

COSC364

Assignment 2



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**Percentage Contribution**

Kate 50

Shan 50

**Problem Formulation and Explanation**

The objective of the assignment is to find a minimum capacity that is load balance. To do this we introduce and auxiliary variable to represent the value of our objective. The demand volume, , of all path between a source node and a destination node for all is stated as = + as shown in equation (1) and (7). There is a global requirement that each demand volume shall be split equally over exactly 3 different paths hence we use a binary variable where if the path - - is used to carry the flow then the value of else . We use this variable to determine that the sum of all flow from source to destination for all transit node are split into 3 different paths as in equation (2) while equation (3) ensures that the splits are done equally. It also indicates the minimum capacity needed for the link. Next, equation (4) and equation (5) defines the constraint that the sum of all flows using the path - for all destination is less than or equal to the link capacity, and the sum of all flows using the path - for all destination is less than or equal to the link capacity, respectively. After ensuring that the load is balance, we find the minimum capacities by finding the sum of capacities going through node for all source node as in equation (6). Equation (8) defines as a binary variable while Equation (9) – (12) describes that the decisions variables are of non-negative values.

|  |  |  |  |
| --- | --- | --- | --- |
| **Minimize [x, r]** |  |  |  |
| **Subject to** |  |  | ……….. (1) |
|  |  |  | ……….. (2) |
|  |  |  | ……….. (3) |
|  |  |  | ……….. (4) |
|  |  |  | ……….. (5) |
|  |  |  | ……….. (6) |
|  |  |  | ……….. (7) |
|  |  |  | ……….. (8) |
|  |  |  | ……….. (9) |
|  |  |  | ….….. (10) |
|  |  |  | ….….. (11) |
|  |  |  | .…….. (12) |

**CPLEX execution time, numbers of non-zero capacity links and the highest capacity link for varying Y**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| # of Transit Nodes | 3 | 4 | 5 | 6 | 7 |
| r | 130.666667 | 98 | 78.666667 | 65.333333 | 56 |
| Load 1  Load 2  Load 3  Load 4  Load 5  Load 6  Load 7 | 130.666667  130.666667  130.666667  -  -  -  - | 98  98  98  98  -  -  - | 78  78.666667  78.666667  78.666667  78  -  - | 65.333333  65.333333  65.333333  65.333333  65.333333  65.333333  - | 56  56  56  56  56  56  56 |
| CPLEX execution time | 0.0285 | 0.0529 | 0.0634 | 0.1202 | 0.1634 |
| # of non-zero capacity links | 42 | 56 | 69 | 82 | 94 |
| Highest capacity link | 25.666667 | 23.333333 | 21.666667 | 23 | 19 |

**Appendix I – Source Code**

**Appendix II – LP file generated for (X = 3, Y = 2, Z = 4)**

Minimize

r

Subject to

r1: yS1T1 + yS2T1 + yS3T1 - r <= 0

r2: yS1T2 + yS2T2 + yS3T2 - r <= 0

load1: xS1T1D1 + xS1T1D2 + xS1T1D3 + xS1T1D4 + xS2T1D1 + xS2T1D2 + xS2T1D3 + xS2T1D4 + xS3T1D1 + xS3T1D2 + xS3T1D3 + xS3T1D4 - lT1 = 0

load2: xS1T2D1 + xS1T2D2 + xS1T2D3 + xS1T2D4 + xS2T2D1 + xS2T2D2 + xS2T2D3 + xS2T2D4 + xS3T2D1 + xS3T2D2 + xS3T2D3 + xS3T2D4 - lT2 = 0

hS1D1: xS1T1D1 + xS1T2D1 = 2

hS1D2: xS1T1D2 + xS1T2D2 = 3

hS1D3: xS1T1D3 + xS1T2D3 = 4

hS1D4: xS1T1D4 + xS1T2D4 = 5

hS2D1: xS2T1D1 + xS2T2D1 = 3

hS2D2: xS2T1D2 + xS2T2D2 = 4

hS2D3: xS2T1D3 + xS2T2D3 = 5

hS2D4: xS2T1D4 + xS2T2D4 = 6

hS3D1: xS3T1D1 + xS3T2D1 = 4

hS3D2: xS3T1D2 + xS3T2D2 = 5

hS3D3: xS3T1D3 + xS3T2D3 = 6

hS3D4: xS3T1D4 + xS3T2D4 = 7

dfS1T1D1: 3 xS1T1D1 - 2 uS1T1D1 = 0

dfS1T2D1: 3 xS1T2D1 - 2 uS1T2D1 = 0

dfS1T1D2: 3 xS1T1D2 - 3 uS1T1D2 = 0

dfS1T2D2: 3 xS1T2D2 - 3 uS1T2D2 = 0

dfS1T1D3: 3 xS1T1D3 - 4 uS1T1D3 = 0

dfS1T2D3: 3 xS1T2D3 - 4 uS1T2D3 = 0

dfS1T1D4: 3 xS1T1D4 - 5 uS1T1D4 = 0

dfS1T2D4: 3 xS1T2D4 - 5 uS1T2D4 = 0

dfS2T1D1: 3 xS2T1D1 - 3 uS2T1D1 = 0

dfS2T2D1: 3 xS2T2D1 - 3 uS2T2D1 = 0

dfS2T1D2: 3 xS2T1D2 - 4 uS2T1D2 = 0

dfS2T2D2: 3 xS2T2D2 - 4 uS2T2D2 = 0

dfS2T1D3: 3 xS2T1D3 - 5 uS2T1D3 = 0

dfS2T2D3: 3 xS2T2D3 - 5 uS2T2D3 = 0

dfS2T1D4: 3 xS2T1D4 - 6 uS2T1D4 = 0

dfS2T2D4: 3 xS2T2D4 - 6 uS2T2D4 = 0

dfS3T1D1: 3 xS3T1D1 - 4 uS3T1D1 = 0

dfS3T2D1: 3 xS3T2D1 - 4 uS3T2D1 = 0

dfS3T1D2: 3 xS3T1D2 - 5 uS3T1D2 = 0

dfS3T2D2: 3 xS3T2D2 - 5 uS3T2D2 = 0

dfS3T1D3: 3 xS3T1D3 - 6 uS3T1D3 = 0

dfS3T2D3: 3 xS3T2D3 - 6 uS3T2D3 = 0

dfS3T1D4: 3 xS3T1D4 - 7 uS3T1D4 = 0

dfS3T2D4: 3 xS3T2D4 - 7 uS3T2D4 = 0

cS1T1: xS1T1D1 + xS1T1D2 + xS1T1D3 + xS1T1D4 - yS1T1 = 0

cS1T2: xS1T2D1 + xS1T2D2 + xS1T2D3 + xS1T2D4 - yS1T2 = 0

cS2T1: xS2T1D1 + xS2T1D2 + xS2T1D3 + xS2T1D4 - yS2T1 = 0

cS2T2: xS2T2D1 + xS2T2D2 + xS2T2D3 + xS2T2D4 - yS2T2 = 0

cS3T1: xS3T1D1 + xS3T1D2 + xS3T1D3 + xS3T1D4 - yS3T1 = 0

cS3T2: xS3T2D1 + xS3T2D2 + xS3T2D3 + xS3T2D4 - yS3T2 = 0

dT1D1: xS1T1D1 + xS2T1D1 + xS3T1D1 - yT1D1 = 0

dT2D1: xS1T2D1 + xS2T2D1 + xS3T2D1 - yT2D1 = 0

dT1D2: xS1T1D2 + xS2T1D2 + xS3T1D2 - yT1D2 = 0

dT2D2: xS1T2D2 + xS2T2D2 + xS3T2D2 - yT2D2 = 0

dT1D3: xS1T1D3 + xS2T1D3 + xS3T1D3 - yT1D3 = 0

dT2D3: xS1T2D3 + xS2T2D3 + xS3T2D3 - yT2D3 = 0

dT1D4: xS1T1D4 + xS2T1D4 + xS3T1D4 - yT1D4 = 0

dT2D4: xS1T2D4 + xS2T2D4 + xS3T2D4 - yT2D4 = 0

uS1D1: uS1T1D1 + uS1T2D1 = 3

uS1D2: uS1T1D2 + uS1T2D2 = 3

uS1D3: uS1T1D3 + uS1T2D3 = 3

uS1D4: uS1T1D4 + uS1T2D4 = 3

uS2D1: uS2T1D1 + uS2T2D1 = 3

uS2D2: uS2T1D2 + uS2T2D2 = 3

uS2D3: uS2T1D3 + uS2T2D3 = 3

uS2D4: uS2T1D4 + uS2T2D4 = 3

uS3D1: uS3T1D1 + uS3T2D1 = 3

uS3D2: uS3T1D2 + uS3T2D2 = 3

uS3D3: uS3T1D3 + uS3T2D3 = 3

uS3D4: uS3T1D4 + uS3T2D4 = 3

Bounds

xS1T1D1 >= 0

xS1T2D1 >= 0

xS1T1D2 >= 0

xS1T2D2 >= 0

xS1T1D3 >= 0

xS1T2D3 >= 0

xS1T1D4 >= 0

xS1T2D4 >= 0

xS2T1D1 >= 0

xS2T2D1 >= 0

xS2T1D2 >= 0

xS2T2D2 >= 0

xS2T1D3 >= 0

xS2T2D3 >= 0

xS2T1D4 >= 0

xS2T2D4 >= 0

xS3T1D1 >= 0

xS3T2D1 >= 0

xS3T1D2 >= 0

xS3T2D2 >= 0

xS3T1D3 >= 0

xS3T2D3 >= 0

xS3T1D4 >= 0

xS3T2D4 >= 0

yS1T1 >= 0

yS1T2 >= 0

yS2T1 >= 0

yS2T2 >= 0

yS3T1 >= 0

yS3T2 >= 0

yT1D1 >= 0

yT2D1 >= 0

yT1D2 >= 0

yT2D2 >= 0

yT1D3 >= 0

yT2D3 >= 0

yT1D4 >= 0

yT2D4 >= 0

r >= 0

Binaries

uS1T1D1

uS1T2D1

uS1T1D2

uS1T2D2

uS1T1D3

uS1T2D3

uS1T1D4

uS1T2D4

uS2T1D1

uS2T2D1

uS2T1D2

uS2T2D2

uS2T1D3

uS2T2D3

uS2T1D4

uS2T2D4

uS3T1D1

uS3T2D1

uS3T1D2

uS3T2D2

uS3T1D3

uS3T2D3

uS3T1D4

uS3T2D4

End