```
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=55556
 3
   import sys; print('Python %s on %s' % (sys.version, sys.platform))
   sys.path.extend(|'E:\\1 000\\3 0000\\1 00000\\1 000000\\1 00000\\1 LW 0000\\4 0000\\3 python code\\9 Code for this
   6
   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
 8
   >>> runfile('E:/1 000/3 0000/1 00000/1 000000/1 000000/1 000000/1 LW 000/3 python_code/9 Code for this paper/main_RO_TWS.py', wdir='E:/1 0000/3 0000/1 000000/1 000000/1 000000/1 000000/1 LW 000/3 python_code/9 Code for
   this paper')
10 Backend TkAgg is interactive backend. Turning interactive mode on.
   Waiting 5s....
   Set parameter MIPGap to value 1e-10
12
   Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
13
15
   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
16
17
   Optimize a model with 377728 rows, 34789 columns and 1041116 nonzeros
19
   Model fingerprint: 0x46f72647
   Variable types: 1 continuous, 34788 integer (34764 binary)
20
21 Coefficient statistics:
    Matrix range [1e+00, 1e+10]
    Objective range [1e+00, 2e+01]
23
    Bounds range [1e+00, 1e+00]
24
                  [1e+00, 2e+10]
    RHS range
26
   Warning: Model contains large matrix coefficients
27
   Warning: Model contains large rhs
28
        Consider reformulating model or setting NumericFocus parameter
29
        to avoid numerical issues.
30
   Presolve removed 213113 rows and 13994 columns (presolve time = 5s) ...
   Presolve removed 337449 rows and 22786 columns
31
   Presolve time: 6.17s
   Presolved: 40279 rows, 12003 columns, 163014 nonzeros
   Variable types: 0 continuous, 12003 integer (11988 binary)
34
35
   Deterministic concurrent LP optimizer: primal and dual simplex (primal and dual model)
37
   Showing first log only...
38
39
   Root relaxation presolved: 40277 rows, 12003 columns, 163010 nonzeros
40
41
   Concurrent spin time: 0.02s
42
43
   Solved with dual simplex (primal model)
44
45
   Root relaxation: objective 7.880000e+02, 1547 iterations, 0.20 seconds (0.18 work units)
46
47
     Nodes | Current Node | Objective Bounds
48
   Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
49
50
      0 0 788.00000 0 17
                                 - 788.00000
                      1768.0000000 788.00000 55.4% - 7s
51 H 0 0
                       788.0000000 788.00000 0.00%
52 H 0 0
      0 0 788.00000 0 112 788.00000 788.00000 0.00%
53
54
55
   Cutting planes:
56
    Gomory: 7
57
    Cover: 36
    Implied bound: 6
59
    Clique: 2
    MIR: 32
60
    StrongCG: 20
62
    GUB cover: 1
63
    Zero half: 1
64
    RLT: 12
65
    Relax-and-lift: 6
66
67
   Explored 1 nodes (4325 simplex iterations) in 7.84 seconds (12.17 work units)
68
   Thread count was 8 (of 8 available processors)
69
70
   Solution count 2: 788 1768
   Optimal solution found (tolerance 1.00e-10)
73
   Best objective 7.880000000000e+02, best bound 7.88000000000e+02, gap 0.0000%
   Set parameter MIPGap to value 1e-08
74
75
   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]
77
78
   Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
```

```
80 Optimize a model with 252634 rows, 9618 columns and 522244 nonzeros
 81 Model fingerprint: 0x879bae13
    Variable types: 24 continuous, 9594 integer (5544 binary)
 83 Coefficient statistics:
     Matrix range [1e-01, 1e+10]
 85
      Objective range [6e-05, 5e+01]
      Bounds range [1e+00, 1e+00]
 86
 87
     RHS range
                   [8e-01, 1e+10]
     Warning: Model contains large matrix coefficients
 88
     Warning: Model contains large rhs
 89
          Consider reformulating model or setting NumericFocus parameter
 90
 91
          to avoid numerical issues.
 92 Presolve removed 250362 rows and 8728 columns
 93
    Presolve time: 0.23s
 94
    Presolved: 2272 rows, 890 columns, 6112 nonzeros
    Variable types: 4 continuous, 886 integer (498 binary)
 96 Found heuristic solution: objective 3850.3983806
 97
 98 Root relaxation: objective 5.221000e+03, 582 iterations, 0.00 seconds (0.00 work units)
 99
100
       Nodes | Current Node | Objective Bounds
                                                      Work
101
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
102
103
       0 0 5221.00000 0 8 3850.39838 5221.00000 35.6% - 0s
104 H 0 0
                        5221.0000000 5221.00000 0.00% - 0s
105
       0 0 5221.00000 0 8 5221.00000 5221.00000 0.00%
106
107 Explored 1 nodes (582 simplex iterations) in 0.31 seconds (0.46 work units)
108 Thread count was 8 (of 8 available processors)
109
110 Solution count 2: 5221 3850.4
111
112 Optimal solution found (tolerance 1.00e-08)
113 Best objective 5.221000000000e+03, best bound 5.22100000000e+03, gap 0.0000%
114 SP is solved
115 SP's optimal solution is' □ 5221
116
117 Itr = 0
118 Collect_LB = [788.0]
119 Collect_UB = [11230.0000000000004]
120 Collect_Hua = [0.0]
121 Collect SPObjVal = [5221.0000000000002]
122 Collect MPObjValNHua = [788.0]
123
124
125 Set parameter MIPGap to value 1e-10
126 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
127
128 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
129 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
130
131 Optimize a model with 382373 rows, 137605 columns and 1045776 nonzeros
132 Model fingerprint: 0xe7894bd1
133 Variable types: 1 continuous, 137604 integer (137580 binary)
134 Coefficient statistics:
     Matrix range [1e+00, 1e+10]
135
136
     Objective range [1e+00, 2e+01]
137
     Bounds range [1e+00, 1e+00]
      RHS range
138
                   [1e+00, 2e+10]
139 Warning: Model contains large matrix coefficients
140 Warning: Model contains large rhs
141
          Consider reformulating model or setting NumericFocus parameter
142
          to avoid numerical issues.
143 Presolve removed 247724 rows and 121850 columns (presolve time = 5s) ...
144 Presolve removed 364020 rows and 131279 columns
145 Presolve time: 5.87s
146 Presolved: 18353 rows, 6326 columns, 77807 nonzeros
147 Variable types: 0 continuous, 6326 integer (6312 binary)
148
149 Root simplex log...
150
151 Iteration Objective
                          Primal Inf. Dual Inf.
152
        0 6.0610000e+03 7.871250e+02 0.000000e+00
       2660 6.0610000e+03 0.000000e+00 0.000000e+00
153
154
155 Root relaxation: objective 6.061000e+03, 2660 iterations, 0.06 seconds (0.07 work units)
156
157
       Nodes | Current Node | Objective Bounds
                                                          Work
158
     Expl\ Unexpl\ |\ \ Obj\ \ Depth\ IntInf\ |\ Incumbent \qquad BestBd \quad Gap\ |\ It/Node\ Time
159
160
           0.6061.00000 \quad 0.19
                                     - 6061.00000
           0 6061.00000 0 268
                                     -6061.00000 - - 7s
161
       0
           0 6061.00000 0 269
                                     - 6061,00000
162
       0
                                                    - - 7s
       0
           0 6061.00000 0 245
                                     - 6061.00000
                                                           7s
163
```

```
164
           0 6061.00000 0 243
                                     - 6061.00000
165
           0 6061.00000 0 54
                                    - 6061.00000
                                                          8s
       0 \quad \  \  0.6061.00000 \quad 0 \quad 52
                                    - 6061.00000
166
                                                          8s
167 H 0 0
                       6061.0000000 6061.00000 0.00%
           168
169
170 Cutting planes:
171
     Learned: 2
172
      Gomory: 1
173
      Cover: 267
     Implied bound: 14
174
175
      Clique: 58
176
      MIR: 28
      StrongCG: 7
177
178
      GUB cover: 38
179
      RLT: 1
180
      Relax-and-lift: 5
181
      BOP: 3
182
183 Explored 1 nodes (16800 simplex iterations) in 9.15 seconds (12.74 work units)
184 Thread count was 8 (of 8 available processors)
185
    Solution count 1: 6061
186
187
188 Optimal solution found (tolerance 1.00e-10)
189 Best objective 6.061000000000e+03, best bound 6.06100000000e+03, gap 0.0000%
190 Set parameter MIPGap to value 1e-08
191 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
192
193 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
194 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
195
196 Optimize a model with 252634 rows, 9618 columns and 522244 nonzeros
197 Model fingerprint: 0xca8aaa3d
198 Variable types: 24 continuous, 9594 integer (5544 binary)
199 Coefficient statistics:
200
     Matrix range [1e-01, 1e+10]
201
      Objective range [6e-05, 5e+01]
      Bounds range [1e+00, 1e+00]
202
203
      RHS range
                    [8e-01, 1e+10]
204 Warning: Model contains large matrix coefficients
205 Warning: Model contains large rhs
206
          Consider reformulating model or setting NumericFocus parameter
207
          to avoid numerical issues.
208 Presolve removed 247378 rows and 7875 columns
209 Presolve time: 0.22s
210 Presolved: 5256 rows, 1743 columns, 14014 nonzeros
211 Variable types: 4 continuous, 1739 integer (994 binary)
212 Found heuristic solution: objective 3874.6085125
213 Found heuristic solution: objective 3894.6085125
214
215 Root relaxation: objective 5.472000e+03, 1514 iterations, 0.03 seconds (0.02 work units)
216
217
       Nodes | Current Node | Objective Bounds
                                                         Work
218
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
219
       0 0 5472.00000 0 14 3894.60851 5472.00000 40.5%
220
                        4539.9153674 5472.00000 20.5% - 0s
221 H 0 0
222 H 0 0
                        4567.0000000 5472.00000 19.8%
       0 0 5472.00000 0 4 4567.00000 5472.00000 19.8% -
                                                                 0s
                        5472.0000000 5472.00000 0.00% - 0s
224 H 0 0
225
       0 0 5472.00000 0 4 5472.00000 5472.00000 0.00%
226
227 Cutting planes:
228
     Gomory: 3
229
      Cover: 1
230
      Clique: 3
231
      Zero half: 1
232
233 Explored 1 nodes (2419 simplex iterations) in 0.38 seconds (0.57 work units)
234 Thread count was 8 (of 8 available processors)
235
236 Solution count 5: 5472 4567 4539.92 ... 3874.61
237
238 Optimal solution found (tolerance 1.00e-08)
239 Best objective 5.472000000000e+03, best bound 5.47200000000e+03, gap 0.0000%
240 SP is solved
241 SP's optimal solution is' ☐ 5472
242
243 Itr = 1
244 Collect LB = [788.0, 6061.0000000000002]
245 Collect_UB = [11230.00000000004, 6312.000000000002]
246 Collect_Hua = [0.0, 5221.000000000000]
247 Collect_SPObjVal = [5221.00000000002, 5472.000000000002]
```

```
248 Collect MPObjValNHua = [788.0, 840.0]
249
250
251 Set parameter MIPGap to value 1e-10
252 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
253
254 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
255 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
256
257 Optimize a model with 382373 rows, 137605 columns and 1045776 nonzeros
258 Model fingerprint: 0x5b09e65d
259 Variable types: 1 continuous, 137604 integer (137580 binary)
260 Coefficient statistics:
     Matrix range [1e+00, 1e+10]
261
262
     Objective range [1e+00, 2e+01]
263 Bounds range [1e+00, 1e+00]
     RHS range
                    [1e+00, 2e+10]
264
265 Warning: Model contains large matrix coefficients
266 Warning: Model contains large rhs
267
          Consider reformulating model or setting NumericFocus parameter
          to avoid numerical issues.
268
269 Presolve removed 247724 rows and 121850 columns (presolve time = 5s) ...
270 Presolve removed 364020 rows and 131279 columns
271 Presolve time: 5.81s
272 Presolved: 18353 rows, 6326 columns, 77807 nonzeros
273 Variable types: 0 continuous, 6326 integer (6312 binary)
275 Root simplex log...
276
277 Iteration Objective
                           Primal Inf. Dual Inf.
278
        0 6.3120000e+03 7.871250e+02 0.000000e+00
279
       2660 6.3120000e+03 0.000000e+00 0.000000e+00
280
281 Root relaxation: objective 6.312000e+03, 2660 iterations, 0.05 seconds (0.07 work units)
282
283
       Nodes | Current Node | Objective Bounds

↓ Work

284
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
285
           0 6312.00000 0 19
286
       0
                                     - 6312.00000
                                                           6s
287
       0
           0 6312.00000 0 268
                                     - 6312.00000
                                                           7s
288
           0 6312.00000 0 269
                                     - 6312.00000
289
       0
           0 6312.00000 0 245
                                     - 6312.00000
                                                           7s
290
           0.6312.00000 0.243
                                     - 6312.00000
       0
                                                           7s
291
       0
           0 6312.00000 0 54
                                     - 6312.00000
                                                           8s
           0.6312.00000 \quad 0 \quad 52
292
       0
                                     - 6312.00000
293 H 0 0
                      6312.0000000 6312.00000 0.00% - 9s
       0 \quad \  \  0.6312.00000 \quad 0.134.6312.00000.6312.00000.00\%
294
295
296 Cutting planes:
297
     Learned: 2
298
     Gomory: 1
299
      Cover: 267
300
     Implied bound: 14
301
      Clique: 58
302
      MIR: 28
      StrongCG: 7
303
304
      GUB cover: 38
305
      RLT: 1
306
      Relax-and-lift: 5
307
308
309 Explored 1 nodes (16800 simplex iterations) in 9.16 seconds (12.74 work units)
310 Thread count was 8 (of 8 available processors)
311
312 Solution count 1: 6312
313
314 Optimal solution found (tolerance 1.00e-10)
315 Best objective 6.312000000000e+03, best bound 6.31200000000e+03, gap 0.0000%
316 Set parameter MIPGap to value 1e-08
317 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
318
319 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
320 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
321
322 Optimize a model with 252634 rows, 9618 columns and 522244 nonzeros
323 Model fingerprint: 0xca8aaa3d
324 Variable types: 24 continuous, 9594 integer (5544 binary)
325 Coefficient statistics:
     Matrix range [1e-01, 1e+10]
326
327
      Objective range [6e-05, 5e+01]
      Bounds range [1e+00, 1e+00]
328
                   [8e-01, 1e+10]
329
     RHS range
330 Warning: Model contains large matrix coefficients
     Warning: Model contains large rhs
331
```

```
332
                 Consider reformulating model or setting NumericFocus parameter
333
                 to avoid numerical issues.
334 Presolve removed 247378 rows and 7875 columns
335 Presolve time: 0.22s
336 Presolved: 5256 rows, 1743 columns, 14014 nonzeros
337
        Variable types: 4 continuous, 1739 integer (994 binary)
338 Found heuristic solution: objective 3874.6085125
339 Found heuristic solution: objective 3894.6085125
340
Root relaxation: objective 5.472000e+03, 1514 iterations, 0.02 seconds (0.02 work units)
342
343
            Nodes | Current Node | Objective Bounds | Work
344
         Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
345
346
              0 0 5472.00000 0 14 3894.60851 5472.00000 40.5% - 0s
347 H 0 0
                                          4539.9153674 5472.00000 20.5% - 0s
348 H 0 0
                                           4567.0000000 5472.00000 19.8%
             0 0 5472.00000 0 4 4567.00000 5472.00000 19.8% - 0s
349
350 H 0 0
                                          5472.0000000 5472.00000 0.00% - 0s
351
             0 0 5472.00000 0 4 5472.00000 5472.00000 0.00%
352
353 Cutting planes:
354
          Gomory: 3
355
          Cover: 1
356
          Clique: 3
357
           Zero half: 1
358
359 Explored 1 nodes (2419 simplex iterations) in 0.38 seconds (0.57 work units)
360 Thread count was 8 (of 8 available processors)
361
362 Solution count 5: 5472 4567 4539.92 ... 3874.61
363
364 Optimal solution found (tolerance 1.00e-08)
365 Best objective 5.472000000000e+03, best bound 5.47200000000e+03, gap 0.0000%
366 SP is solved
367 SP's optimal solution is' □ 5472
368
369 	ext{ Itr} = 2
370 Collect LB = [788.0, 6061.000000000002, 6312.000000000002]
371 Collect_UB = [11230.000000000004, 6312.000000000002, 6312.000000000002]
372 Collect_Hua = [0.0, 5221.00000000002, 5472.000000000002]
373 Collect SPObjVal = [5221.000000000002, 5472.00000000002, 5472.0000000000002]
374 Collect MPObjValNHua = [788.0, 840.0, 840.0]
375
376
          Reach the termination conditions, stop iteration
377
         Values adopted from the Itr' th iteration, and Itr = \{2\}, judgeCount = \{2\}
378
379
                            \simjudge = 2, SPObj SPF = 5472.000000000002
380
                                pi: 0-7, \quad ai-di: 8-25, \quad gi\_SP-gpi\_SP: 0.000000-0.000000, \quad ai\_SP-di: 8-25, \quad taoi-deltai: 8-25, \quad taoPi\_SP-deltaPi\_SP: 8-25, \quad taoPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-deltaPi\_SP-del
381 Vessel i: 0:
                                                                                                                                                                                                                                                   betaNi: 17
               bi: 17
382 Vessel i: 1:
                                                     ai-di: 14-24, gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                                                                                                                                              taoPi_SP-deltaPi_SP: 14-25,
                                pi: 22-28,
                                                                                                                                            ai_SP-di: 14-24,
                                                                                                                                                                            taoi-deltai: 14-25,
        betaNi: 11,
                                bi: 11
                                pi: 16-22,
                                                                               gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                                                                                                            taoi-deltai: 14-47,
                                                                                                                                                                                                              taoPi_SP-deltaPi_SP: 14-47,
        Vessel i: 2:
                                                     ai-di: 14-49,
                                                                                                                                            ai_SP-di: 14-49,
        betaNi: 33,
                                bi: 33
         Vessel i: 3:
                                pi: 11-16,
                                                     ai-di: 22-48,
                                                                              gi SP-gpi SP: 0.000000-0.000000,
                                                                                                                                            ai SP-di: 22-48,
                                                                                                                                                                            taoi-deltai: 22-49,
                                                                                                                                                                                                              taoPi SP-deltaPi SP: 22-49,
        betaNi: 27.
                                bi: 27
385
        Vessel i: 4:
                                pi: 16-22,
                                                     ai-di: 43-56,
                                                                              gi_SP-gpi_SP: 1.000000-0.600000,
                                                                                                                                            ai_SP-di: 48-56,
                                                                                                                                                                            taoi-deltai: 48-58,
                                                                                                                                                                                                              taoPi_SP-deltaPi_SP: 48-58,
         betaNi: 10,
                                bi: 10
        Vessel i: 5:
                                pi: 22-27,
                                                     ai-di: 35-75,
                                                                             gi_SP-gpi_SP: 0.200000-0.600000,
                                                                                                                                            ai SP-di: 35-75,
                                                                                                                                                                            taoi-deltai: 36-70,
                                                                                                                                                                                                              taoPi SP-deltaPi SP: 36-70,
        betaNi: 34,
                                bi: 34
387
388 round LB = [788, 6061, 6312]
389 round UB = [11230, 6312, 6312]
390 round Hua = [0, 5221, 5472]
391 round SPObjVal = [5221, 5472, 5472]
392 round MPObjValNHua = [788, 840, 840]
393
394 OptimalObj = 6312.000000000002
395
       Time: 70.000000
396
397
398
399
```