```
"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=39456

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 599385 rows, 52642 columns and 1660437 nonzeros
Model fingerprint: 0xa7479769
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 370756 rows and 24895 columns (presolve time = 5s) ...
Presolve removed 530972 rows and 37088 columns
Presolve time: 9.89s
Presolved: 68413 rows, 15554 columns, 230775 nonzeros
Variable types: 0 continuous, 15554 integer (15527 binary)

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

Root relaxation presolved: 15554 rows, 83967 columns, 246329 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0    6.4700000e+02   0.000000e+00   9.240000e+02     10s
Concurrent spin time: 0.00s

Solved with dual simplex (primal model)

Root relaxation: objective 6.470000e+02, 2678 iterations, 0.35 seconds (0.31 work units)

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

     0     0  647.00000    0   12          -  647.00000      -     -   11s
H    0     0                1527.0000000  647.00000  57.6%     -   11s
H    0     0                947.0000000  647.00000  31.7%     -   11s
H    0     0                787.0000000  647.00000  17.8%     -   12s
     0     0  647.00000    0   68  787.00000  647.00000  17.8%     -   12s
H    0     0                747.0000000  647.00000  13.4%     -   12s
H    0     0                727.0000000  647.00000  11.0%     -   12s
     0     0  647.00000    0   67  727.00000  647.00000  11.0%     -   12s
H    0     0                707.0000000  647.00000  8.49%     -   13s
H    0     0                647.0000000  647.00000  0.00%     -   13s

Cutting planes:
  Gomory: 3
  Cover: 136
  Implied bound: 504
  Clique: 3
  MIR: 18
  StrongCG: 25
  GUB cover: 6
  RLT: 14
  Relax-and-lift: 2

Explored 1 nodes (9739 simplex iterations) in 14.02 seconds (20.47 work units)
Thread count was 8 (of 8 available processors)

```

```
Solution count 7: 647 707 727 ... 1527

Optimal solution found (tolerance 1.00e-10)
Best objective 6.470000000000e+02, best bound 6.470000000000e+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 536302 rows, 14427 columns and 1098833 nonzeros
Model fingerprint: 0x0004302a
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 533304 rows and 13361 columns
Presolve time: 0.40s
Presolved: 2998 rows, 1066 columns, 7940 nonzeros
Variable types: 8 continuous, 1058 integer (626 binary)
Found heuristic solution: objective 3251.8528892
Found heuristic solution: objective 3465.7100450

Root relaxation: objective 4.383942e+03, 1006 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

     0     0 4383.94217    0   22 3465.71005 4383.94217  26.5%     -    0s
H    0     0                4358.0671749 4383.94217  0.59%     -    0s
H    0     0                4378.0671749 4383.94217  0.13%     -    0s
     0     0 4383.66052    0   22 4378.06717 4383.66052  0.13%     -    0s
     0     0 4383.66052    0   18 4378.06717 4383.66052  0.13%     -    0s
     0     0 4383.66052    0    9 4378.06717 4383.66052  0.13%     -    0s
H    0     0                4381.8528892 4383.66052  0.04%     -    0s

Cutting planes:
  Learned: 2
  Flow cover: 1

Explored 1 nodes (2005 simplex iterations) in 0.62 seconds (0.80 work units)
Thread count was 8 (of 8 available processors)

Solution count 5: 4381.85 4378.07 4358.07 ... 3251.85

Optimal solution found (tolerance 1.00e-08)
Best objective 4.381852889165e+03, best bound 4.381852889165e+03, gap 0.0000%
SP is solved
SP's optimal solution is'□4381

 Itr = 0
Collect_LB =   [647.0]
Collect_UB =   [9410.705778330703]
Collect_Hua =   [0.0]
Collect_SPObjVal =   [4381.852889165351]
Collect_MPObjValNHua =   [647.0]


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 604258 rows, 283978 columns and 1665346 nonzeros
Model fingerprint: 0x48867975
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 421044 rows and 262659 columns (presolve time = 5s) ...
Presolve removed 421044 rows and 262659 columns (presolve time = 10s) ...
```

```
Presolve removed 543267 rows and 274297 columns
Presolve time: 11.37s
Presolved: 60991 rows, 9681 columns, 155633 nonzeros
Variable types: 0 continuous, 9681 integer (9654 binary)
Root relaxation presolved: 9681 rows, 70672 columns, 165314 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0      handle free variables                      12s
    7677    5.0288529e+03   0.000000e+00   0.000000e+00     13s
    7677    5.0288529e+03   0.000000e+00   0.000000e+00     13s

Root relaxation: objective 5.028853e+03, 7677 iterations, 1.39 seconds (2.81 work units)

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

     0     0 5028.85289    0   14          - 5028.85289      -     -   13s
H    0     0                 7148.8528892 5028.85289  29.7%     -   13s
     0     0 5028.85289    0   71 7148.85289 5028.85289  29.7%     -   14s
H    0     0                 6808.8528892 5028.85289  26.1%     -   14s
     0     0 5028.85289    0   99 6808.85289 5028.85289  26.1%     -   14s
     0     0 5028.85289    0  100 6808.85289 5028.85289  26.1%     -   17s
     0     0 5028.85289    0  161 6808.85289 5028.85289  26.1%     -   18s
     0     0 5028.85289    0  117 6808.85289 5028.85289  26.1%     -   18s
     0     0 5028.85289    0   89 6808.85289 5028.85289  26.1%     -   19s
     0     0 5028.85289    0  120 6808.85289 5028.85289  26.1%     -   20s
     0     0 5028.85289    0   53 6808.85289 5028.85289  26.1%     -   21s
     0     0 5028.85289    0   53 6808.85289 5028.85289  26.1%     -   21s
H    0     0                 5028.8528892 5028.85289  0.00%     -   24s
     0     0 5028.85289    0   53 5028.85289 5028.85289  0.00%     -   24s

Cutting planes:
  Learned: 2
  Gomory: 2
  Cover: 133
  Implied bound: 22
  Clique: 771
  MIR: 188
  StrongCG: 195
  GUB cover: 15
  Zero half: 5
  RLT: 1
  Relax-and-lift: 29
  BQP: 14
  PSD: 1

Explored 1 nodes (46536 simplex iterations) in 24.71 seconds (36.45 work units)
Thread count was 8 (of 8 available processors)

Solution count 3: 5028.85 6808.85 7148.85

Optimal solution found (tolerance 1.00e-10)
Best objective 5.028852889165e+03, best bound 5.028852889165e+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 536302 rows, 14427 columns and 1098833 nonzeros
Model fingerprint: 0xe48abb62
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 532419 rows and 13098 columns
Presolve time: 0.36s
Presolved: 3883 rows, 1329 columns, 10423 nonzeros
Variable types: 8 continuous, 1321 integer (768 binary)

Root relaxation: objective 4.780567e+03, 1122 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 4780.56717    0   27          - 4780.56717      -     -    0s
H    0     0                    4769.8528892 4780.56717  0.22%     -    0s
H    0     0                    4775.5671749 4780.56717  0.10%     -    0s
H    0     0                    4775.5671756 4780.56717  0.10%     -    0s
     0     0 4780.56717    0    8 4775.56718 4780.56717  0.10%     -    0s
*    0     0               0    4780.5671749 4780.56717  0.00%     -    0s

Explored 1 nodes (1738 simplex iterations) in 0.59 seconds (0.78 work units)
Thread count was 8 (of 8 available processors)

Solution count 4: 4780.57 4775.57 4775.57 4769.85

Optimal solution found (tolerance 1.00e-08)
Best objective 4.780567174880e+03, best bound 4.780567174880e+03, gap 0.0000%
SP is solved
SP's optimal solution is'□4780

 Itr = 1
Collect_LB =   [647.0, 5028.852889165351]
Collect_UB =   [9410.705778330703, 5427.567174879638]
Collect_Hua =   [0.0, 4381.852889165351]
Collect_SPObjVal =   [4381.852889165351, 4780.567174879638]
Collect_MPObjValNHua =   [647.0, 647.0]


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 604258 rows, 283978 columns and 1665346 nonzeros
Model fingerprint: 0x5b7a6de3
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 421493 rows and 262706 columns (presolve time = 5s) ...
Presolve removed 421493 rows and 262706 columns (presolve time = 10s) ...
Presolve removed 543521 rows and 274334 columns
Presolve time: 10.72s
Presolved: 60737 rows, 9644 columns, 155020 nonzeros
Variable types: 0 continuous, 9644 integer (9617 binary)
Root relaxation presolved: 9644 rows, 70381 columns, 164664 nonzeros


Root simplex log...

Iteration    Objective       Primal Inf.    Dual Inf.      Time
       0      handle free variables                         11s
    7952    5.4418529e+03   0.000000e+00   0.000000e+00     12s
    7952    5.4418529e+03   0.000000e+00   0.000000e+00     12s

Root relaxation: objective 5.441853e+03, 7952 iterations, 1.27 seconds (2.40 work units)

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

     0     0 5441.85289    0   23          - 5441.85289      -     -   12s
     0     0 5441.85289    0   45          - 5441.85289      -     -   13s
     0     0 5441.85289    0  263          - 5441.85289      -     -   14s
     0     0 5441.85289    0  262          - 5441.85289      -     -   14s
     0     0 5441.85289    0  177          - 5441.85289      -     -   16s
     0     0 5441.85289    0  276          - 5441.85289      -     -   17s
     0     0 5441.85289    0  270          - 5441.85289      -     -   17s
     0     0 5441.85289    0   89          - 5441.85289      -     -   18s
     0     0 5441.85289    0  180          - 5441.85289      -     -   19s
     0     0 5441.85289    0   74          - 5441.85289      -     -   20s
H    0     0                    9521.8528892 5441.85289  42.8%     -   20s
     0     0 5441.85289    0   66 9521.85289 5441.85289  42.8%     -   20s
H    0     0                    7821.8528892 5441.85289  30.4%     -   20s
H    0     0                    5441.8528892 5441.85289  0.00%     -   23s
     0     0 5441.85289    0   66 5441.85289 5441.85289  0.00%     -   23s

Cutting planes:
  Learned: 1
  Gomory: 1
  Cover: 217
```

```
  Implied bound: 22
  Clique: 801
  MIR: 92
  StrongCG: 102
  GUB cover: 20
  Zero half: 3
  RLT: 2
  Relax-and-lift: 6
  BQP: 5

Explored 1 nodes (37786 simplex iterations) in 23.27 seconds (34.28 work units)
Thread count was 8 (of 8 available processors)

Solution count 3: 5441.85 7821.85 9521.85

Optimal solution found (tolerance 1.00e-10)
Best objective 5.441852889165e+03, best bound 5.441852889165e+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 536302 rows, 14427 columns and 1098833 nonzeros
Model fingerprint: 0xf3ad5819
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 532056 rows and 13001 columns
Presolve time: 0.34s
Presolved: 4246 rows, 1426 columns, 11305 nonzeros
Variable types: 8 continuous, 1418 integer (820 binary)
Found heuristic solution: objective 3388.5671749

Root relaxation: objective 4.765567e+03, 1242 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

H    0     0                    4765.5671749 12906.7410   171%     -    0s
     0     0          -    0     4765.56717 4765.56717  0.00%     -    0s

Explored 1 nodes (1637 simplex iterations) in 0.52 seconds (0.71 work units)
Thread count was 8 (of 8 available processors)

Solution count 2: 4765.57 3388.57

Optimal solution found (tolerance 1.00e-08)
Best objective 4.765567174880e+03, best bound 4.765567174880e+03, gap 0.0000%
SP is solved
SP's optimal solution is'□4765

 Itr = 2
Collect_LB =   [647.0, 5028.852889165351, 5441.852889165351]
Collect_UB =   [9410.705778330703, 5427.567174879638, 5426.852889165351]
Collect_Hua =   [0.0, 4381.852889165351, 4780.567174879638]
Collect_SPObjVal =   [4381.852889165351, 4780.567174879638, 4765.567174879638]
Collect_MPObjValNHua =   [647.0, 647.0, 661.2857142857138]


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

~~~~~~~~~~judge = 2, SPObj_SPF = 4765.567174879638
Vessel i: 0:     pi: 0-5,     ai-di: 8-25,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 8-25,     taoi-deltai: 8-17,     taoPi_SP-deltaPi_SP: 8-17,     betaNi: 9,
    bi: 9
Vessel i: 1:     pi: 10-15,     ai-di: 3-21,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 3-21,     taoi-deltai: 3-15,     taoPi_SP-deltaPi_SP: 3-15,     betaNi: 12
,     bi: 12
Vessel i: 2:     pi: 5-10,     ai-di: 13-36,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 13-36,     taoi-deltai: 13-28,     taoPi_SP-deltaPi_SP: 22-28,     betaNi
: 15,     bi: 15
Vessel i: 3:     pi: 10-16,     ai-di: 22-49,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 22-49,     taoi-deltai: 22-39,     taoPi_SP-deltaPi_SP: 22-39,
    betaNi: 17,     bi: 17
Vessel i: 4:     pi: 16-22,     ai-di: 35-57,     gi_SP-gpi_SP: 0.000000-0.000000,     ai_SP-di: 35-57,     taoi-deltai: 35-48,     taoPi_SP-deltaPi_SP: 35-48,
    betaNi: 13,     bi: 13
Vessel i: 5:     pi: 16-23,     ai-di: 3-35,     gi_SP-gpi_SP: 0.257143-0.800000,     ai_SP-di: 4-35,     taoi-deltai: 5-20,     taoPi_SP-deltaPi_SP: 5-20,     betaNi: 15
,     bi: 15
Vessel i: 6:     pi: 29-34,     ai-di: 2-29,     gi_SP-gpi_SP: 1.000000-0.000000,     ai_SP-di: 10-29,     taoi-deltai: 10-18,     taoPi_SP-deltaPi_SP: 10-18,     betaNi
```

```
: 8,      bi: 8
Vessel i: 7:      pi: 27-34,      ai-di: 27-68,      gi_SP-gpi_SP: 1.000000-0.600000,      ai_SP-di: 37-68,      taoi-deltai: 37-53,      taoPi_SP-deltaPi_SP: 37-53,
betaNi: 16,      bi: 16
Vessel i: 8:      pi: 28-34,      ai-di: 29-59,      gi_SP-gpi_SP: 0.142857-1.000000,      ai_SP-di: 30-59,      taoi-deltai: 30-35,      taoPi_SP-deltaPi_SP: 30-35,
betaNi: 5,      bi: 5

round LB =   [647, 5029, 5442]
round UB =   [9411, 5428, 5427]
round Hua =   [0, 4382, 4781]
round SPObjVal =   [4382, 4781, 4766]
round MPObjValNHua =   [647, 647, 661]

OptimalObj = 5441.852889165351
Time: 135.000000



libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
libpng warning: iCCP: known incorrect sRGB profile
```