```
"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=16143

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_TWS.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 455904 rows, 40692 columns and 1255082 nonzeros
Model fingerprint: 0x0544b721
Variable types: 1 continuous, 40691 integer (40663 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 302987 rows and 21615 columns (presolve time = 5s) ...
Presolve removed 405682 rows and 29722 columns
Presolve time: 6.58s
Presolved: 50222 rows, 10970 columns, 163928 nonzeros
Variable types: 0 continuous, 10970 integer (10949 binary)

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

Root relaxation presolved: 50219 rows, 10973 columns, 163919 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0    5.3800000e+02   6.831250e+01   1.510929e+08      7s
Concurrent spin time: 0.01s

Solved with dual simplex (primal model)

Root relaxation: objective 5.380000e+02, 1854 iterations, 0.26 seconds (0.20 work units)

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

     0     0  538.00000    0    9          -  538.00000      -     -    7s
H    0     0                1098.0000000  538.00000  51.0%     -    7s
H    0     0                1058.0000000  538.00000  49.1%     -    8s
H    0     0                 818.0000000  538.00000  34.2%     -    8s
H    0     0                 618.0000000  538.00000  12.9%     -    8s
H    0     0                 538.0000000  538.00000  0.00%     -    8s
     0     0  538.00000    0   42  538.00000  538.00000  0.00%     -    8s

Cutting planes:
  Gomory: 3
  Cover: 72
  Implied bound: 2
  Clique: 2
  MIR: 4
  StrongCG: 7
  GUB cover: 1
  Zero half: 1
  RLT: 2
  Relax-and-lift: 5

Explored 1 nodes (8791 simplex iterations) in 8.46 seconds (13.23 work units)
Thread count was 8 (of 8 available processors)

Solution count 5: 538 618 818 ... 1098

```

```
Optimal solution found (tolerance 1.00e-10)
Best objective 5.380000000000e+02, best bound 5.380000000000e+02, 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 335541 rows, 11221 columns and 691168 nonzeros
Model fingerprint: 0xd9af1d3a
Variable types: 28 continuous, 11193 integer (6468 binary)
Coefficient statistics:
  Matrix range     [1e-01, 1e+10]
  Objective range  [6e-05, 5e+01]
  Bounds range     [1e+00, 1e+00]
  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 334584 rows and 10872 columns
Presolve time: 0.48s
Presolved: 957 rows, 349 columns, 2567 nonzeros
Variable types: 0 continuous, 349 integer (203 binary)
Found heuristic solution: objective 3293.6923132
Found heuristic solution: objective 3403.6923132

Root relaxation: objective 3.755692e+03, 245 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                    3755.6923132 5535.69231  47.4%     -    0s
     0     0         -    0     3755.69231 3755.69231  0.00%     -    0s

Explored 1 nodes (328 simplex iterations) in 0.57 seconds (0.57 work units)
Thread count was 8 (of 8 available processors)

Solution count 3: 3755.69 3403.69 3293.69

Optimal solution found (tolerance 1.00e-08)
Best objective 3.755692313203e+03, best bound 3.755692313203e+03, gap 0.0000%
SP is solved
SP's optimal solution is'□3755

 Itr = 0
Collect_LB =   [538.0]
Collect_UB =   [8049.384626406991]
Collect_Hua =   [0.0]
Collect_SPObjVal =   [3755.6923132034954]
Collect_MPObjValNHua =   [538.0]


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 459706 rows, 180636 columns and 1258905 nonzeros
Model fingerprint: 0x687d9101
Variable types: 1 continuous, 180635 integer (180607 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 341195 rows and 166583 columns (presolve time = 5s) ...
Presolve removed 420684 rows and 174163 columns
Presolve time: 6.34s
Presolved: 39022 rows, 6473 columns, 100972 nonzeros
Variable types: 0 continuous, 6473 integer (6452 binary)
Root relaxation presolved: 6473 rows, 45495 columns, 107445 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0     handle free variables                          7s
    4432    4.2961923e+03   0.000000e+00   0.000000e+00      7s
```

```
     4432    4.2961923e+03   0.000000e+00   0.000000e+00      7s

Root relaxation: objective 4.296192e+03, 4432 iterations, 0.49 seconds (0.78 work units)

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

     0     0 4296.19231    0   16          - 4296.19231      -     -    7s
H    0     0                4436.1923132 4296.19231  3.16%     -    7s
     0     0 4296.19231    0   25 4436.19231 4296.19231  3.16%     -    7s
     0     0 4296.19231    0   40 4436.19231 4296.19231  3.16%     -    7s
     0     0 4296.19231    0   29 4436.19231 4296.19231  3.16%     -    7s
H    0     0                4416.1923132 4296.19231  2.72%     -    8s
     0     0 4296.19231    0   83 4416.19231 4296.19231  2.72%     -    8s
     0     0 4296.19231    0    5 4416.19231 4296.19231  2.72%     -    9s
H    0     0                4396.1923132 4296.19231  2.27%     -    9s
H    0     0                4316.1923132 4296.19231  0.46%     -    9s
     0     0 4296.19231    0   68 4316.19231 4296.19231  0.46%     -    9s
     0     0 4296.19231    0   17 4316.19231 4296.19231  0.46%     -    9s
     0     0 4296.19231    0   29 4316.19231 4296.19231  0.46%     -    9s
H    0     0                4296.1923132 4296.19231  0.00%     -    9s

Cutting planes:
  Learned: 1
  Gomory: 17
  Cover: 87
  Implied bound: 4
  Clique: 15
  MIR: 57
  StrongCG: 38
  GUB cover: 2
  Zero half: 5
  RLT: 6
  Relax-and-lift: 9

Explored 1 nodes (12871 simplex iterations) in 9.50 seconds (14.56 work units)
Thread count was 8 (of 8 available processors)

Solution count 5: 4296.19 4316.19 4396.19 ... 4436.19

Optimal solution found (tolerance 1.00e-10)
Best objective 4.296192313203e+03, best bound 4.296192313203e+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 335541 rows, 11221 columns and 691168 nonzeros
Model fingerprint: 0x434545db
Variable types: 28 continuous, 11193 integer (6468 binary)
Coefficient statistics:
  Matrix range     [1e-01, 1e+10]
  Objective range  [6e-05, 5e+01]
  Bounds range     [1e+00, 1e+00]
  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 334304 rows and 10788 columns
Presolve time: 0.45s
Presolved: 1237 rows, 433 columns, 3330 nonzeros
Variable types: 0 continuous, 433 integer (254 binary)
Found heuristic solution: objective 3569.2222222

Root relaxation: objective 4.125222e+03, 249 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

*    0     0               0    4125.2222222 4125.22222  0.00%     -    0s

Explored 1 nodes (249 simplex iterations) in 0.54 seconds (0.59 work units)
Thread count was 8 (of 8 available processors)

Solution count 2: 4125.22 3569.22

Optimal solution found (tolerance 1.00e-08)
Best objective 4.125222222222e+03, best bound 4.125222222222e+03, gap 0.0000%
SP is solved
SP's optimal solution is'□4125

 Itr = 1
```

```
Collect_LB =   [538.0, 4296.192313203495]
Collect_UB =   [8049.384626406991, 4665.722222222223]
Collect_Hua =   [0.0, 3755.6923132034954]
Collect_SPObjVal =   [3755.6923132034954, 4125.222222222223]
Collect_MPObjValNHua =   [538.0, 540.5]


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 459706 rows, 180636 columns and 1258905 nonzeros
Model fingerprint: 0x47fc47a8
Variable types: 1 continuous, 180635 integer (180607 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 341858 rows and 166624 columns (presolve time = 5s) ...
Presolve removed 421054 rows and 174215 columns
Presolve time: 6.26s
Presolved: 38652 rows, 6421 columns, 100028 nonzeros
Variable types: 0 continuous, 6421 integer (6400 binary)
Root relaxation presolved: 6421 rows, 45073 columns, 106449 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0      handle free variables                      7s
    4859    4.6657222e+03   0.000000e+00   0.000000e+00      7s
    4859    4.6657222e+03   0.000000e+00   0.000000e+00      7s

Root relaxation: objective 4.665722e+03, 4859 iterations, 0.48 seconds (0.90 work units)

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

     0     0 4665.72222    0   10          - 4665.72222      -     -    7s
     0     0 4665.72222    0   27          - 4665.72222      -     -    8s
     0     0 4665.72222    0   48          - 4665.72222      -     -    8s
H    0     0                5145.7222222 4665.72222  9.33%     -    8s
     0     0 4665.72222    0   47 5145.72222 4665.72222  9.33%     -    8s
     0     0 4665.72222    0   47 5145.72222 4665.72222  9.33%     -    8s
     0     0 4665.72222    0   47 5145.72222 4665.72222  9.33%     -    8s
H    0     0                4905.7222222 4665.72222  4.89%     -    9s
     0     0 4665.72222    0   18 4905.72222 4665.72222  4.89%     -    9s
     0     0 4665.72222    0   19 4905.72222 4665.72222  4.89%     -    9s
     0     0 4665.72222    0   19 4905.72222 4665.72222  4.89%     -    9s
     0     0 4665.72222    0   28 4905.72222 4665.72222  4.89%     -    9s
     0     0 4665.72222    0  103 4905.72222 4665.72222  4.89%     -    9s
     0     0 4665.72222    0    9 4905.72222 4665.72222  4.89%     -   10s
     0     0 4665.72222    0   66 4905.72222 4665.72222  4.89%     -   11s
     0     0 4665.72222    0  178 4905.72222 4665.72222  4.89%     -   11s
H    0     0                4665.7222222 4665.72222  0.00%     -   11s
     0     0 4665.72222    0    6 4665.72222 4665.72222  0.00%     -   11s

Cutting planes:
  Learned: 3
  Gomory: 54
  Cover: 237
  Implied bound: 19
  Clique: 101
  MIR: 84
  StrongCG: 60
  GUB cover: 6
  Zero half: 16
  RLT: 1
  Relax-and-lift: 48

Explored 1 nodes (27017 simplex iterations) in 11.59 seconds (17.14 work units)
Thread count was 8 (of 8 available processors)

Solution count 3: 4665.72 4905.72 5145.72

Optimal solution found (tolerance 1.00e-10)
Best objective 4.665722222222e+03, best bound 4.665722222222e+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 335541 rows, 11221 columns and 691168 nonzeros
Model fingerprint: 0xb105b898
Variable types: 28 continuous, 11193 integer (6468 binary)
Coefficient statistics:
  Matrix range     [1e-01, 1e+10]
  Objective range  [6e-05, 5e+01]
  Bounds range     [1e+00, 1e+00]
  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 332391 rows and 10098 columns
Presolve time: 0.23s
Presolved: 3150 rows, 1123 columns, 8375 nonzeros
Variable types: 6 continuous, 1117 integer (656 binary)
Found heuristic solution: objective 2847.8034243

Root relaxation: objective 4.145222e+03, 935 iterations, 0.00 seconds (0.01 work units)

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

     0     0 4145.22222    0   76 2847.80342 4145.22222  45.6%     -    0s
H    0     0                3572.5812021 4145.22222  16.0%     -    0s
H    0     0                3604.2478688 4145.22222  15.0%     -    0s
     0     0 4140.09911    0   45 3604.24787 4140.09911  14.9%     -    0s
H    0     0                4135.6923132 4140.09911  0.11%     -    0s
     0     0    cutoff    0      4135.69231 4135.69231  0.00%     -    0s

Cutting planes:
  Learned: 2
  Gomory: 2
  Cover: 10
  Clique: 25
  MIR: 1
  Zero half: 4

Explored 1 nodes (1463 simplex iterations) in 0.38 seconds (0.49 work units)
Thread count was 8 (of 8 available processors)

Solution count 4: 4135.69 3604.25 3572.58 2847.8

Optimal solution found (tolerance 1.00e-08)
Best objective 4.135692313203e+03, best bound 4.135692313203e+03, gap 0.0000%
SP is solved
SP's optimal solution is'□4135

 Itr = 2
Collect_LB =   [538.0, 4296.192313203495, 4665.722222222223]
Collect_UB =   [8049.384626406991, 4665.722222222223, 4665.722222222223]
Collect_Hua =   [0.0, 3755.6923132034954, 4125.222222222223]
Collect_SPObjVal =   [3755.6923132034954, 4125.222222222223, 4135.6923132034935]
Collect_MPObjValNHua =   [538.0, 540.5, 540.5]


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

~~~~~~~~~~judgeCount = 1, SPObj_SPF = 4125.222222222223
Vessel i: 0:     pi: 0-5,     ai-di: 2-10,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 2-10,     taoi-deltai: 2-8,     taoPi_SP-deltaPi_SP: 2-8,     betaNi: 6,     bi
: 6
Vessel i: 1:     pi: 5-12,     ai-di: 1-25,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 1-25,     taoi-deltai: 1-23,     taoPi_SP-deltaPi_SP: 1-23,     betaNi: 22
,     bi: 22
Vessel i: 2:     pi: 15-20,     ai-di: 3-10,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 3-10,     taoi-deltai: 3-8,     taoPi_SP-deltaPi_SP: 3-8,     betaNi: 5,
bi: 5
Vessel i: 3:     pi: 24-29,     ai-di: 22-40,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 22-40,     taoi-deltai: 22-38,     taoPi_SP-deltaPi_SP: 22-38,
betaNi: 16,     bi: 16
Vessel i: 4:     pi: 19-24,     ai-di: 20-45,     gi_SP-gpi_SP: 0.375000-0.025000,     ai_SP-di: 21-45,     taoi-deltai: 24-33,     taoPi_SP-deltaPi_SP: 24-33,
betaNi: 9,     bi: 9
Vessel i: 5:     pi: 12-19,     ai-di: 28-68,     gi_SP-gpi_SP: 0.625000-0.975000,     ai_SP-di: 33-68,     taoi-deltai: 33-55,     taoPi_SP-deltaPi_SP: 33-55,
betaNi: 22,     bi: 22
Vessel i: 6:     pi: 21-26,     ai-di: 35-65,     gi_SP-gpi_SP: 0.800000-0.800000,     ai_SP-di: 43-65,     taoi-deltai: 39-49,     taoPi_SP-deltaPi_SP: 43-49,
betaNi: 10,     bi: 10

round LB =   [538, 4296, 4666]
round UB =   [8049, 4666, 4666]
round Hua =   [0, 3756, 4125]
```

```
round SPObjVal =   [3756, 4125, 4136]
round MPObjValNHua =   [538, 540, 540]

OptimalObj = 4665.722222222223
Time: 83.000000
```