```
"E:\1 □□□□\3 □□□□□\1 □□□□□□\1 □□□□□□□□\1_□□□□□□_□□□□\1_LW _□□□□\4 □□□□\3 python_code\1 exzample\2 □□□□□□\9 Code for this paper\Scripts\python.exe" "D:\Python\Pycharm\setroute\PyCharm Community Edition 2021.2.3\plugins\python-ce\helpers\pydev\pydevconsole.py" --mode=client --port=59029

import sys; print('Python %s on %s' % (sys.version, sys.platform))
sys.path.extend(['E:\\1 □□□□\\3 □□□□□\\1 □□□□□□\\1 □□□□□□□□\\1_□□□□□□_□□□□\\1_LW _□□□□\\4 □□□□\\3 python_code\\9 Code for this paper', 'E:/1 □□□□/3 □□□□□/1 □□□□□□/1 □□□□□□□□/1_□□□□□□_□□□□/1_LW _□□□□/4 □□□□/3 python_code/9 Code for this paper'])

PyDev console: starting.

Python 3.9.7 (tags/v3.9.7:1016ef3, Aug 30 2021, 20:19:38) [MSC v.1929 64 bit (AMD64)] on win32
>>> runfile('E:/1 □□□□/3 □□□□□/1 □□□□□□/1 □□□□□□□□/1_□□□□□□_□□□□/1_LW _□□□□/4 □□□□/3 python_code/9 Code for this paper/main_RO_BDC.py', wdir='E:/1 □□□□/3 □□□□□/1 □□□□□□/1 □□□□□□□□/1_□□□□□□_□□□□/1_LW _□□□□/4 □□□□/3 python_code/9 Code for this paper')
Backend TkAgg is interactive backend. Turning interactive mode on.
Waiting 5s.....
Set parameter MIPGap to value 1e-10
Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)

CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
Thread count: 4 physical cores, 8 logical processors, using up to 8 threads

Optimize a model with 394700 rows, 34789 columns and 1080704 nonzeros
Model fingerprint: 0x7c692d28
Variable types: 1 continuous, 34788 integer (34764 binary)
Coefficient statistics:
  Matrix range     [1e+00, 1e+10]
  Objective range  [1e+00, 2e+01]
  Bounds range     [1e+00, 1e+00]
  RHS range        [1e+00, 2e+10]
Warning: Model contains large matrix coefficients
Warning: Model contains large rhs
         Consider reformulating model or setting NumericFocus parameter
         to avoid numerical issues.
Presolve removed 303964 rows and 24242 columns (presolve time = 5s) ...
Presolve removed 358306 rows and 24242 columns
Presolve time: 5.73s
Presolved: 36394 rows, 10547 columns, 140686 nonzeros
Variable types: 0 continuous, 10547 integer (10533 binary)

Deterministic concurrent LP optimizer: primal and dual simplex (primal and dual model)
Showing first log only...

Root relaxation presolved: 36392 rows, 10549 columns, 140680 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0    6.3100000e+02   4.900000e+01   1.057647e+08      6s
Concurrent spin time: 0.00s

Solved with dual simplex (primal model)

Root relaxation: objective 6.310000e+02, 1663 iterations, 0.16 seconds (0.18 work units)

    Nodes    |    Current Node    |     Objective Bounds      |     Work
 Expl Unexpl |  Obj  Depth IntInf | Incumbent    BestBd   Gap | It/Node Time

     0     0  631.00000    0   11          -  631.00000      -     -    6s
     0     0  631.00000    0   56          -  631.00000      -     -    6s
H    0     0                4591.0000000  631.00000  86.3%     -    7s
H    0     0                3271.0000000  631.00000  80.7%     -    7s
     0     0  631.00000    0   56 3271.00000  631.00000  80.7%     -    7s
H    0     0                 631.0000000  631.00000  0.00%     -    8s
     0     0  631.00000    0   42  631.00000  631.00000  0.00%     -    8s

Cutting planes:
  Learned: 4
  Gomory: 5
  Cover: 74
  Implied bound: 1932
  Clique: 14
  MIR: 8
  StrongCG: 5
  GUB cover: 1
  Zero half: 2
  RLT: 6
  Relax-and-lift: 3

Explored 1 nodes (10873 simplex iterations) in 8.64 seconds (13.82 work units)
Thread count was 8 (of 8 available processors)

Solution count 3: 631 3271 4591
```

```
 80
 81  Optimal solution found (tolerance 1.00e-10)
 82  Best objective 6.310000000000e+02, best bound 6.310000000000e+02, gap 0.0000%
 83  Set parameter MIPGap to value 1e-08
 84  Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
 85
 86  CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
 87  Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
 88
 89  Optimize a model with 1153962 rows, 901813 columns and 7830224 nonzeros
 90  Model fingerprint: 0x0e22e6de
 91  Variable types: 441325 continuous, 460488 integer (456438 binary)
 92  Coefficient statistics:
 93    Matrix range     [1e-01, 1e+10]
 94    Objective range  [6e-05, 5e+01]
 95    Bounds range     [1e+00, 8e+01]
 96    RHS range        [8e-01, 1e+10]
 97  Warning: Model contains large matrix coefficients
 98  Warning: Model contains large rhs
 99          Consider reformulating model or setting NumericFocus parameter
100          to avoid numerical issues.
101  Presolve removed 1152599 rows and 901329 columns
102  Presolve time: 2.62s
103  Presolved: 1363 rows, 484 columns, 3603 nonzeros
104  Variable types: 0 continuous, 484 integer (286 binary)
105  Found heuristic solution: objective 3832.5977589
106  Found heuristic solution: objective 3993.5977589
107
108  Root relaxation: objective 4.432598e+03, 410 iterations, 0.00 seconds (0.00 work units)
109
110      Nodes    |    Current Node    |     Objective Bounds      |     Work
111   Expl Unexpl |  Obj  Depth IntInf | Incumbent    BestBd   Gap | It/Node Time
112
113  H    0     0                    4432.5977589 6792.59776  53.2%     -    3s
114       0     0          -    0     4432.59776 4432.59776  0.00%     -    3s
115
116  Explored 1 nodes (539 simplex iterations) in 3.33 seconds (3.61 work units)
117  Thread count was 8 (of 8 available processors)
118
119  Solution count 3: 4432.6 3993.6 3832.6
120
121  Optimal solution found (tolerance 1.00e-08)
122  Best objective 4.432597758931e+03, best bound 4.432597758931e+03, gap 0.0000%
123  SP is solved
124  SP's optimal solution is'□4432
125
126    Itr = 0
127  Collect_LB =   [631.0]
128  Collect_UB =   [9496.19551786163]
129  Collect_Hua =   [0.0]
130  Collect_SPObjVal =   [4432.597758930815]
131  Collect_MPObjValNHua =   [631.0]
132
133
134  Set parameter TimeLimit to value 12000
135  Set parameter MIPGap to value 0.0005
136  Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
137
138  CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
139  Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
140
141  Optimize a model with 397646 rows, 137605 columns and 1083677 nonzeros
142  Model fingerprint: 0x0cbe152a
143  Variable types: 1 continuous, 137604 integer (137580 binary)
144  Coefficient statistics:
145    Matrix range     [1e+00, 1e+10]
146    Objective range  [1e+00, 2e+01]
147    Bounds range     [1e+00, 1e+00]
148    RHS range        [1e+00, 2e+10]
149  Warning: Model contains large matrix coefficients
150  Warning: Model contains large rhs
151          Consider reformulating model or setting NumericFocus parameter
152          to avoid numerical issues.
153  Presolve removed 269986 rows and 121919 columns (presolve time = 5s) ...
154  Presolve removed 355756 rows and 130625 columns
155  Presolve time: 6.35s
156  Presolved: 41890 rows, 6980 columns, 107458 nonzeros
157  Variable types: 0 continuous, 6980 integer (6966 binary)
158  Root relaxation presolved: 6980 rows, 48870 columns, 114438 nonzeros
159
160
161  Root simplex log...
162
163  Iteration    Objective       Primal Inf.    Dual Inf.      Time
```

```
     0      handle free variables                      7s
  4813   5.0785978e+03   0.000000e+00   0.000000e+00      7s
  4813   5.0785978e+03   0.000000e+00   0.000000e+00      7s

Root relaxation: objective 5.078598e+03, 4813 iterations, 0.42 seconds (0.86 work units)

    Nodes    |    Current Node    |     Objective Bounds      |     Work
 Expl Unexpl |  Obj  Depth IntInf | Incumbent    BestBd   Gap | It/Node Time

     0     0 5078.59776    0  15          - 5078.59776      -     -    7s
     0     0 5078.59776    0 127          - 5078.59776      -     -    8s
     0     0 5078.59776    0 124          - 5078.59776      -     -    8s
     0     0 5078.59776    0 143          - 5078.59776      -     -    8s
H    0     0                6398.5977589 5078.59776  20.6%     -    9s
H    0     0                6238.5977589 5078.59776  18.6%     -    9s
     0     0 5078.59776    0  31 6238.59776 5078.59776  18.6%     -    9s
     0     0 5078.59776    0  81 6238.59776 5078.59776  18.6%     -    9s
     0     0 5078.59776    0  55 6238.59776 5078.59776  18.6%     -   10s
     0     0 5078.59776    0 123 6238.59776 5078.59776  18.6%     -   10s
     0     0 5078.59776    0 104 6238.59776 5078.59776  18.6%     -   10s
     0     0 5078.59776    0  38 6238.59776 5078.59776  18.6%     -   11s
     0     0 5078.59776    0  28 6238.59776 5078.59776  18.6%     -   11s
     0     0 5078.59776    0  20 6238.59776 5078.59776  18.6%     -   11s
     0     0 5078.59776    0  53 6238.59776 5078.59776  18.6%     -   11s
     0     0 5078.59776    0  29 6238.59776 5078.59776  18.6%     -   12s
     0     0 5078.59776    0  16 6238.59776 5078.59776  18.6%     -   12s
H    0     0                5718.5977589 5078.59776  11.2%     -   12s
H    0     0                5078.5977589 5078.59776  0.00%     -   13s
     0     0 5078.59776    0  16 5078.59776 5078.59776  0.00%     -   13s

Cutting planes:
  Learned: 1
  Gomory: 2
  Cover: 133
  Implied bound: 77
  Clique: 238
  MIR: 46
  StrongCG: 28
  GUB cover: 4
  Zero half: 4
  RLT: 1
  Relax-and-lift: 30
  BQP: 5

Explored 1 nodes (36641 simplex iterations) in 13.58 seconds (21.05 work units)
Thread count was 8 (of 8 available processors)

Solution count 4: 5078.6 5718.6 6238.6 6398.6

Optimal solution found (tolerance 5.00e-04)
Best objective 5.078597758931e+03, best bound 5.078597758931e+03, gap 0.0000%
Set parameter MIPGap to value 1e-08
Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)

CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
Thread count: 4 physical cores, 8 logical processors, using up to 8 threads

Optimize a model with 1153962 rows, 901813 columns and 7830224 nonzeros
Model fingerprint: 0x3f74b822
Variable types: 441325 continuous, 460488 integer (456438 binary)
Coefficient statistics:
  Matrix range     [1e-01, 1e+10]
  Objective range  [6e-05, 5e+01]
  Bounds range     [1e+00, 8e+01]
  RHS range        [8e-01, 1e+10]
Warning: Model contains large matrix coefficients
Warning: Model contains large rhs
         Consider reformulating model or setting NumericFocus parameter
         to avoid numerical issues.
Presolve removed 1149556 rows and 900326 columns
Presolve time: 2.36s
Presolved: 4406 rows, 1487 columns, 11639 nonzeros
Variable types: 4 continuous, 1483 integer (866 binary)
Found heuristic solution: objective 3396.6666667
Found heuristic solution: objective 3488.6666667

Root relaxation: objective 4.946667e+03, 1255 iterations, 0.01 seconds (0.01 work units)

    Nodes    |    Current Node    |     Objective Bounds      |     Work
 Expl Unexpl |  Obj  Depth IntInf | Incumbent    BestBd   Gap | It/Node Time

H    0     0                4946.6666667 12856.0000   160%     -    3s
     0     0        -    0     4946.66667 4946.66667  0.00%     -    3s
```

```
Explored 1 nodes (1753 simplex iterations) in 3.11 seconds (3.18 work units)
Thread count was 8 (of 8 available processors)

Solution count 3: 4946.67 3488.67 3396.67

Optimal solution found (tolerance 1.00e-08)
Best objective 4.946666666667e+03, best bound 4.946666666667e+03, gap 0.0000%
SP is solved
SP's optimal solution is'□4946

 Itr = 1
Collect_LB =   [631.0, 5078.597758930815]
Collect_UB =   [9496.19551786163, 5592.666666666666]
Collect_Hua =   [0.0, 4432.597758930815]
Collect_SPObjVal =   [4432.597758930815, 4946.666666666666]
Collect_MPObjValNHua =   [631.0, 646.0]


Set parameter TimeLimit to value 12000
Set parameter MIPGap to value 0.0005
Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)

CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
Thread count: 4 physical cores, 8 logical processors, using up to 8 threads

Optimize a model with 397647 rows, 137605 columns and 1083690 nonzeros
Model fingerprint: 0xa968cd14
Variable types: 1 continuous, 137604 integer (137580 binary)
Coefficient statistics:
  Matrix range     [1e+00, 1e+10]
  Objective range  [1e+00, 2e+01]
  Bounds range     [1e+00, 1e+00]
  RHS range        [1e+00, 2e+10]
Warning: Model contains large matrix coefficients
Warning: Model contains large rhs
         Consider reformulating model or setting NumericFocus parameter
         to avoid numerical issues.
Presolve removed 270384 rows and 121964 columns (presolve time = 5s) ...
Presolve removed 355751 rows and 130623 columns
Presolve time: 6.38s
Presolved: 41896 rows, 6982 columns, 107478 nonzeros
Variable types: 0 continuous, 6982 integer (6968 binary)
Root relaxation presolved: 6982 rows, 48878 columns, 114460 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0     handle free variables                       7s
    4705    5.5776667e+03   0.000000e+00   0.000000e+00      7s
    4705    5.5776667e+03   0.000000e+00   0.000000e+00      7s

Root relaxation: objective 5.577667e+03, 4705 iterations, 0.40 seconds (0.77 work units)

    Nodes    |    Current Node    |     Objective Bounds      |     Work
 Expl Unexpl |  Obj  Depth IntInf | Incumbent    BestBd   Gap | It/Node Time

     0     0 5577.66667    0   14          - 5577.66667      -     -    7s
H    0     0                7777.6666667 5577.66667  28.3%     -    7s
     0     0 5577.66667    0   92 7777.66667 5577.66667  28.3%     -    7s
     0     0 5577.66667    0   92 7777.66667 5577.66667  28.3%     -    8s
     0     0 5577.66667    0   90 7777.66667 5577.66667  28.3%     -    8s
H    0     0                7737.6666667 5577.66667  27.9%     -    9s
     0     0 5577.66667    0   51 7737.66667 5577.66667  27.9%     -    9s
     0     0 5577.66667    0   49 7737.66667 5577.66667  27.9%     -    9s
H    0     0                6377.6666667 5577.66667  12.5%     -    9s
H    0     0                6217.6666667 5577.66667  10.3%     -    9s
H    0     0                5817.6666667 5577.66667  4.13%     -    9s
     0     0 5577.66667    0  124 5817.66667 5577.66667  4.13%     -    9s
     0     0 5577.66667    0  120 5817.66667 5577.66667  4.13%     -    9s
     0     0 5577.66667    0  172 5817.66667 5577.66667  4.13%     -   10s
     0     0 5577.66667    0   12 5817.66667 5577.66667  4.13%     -   10s
H    0     0                5577.6666667 5577.66667  0.00%     -   11s
     0     0 5577.66667    0  137 5577.66667 5577.66667  0.00%     -   11s

Cutting planes:
  Learned: 4
  Gomory: 2
  Cover: 5
  Implied bound: 690
  Clique: 12
  MIR: 7
  StrongCG: 5
  GUB cover: 6
```

```
  RLT: 2
  Relax-and-lift: 5

Explored 1 nodes (26603 simplex iterations) in 11.25 seconds (17.25 work units)
Thread count was 8 (of 8 available processors)

Solution count 6: 5577.67 5817.67 6217.67 ... 7777.67

Optimal solution found (tolerance 5.00e-04)
Best objective 5.577666666667e+03, best bound 5.577666666667e+03, gap 0.0000%
Set parameter MIPGap to value 1e-08
Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)

CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
Thread count: 4 physical cores, 8 logical processors, using up to 8 threads

Optimize a model with 1153962 rows, 901813 columns and 7830224 nonzeros
Model fingerprint: 0x8b251de0
Variable types: 441325 continuous, 460488 integer (456438 binary)
Coefficient statistics:
  Matrix range     [1e-01, 1e+10]
  Objective range  [6e-05, 5e+01]
  Bounds range     [1e+00, 8e+01]
  RHS range        [8e-01, 1e+10]
Warning: Model contains large matrix coefficients
Warning: Model contains large rhs
         Consider reformulating model or setting NumericFocus parameter
         to avoid numerical issues.
Presolve removed 1152614 rows and 901355 columns
Presolve time: 2.41s
Presolved: 1348 rows, 458 columns, 3597 nonzeros
Variable types: 0 continuous, 458 integer (263 binary)
Found heuristic solution: objective 4408.6666667
Found heuristic solution: objective 4502.6666667

Root relaxation: objective 4.872667e+03, 322 iterations, 0.00 seconds (0.00 work units)

    Nodes    |    Current Node    |     Objective Bounds      |     Work
 Expl Unexpl |  Obj  Depth IntInf | Incumbent    BestBd   Gap | It/Node Time

H    0     0                    4872.6666667 7850.66667  61.1%     -    3s
     0     0        -    0      4872.66667 4872.66667  0.00%     -    3s

Explored 1 nodes (421 simplex iterations) in 3.13 seconds (3.42 work units)
Thread count was 8 (of 8 available processors)

Solution count 3: 4872.67 4502.67 4408.67

Optimal solution found (tolerance 1.00e-08)
Best objective 4.872666666667e+03, best bound 4.872666666667e+03, gap 0.0000%
SP is solved
SP's optimal solution is'□4872

 Itr = 2
Collect_LB =   [631.0, 5078.597758930815, 5577.666666666666]
Collect_UB =   [9496.19551786163, 5592.666666666666, 5503.666666666666]
Collect_Hua =   [0.0, 4432.597758930815, 4946.666666666666]
Collect_SPObjVal =   [4432.597758930815, 4946.666666666666, 4872.666666666666]
Collect_MPObjValNHua =   [631.0, 646.0, 631.0]


 Ops, stop iteration
 Values adopted from the Itr-1' th iteration, and Itr = {2}, judgeCount = {1}

~~~~~~~~~~judgeCount = 1, SPObj_SPF = 4946.666666666666
Vessel i: 0:     pi: 0-5,     ai-di: 2-11,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 2-11,     taoi-deltai: 2-11,     taoPi_SP-deltaPi_SP: 2-11,     betaNi: 9,     bi: 9
Vessel i: 1:     pi: 14-20,     ai-di: 7-27,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 7-27,     taoi-deltai: 7-27,     taoPi_SP-deltaPi_SP: 7-27,     betaNi: 20,     bi: 20
Vessel i: 2:     pi: 7-14,     ai-di: 2-15,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 2-15,     taoi-deltai: 2-15,     taoPi_SP-deltaPi_SP: 2-15,     betaNi: 13,     bi: 13
Vessel i: 3:     pi: 7-11,     ai-di: 22-50,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 22-50,     taoi-deltai: 22-50,     taoPi_SP-deltaPi_SP: 23-50,     betaNi: 28,     bi: 28
Vessel i: 4:     pi: 20-25,     ai-di: 23-62,     gi_SP-gpi_SP: 0.200000-1.000000,     ai_SP-di: 24-62,     taoi-deltai: 26-45,     taoPi_SP-deltaPi_SP: 26-45,     betaNi: 19,     bi: 19
Vessel i: 5:     pi: 14-20,     ai-di: 30-70,     gi_SP-gpi_SP: 1.000000-0.200000,     ai_SP-di: 38-70,     taoi-deltai: 36-64,     taoPi_SP-deltaPi_SP: 38-64,     betaNi: 28,     bi: 28

round LB =   [631, 5079, 5578]
round UB =   [9496, 5593, 5504]
round Hua =   [0, 4433, 4947]
round SPObjVal =   [4433, 4947, 4873]
round MPObjValNHua =   [631, 646, 631]

```

```
410   OptimalObj = 5577.666666666666
411   Time: 256.000000
412
413
414
415
```