```
"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=8836

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 602799 rows, 52642 columns and 1675285 nonzeros
Model fingerprint: 0xc5c8e864
Variable types: 1 continuous, 52641 integer (52605 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 381477 rows and 26559 columns (presolve time = 5s) ...
Presolve removed 526889 rows and 37081 columns
Presolve time: 8.85s
Presolved: 75910 rows, 15561 columns, 248987 nonzeros
Variable types: 0 continuous, 15561 integer (15534 binary)

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

Root relaxation presolved: 15561 rows, 91471 columns, 264548 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0    8.4600000e+02   0.000000e+00   1.036000e+03      9s
Concurrent spin time: 0.00s

Solved with dual simplex (primal model)

Root relaxation: objective 8.460000e+02, 2529 iterations, 0.47 seconds (0.40 work units)
Total elapsed time = 10.15s

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

     0     0  846.00000    0   19          -  846.00000      -     -   10s
H    0     0                3806.0000000  846.00000  77.8%     -   10s
     0     0  846.00000    0  174 3806.00000  846.00000  77.8%     -   11s
     0     0  846.00000    0  168 3806.00000  846.00000  77.8%     -   11s
H    0     0                1786.0000000  846.00000  52.6%     -   11s
H    0     0                1206.0000000  846.00000  29.9%     -   11s
     0     0  846.00000    0  154 1206.00000  846.00000  29.9%     -   11s
     0     0  846.00000    0  153 1206.00000  846.00000  29.9%     -   12s
     0     0  846.00000    0   11 1206.00000  846.00000  29.9%     -   13s
     0     0  846.00000    0   20 1206.00000  846.00000  29.9%     -   13s
     0     0  846.00000    0   82 1206.00000  846.00000  29.9%     -   13s
     0     0  846.00000    0   16 1206.00000  846.00000  29.9%     -   15s
     0     0  846.00000    0   19 1206.00000  846.00000  29.9%     -   15s
     0     0  846.00000    0   20 1206.00000  846.00000  29.9%     -   16s
     0     0  846.00000    0   20 1206.00000  846.00000  29.9%     -   17s
     0     2  846.00000    0   20 1206.00000  846.00000  29.9%     -   20s
H   30    32                1106.0000000  846.00000  23.5%   478   23s
    44    47  846.00000   10   25 1106.00000  846.00000  23.5%   531   25s
H   66    67                 846.0000000  846.00000  0.00%   618   27s

Cutting planes:
  Cover: 162
  Implied bound: 1841
  Clique: 7
```

```
  MIR: 41
  StrongCG: 24
  GUB cover: 5
  Zero half: 1
  RLT: 5
  Relax-and-lift: 644

Explored 80 nodes (70377 simplex iterations) in 27.15 seconds (47.23 work units)
Thread count was 8 (of 8 available processors)

Solution count 5: 846 1106 1206 ... 3806

Optimal solution found (tolerance 1.00e-10)
Best objective 8.460000000000e+02, best bound 8.460000000000e+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 536248 rows, 14427 columns and 1098671 nonzeros
Model fingerprint: 0x3404a901
Variable types: 36 continuous, 14391 integer (8316 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 533447 rows and 13375 columns
Presolve time: 0.41s
Presolved: 2801 rows, 1052 columns, 7492 nonzeros
Variable types: 5 continuous, 1047 integer (623 binary)
Found heuristic solution: objective 3368.0500186
Found heuristic solution: objective 3454.0500186

Root relaxation: objective 4.685050e+03, 802 iterations, 0.02 seconds (0.01 work units)

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

     0     0 4685.05002    0   27 3454.05002 4685.05002  35.6%     -    0s
H    0     0                4658.0500186 4685.05002  0.58%     -    0s
H    0     0                4678.0500186 4685.05002  0.15%     -    0s
*    0     0               0    4685.0500186 4685.05002  0.00%     -    0s

Cutting planes:
  Learned: 6
  Mod-K: 1

Explored 1 nodes (1211 simplex iterations) in 0.58 seconds (0.78 work units)
Thread count was 8 (of 8 available processors)

Solution count 5: 4685.05 4678.05 4658.05 ... 3368.05

Optimal solution found (tolerance 1.00e-08)
Best objective 4.685050018628e+03, best bound 4.685050018628e+03, gap 0.0000%
SP is solved
SP's optimal solution is'□4685

 Itr = 0
Collect_LB =   [846.0]
Collect_UB =   [10216.10003725563]
Collect_Hua =   [0.0]
Collect_SPObjVal =   [4685.050018627815]
Collect_MPObjValNHua =   [846.0]


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 609508 rows, 283978 columns and 1682030 nonzeros
Model fingerprint: 0xaf87501e
Variable types: 1 continuous, 283977 integer (283941 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 442590 rows and 265694 columns (presolve time = 5s) ...
Presolve removed 559145 rows and 275982 columns
Presolve time: 9.55s
Presolved: 50363 rows, 7996 columns, 128306 nonzeros
Variable types: 0 continuous, 7996 integer (7969 binary)
Root relaxation presolved: 7996 rows, 58359 columns, 136302 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0     handle free variables                         10s
    2054    4.3560835e+32   1.136138e+33   4.356084e+02     10s
    7699    5.5310500e+03   0.000000e+00   0.000000e+00     11s
    7699    5.5310500e+03   0.000000e+00   0.000000e+00     11s

Root relaxation: objective 5.531050e+03, 7699 iterations, 1.62 seconds (2.53 work units)

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

     0     0 5531.05002    0   11          - 5531.05002      -     -   11s
     0     0 5531.05002    0  224          - 5531.05002      -     -   13s
     0     0 5531.05002    0  152          - 5531.05002      -     -   13s
     0     0 5531.05002    0  152          - 5531.05002      -     -   13s
     0     0 5531.05002    0   31          - 5531.05002      -     -   15s
     0     0 5531.05002    0   57          - 5531.05002      -     -   15s
     0     0 5531.05002    0  111          - 5531.05002      -     -   17s
     0     0 5531.05002    0  141          - 5531.05002      -     -   17s
     0     0 5531.05002    0   15          - 5531.05002      -     -   20s
H    0     0                9531.0500186 5531.05002  42.0%     -   20s
     0     0 5531.05002    0   13 9531.05002 5531.05002  42.0%     -   20s
H    0     0                5531.0500186 5531.05002  0.00%     -   20s
     0     0 5531.05002    0   13 5531.05002 5531.05002  0.00%     -   20s

Cutting planes:
  Learned: 1
  Gomory: 2
  Cover: 132
  Implied bound: 36
  Clique: 1630
  MIR: 41
  StrongCG: 10
  GUB cover: 43
  RLT: 6
  Relax-and-lift: 8
  BQP: 9

Explored 1 nodes (45069 simplex iterations) in 20.80 seconds (28.31 work units)
Thread count was 8 (of 8 available processors)

Solution count 2: 5531.05 9531.05

Optimal solution found (tolerance 1.00e-10)
Best objective 5.531050018628e+03, best bound 5.531050018628e+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 536248 rows, 14427 columns and 1098671 nonzeros
Model fingerprint: 0x313d8092
Variable types: 36 continuous, 14391 integer (8316 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 531123 rows and 12728 columns
Presolve time: 0.41s
Presolved: 5125 rows, 1699 columns, 13666 nonzeros
Variable types: 8 continuous, 1691 integer (967 binary)
Found heuristic solution: objective 3516.0500186
Found heuristic solution: objective 3536.0500186
```

```
Root relaxation: objective 5.133193e+03, 1482 iterations, 0.02 seconds (0.02 work units)

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

H    0     0                    5133.1928758 15078.7410   194%     -    0s
     0     0        -    0      5133.19288 5133.19288  0.00%     -    0s

Explored 1 nodes (1865 simplex iterations) in 0.58 seconds (0.83 work units)
Thread count was 8 (of 8 available processors)

Solution count 3: 5133.19 3536.05 3516.05

Optimal solution found (tolerance 1.00e-08)
Best objective 5.133192875771e+03, best bound 5.133192875771e+03, gap 0.0000%
SP is solved
SP's optimal solution is'□5133

 Itr = 1
Collect_LB =   [846.0, 5531.050018627815]
Collect_UB =   [10216.10003725563, 5979.19287577067]
Collect_Hua =   [0.0, 4685.050018627815]
Collect_SPObjVal =   [4685.050018627815, 5133.19287577067]
Collect_MPObjValNHua =   [846.0, 846.0]


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 609508 rows, 283978 columns and 1682030 nonzeros
Model fingerprint: 0x49dbf7ef
Variable types: 1 continuous, 283977 integer (283941 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 446094 rows and 266092 columns (presolve time = 5s) ...
Presolve removed 560047 rows and 276105 columns
Presolve time: 8.87s
Presolved: 49461 rows, 7873 columns, 126056 nonzeros
Variable types: 0 continuous, 7873 integer (7846 binary)
Root relaxation presolved: 7873 rows, 57334 columns, 133929 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0      handle free variables                         9s
    5676    6.1136560e+03   5.545762e+02   0.000000e+00     10s
    7498    5.9970500e+03   0.000000e+00   0.000000e+00     10s
    7498    5.9970500e+03   0.000000e+00   0.000000e+00     10s

Root relaxation: objective 5.997050e+03, 7498 iterations, 1.32 seconds (2.26 work units)

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

     0     0 5997.05002    0   97          - 5997.05002      -     -   11s
     0     0 5997.05002    0  381          - 5997.05002      -     -   13s
     0     0 5997.05002    0  313          - 5997.05002      -     -   13s
     0     0 5997.05002    0  183          - 5997.05002      -     -   13s
     0     0 5997.05002    0  225          - 5997.05002      -     -   14s
     0     0 5997.05002    0  198          - 5997.05002      -     -   16s
     0     0 5997.05002    0  207          - 5997.05002      -     -   16s
     0     0 5997.05002    0  351          - 5997.05002      -     -   18s
     0     0 5997.05002    0  331          - 5997.05002      -     -   19s
     0     0 5997.05002    0   54          - 5997.05002      -     -   21s
     0     0 5997.05002    0  186          - 5997.05002      -     -   21s
     0     0 5997.05002    0   57          - 5997.05002      -     -   23s
     0     0 5997.05002    0   54          - 5997.05002      -     -   23s
H    0     0                10117.050019 5997.05002  40.7%     -   23s
     0     0 5997.05002    0   50 10117.0500 5997.05002  40.7%     -   24s
H    0     0                8157.0500186 5997.05002  26.5%     -   24s
H    0     0                5997.0500186 5997.05002  0.00%     -   26s
     0     0 5997.05002    0   50 5997.05002 5997.05002  0.00%     -   26s
```

```
332
333  Cutting planes:
334    Learned: 13
335    Gomory: 1
336    Cover: 170
337    Implied bound: 509
338    Clique: 1693
339    MIR: 108
340    StrongCG: 65
341    GUB cover: 61
342    RLT: 16
343    Relax-and-lift: 35
344    BQP: 6
345    PSD: 1
346
347  Explored 1 nodes (58296 simplex iterations) in 26.18 seconds (35.94 work units)
348  Thread count was 8 (of 8 available processors)
349
350  Solution count 3: 5997.05 8157.05 10117.1
351
352  Optimal solution found (tolerance 1.00e-10)
353  Best objective 5.997050018628e+03, best bound 5.997050018628e+03, gap 0.0000%
354  Set parameter MIPGap to value 1e-08
355  Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
356
357  CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
358  Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
359
360  Optimize a model with 536248 rows, 14427 columns and 1098671 nonzeros
361  Model fingerprint: 0x429b8f2b
362  Variable types: 36 continuous, 14391 integer (8316 binary)
363  Coefficient statistics:
364    Matrix range     [1e-01, 1e+10]
365    Objective range  [6e-05, 5e+01]
366    Bounds range     [1e+00, 1e+00]
367    RHS range        [8e-01, 1e+10]
368  Warning: Model contains large matrix coefficients
369  Warning: Model contains large rhs
370           Consider reformulating model or setting NumericFocus parameter
371           to avoid numerical issues.
372  Presolve removed 531230 rows and 12806 columns
373  Presolve time: 0.38s
374  Presolved: 5018 rows, 1621 columns, 13278 nonzeros
375  Variable types: 8 continuous, 1613 integer (931 binary)
376
377  Root relaxation: objective 5.079193e+03, 1378 iterations, 0.02 seconds (0.02 work units)
378
379      Nodes    |    Current Node    |     Objective Bounds      |     Work
380   Expl Unexpl |  Obj  Depth IntInf | Incumbent    BestBd   Gap | It/Node Time
381
382  H    0     0                    5079.1928758 14424.7410   184%     -    0s
383       0     0          -    0     5079.19288 5079.19288  0.00%     -    0s
384
385  Explored 1 nodes (1872 simplex iterations) in 0.54 seconds (0.81 work units)
386  Thread count was 8 (of 8 available processors)
387
388  Solution count 1: 5079.19
389
390  Optimal solution found (tolerance 1.00e-08)
391  Best objective 5.079192875771e+03, best bound 5.079192875771e+03, gap 0.0000%
392  SP is solved
393  SP's optimal solution is'□5079
394
395   Itr = 2
396  Collect_LB =   [846.0, 5531.050018627815, 5997.050018627813]
397  Collect_UB =   [10216.10003725563, 5979.19287577067, 5943.050018627813]
398  Collect_Hua =   [0.0, 4685.050018627815, 5133.19287577067]
399  Collect_SPObjVal =   [4685.050018627815, 5133.19287577067, 5079.19287577067]
400  Collect_MPObjValNHua =   [846.0, 846.0, 863.8571428571431]
401
402
403    Ops, stop iteration
404    Values adopted from the Itr' th iteration, and Itr = {2}, judgeCount = {2}
405
406  ~~~~~~~~~~judge = 2, SPObj  SPF = 5079.19287577067
407  Vessel i: 0:      pi: 0-7,      ai-di: 6-22,      gi_SP-gpi_SP: 0.000000-0.000000,      ai_SP-di: 6-22,      taoi-deltai: 6-21,      taoPi_SP-deltaPi_SP: 6-21,      betaNi: 15
       ,      bi: 15
408  Vessel i: 1:      pi: 0-7,      ai-di: 48-75,      gi_SP-gpi_SP: 0.000000-0.000000,      ai_SP-di: 48-75,      taoi-deltai: 48-74,      taoPi_SP-deltaPi_SP: 48-68,      betaNi:
       26,      bi: 26
409  Vessel i: 2:      pi: 14-21,      ai-di: 25-52,      gi_SP-gpi_SP: 0.000000-0.000000,      ai_SP-di: 25-52,      taoi-deltai: 25-51,      taoPi_SP-deltaPi_SP: 25-51,
       betaNi: 26,      bi: 26
410  Vessel i: 3:      pi: 14-19,      ai-di: 14-21,      gi_SP-gpi_SP: 0.000000-0.000000,      ai_SP-di: 14-21,      taoi-deltai: 14-20,      taoPi_SP-deltaPi_SP: 14-20,
       betaNi: 6,      bi: 6
411  Vessel i: 4:      pi: 7-14,      ai-di: 6-30,      gi_SP-gpi_SP: 0.000000-0.000000,      ai_SP-di: 6-30,      taoi-deltai: 6-29,      taoPi_SP-deltaPi_SP: 6-29,      betaNi: 23
```

```
,      bi: 23
Vessel i: 5:      pi: 7-14,      ai-di: 37-62,      gi_SP-gpi_SP: 0.371429-0.400000,      ai_SP-di: 38-62,      taoi-deltai: 42-55,      taoPi_SP-deltaPi_SP: 42-55,      betaNi: 13,      bi: 13
Vessel i: 6:      pi: 20-25,      ai-di: 2-21,      gi_SP-gpi_SP: 1.000000-0.000000,      ai_SP-di: 10-21,      taoi-deltai: 8-14,      taoPi_SP-deltaPi_SP: 10-14,      betaNi: 6,      bi: 6
Vessel i: 7:      pi: 28-34,      ai-di: 7-27,      gi_SP-gpi_SP: 0.600000-1.000000,      ai_SP-di: 13-27,      taoi-deltai: 11-16,      taoPi_SP-deltaPi_SP: 13-16,      betaNi: 5,      bi: 5
Vessel i: 8:      pi: 14-21,      ai-di: 51-71,      gi_SP-gpi_SP: 0.428571-1.000000,      ai_SP-di: 54-71,      taoi-deltai: 54-59,      taoPi_SP-deltaPi_SP: 54-59,      betaNi: 5,      bi: 5

round LB =   [846, 5531, 5997]
round UB =   [10216, 5979, 5943]
round Hua =   [0, 4685, 5133]
round SPObjVal =   [4685, 5133, 5079]
round MPObjValNHua =   [846, 846, 864]

OptimalObj = 5997.050018627813
Time: 148.000000
```