20 truckloads from Bellingham to the Sacramento Warehouse. (x_{12})
- 55 truckloads from Bellingham to the Albuquerque Warehouse. (x_{14})
- 80 truckloads from Eugene to the Sacramento Warehouse. (x_{21})
- 45 truckloads Eugene to the Salt Lake Warehouse. (x_{22})
- 70 truckloads from Albert Lea to the Rapid City Warehouse. (x_{33})
- 30 truckloads from Albert Lea to the Albuquerque Warehouse. (x_{34})

✓ The minimum total cost would be 152,535 $.

➢ Question 2 – Assignment Problem

In this Assignment Problem, we can see that we have three salespersons and three destinations. The cost of a plane ticket varies depending on who is purchasing it and where they are going. The table below contains all information.

From / To	Denver	Edmonton	Fargo
Austin	250	400	350
Boston	400	600	350
Chicago	200	400	250

The aim is to minimize the cost of plane tickets by assigning a salesperson to each destination.

➢ Answer 2 – Assignment Problem

- Let's write an OPL program for this Assignment Problem!

1. Decision Variables

x_{11}: from Austin to Denver (250)	x_{12}: from Austin to Edmonton (400)	x_{13}: from Austin to Fargo (350)
x_{21}: from Boston to Denver (400)	x_{22}: from Boston to Edmonton (600)	x_{23}: from Boston to Fargo (350)
x_{31}: from Chicago to Denver (200)	x_{32}: from Chicago to Edmonton (400)	x_{33}: from Chicago to Fargo (250)

2. Constraints

Current Location	Destination
$x_{11} + x_{12} + x_{13} = 1$ (There is only one salesperson in Austin.)	$x_{11} + x_{21} + x_{31} = 1$ (There is only one salesperson travelling to Denver.)
$x_{21} + x_{22} + x_{23} = 1$ (There is only one salesperson in Boston.)	$x_{12} + x_{22} + x_{32} = 1$ (There is only one salesperson travelling to Edmonton.)
$x_{31} + x_{32} + x_{33} = 1$ (There is only one salesperson in Chicago.)	$x_{13} + x_{23} + x_{33} = 1$ (There is only one salesperson travelling to Fargo.)

3. Objective Function

Minimize:

$$Z = 200x_{11} + 400x_{12} + 350x_{13} + 400x_{21} + 600x_{22} + 350x_{23} + 200x_{31} + 400x_{32} + 250x_{33}$$

4. OPL Program

➢ Code

```
/*********************************************
 * OPL 22.1.1.0 Model
 * Author: Emir
 * Creation Date: 23 Mar 2023 at 18:02:11
 *********************************************/

dvar int+ x11;
dvar int+ x12;
dvar int+ x13;
dvar int+ x21;
dvar int+ x22;
dvar int+ x23;
dvar int+ x31;
dvar int+ x32;
dvar int+ x33;

minimize
    250 * x11 + 400 * x12 + 350 * x13 + 400 * x21 + 600 * x22 + 350 * x23 + 200 * x31 + 400 * x32 + 250 * x33;

subject to {
    x11 + x12 + x13 == 1;
    x21 + x22 + x23 == 1;
    x31 + x32 + x33 == 1;
    x11 + x21 + x31 == 1;
    x12 + x22 + x32 == 1;
    x13 + x23 + x33 == 1;
}
```

➢ Result

Solution with objective 950

Name	Value
Decision variables (9)	
x11	0
x12	1
x13	0
x21	0
x22	0
x23	1
x31	1
x32	0
x33	0

✓ To minimize the ticket costs, the sales manager should send
- the salesperson in Austin to Edmonton (x_{12})
- the salesperson in Boston to Fargo. (x_{23})
- the salesperson in Chicago to Denver. (x_{31})

✓ The minimum total cost would be 950$.