```
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=55625
 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')
   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 360923 rows, 34789 columns and 1002717 nonzeros
19
   Model fingerprint: 0xa61a2c1f
   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
24
    Bounds range [1e+00, 1e+00]
                  [1e+00, 2e+10]
    RHS range
26
   Warning: Model contains large matrix coefficients
   Warning: Model contains large rhs
27
28
        Consider reformulating model or setting NumericFocus parameter
29
        to avoid numerical issues.
30
   Presolve removed 240521 rows and 21407 columns (presolve time = 5s) ...
31
   Presolve removed 307571 rows and 21407 columns
   Presolve time: 6.22s
   Presolved: 53352 rows, 13382 columns, 204541 nonzeros
34
   Variable types: 0 continuous, 13382 integer (13364 binary)
35
   Deterministic concurrent LP optimizer: primal and dual simplex (primal and dual model)
   Showing first log only...
37
38
39
   Root relaxation presolved: 53351 rows, 13383 columns, 204538 nonzeros
40
41
42
   Root simplex log...
43
44
   Iteration Objective
                        Primal Inf. Dual Inf.
       0 1.1240000e+03 9.687500e+01 1.931714e+08
45
46
   Concurrent spin time: 0.03s
48
   Solved with dual simplex (primal model)
49
50
   Root relaxation: objective 8.040000e+02, 1859 iterations, 0.31 seconds (0.23 work units)
51
52
     Nodes | Current Node | Objective Bounds
                                                     Work
53
    Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
54
55
      0 0 804.00000 0 2
                                - 804.00000
                      2244.0000000 804.00000 64.2% -
56 H 0 0
                                                        7s
57
   Η
      0 0
                      1364.0000000 804.00000 41.1%
      0 0 804.00000 0 19 1364.00000 804.00000 41.1%
59 H 0 0
                       804.0000000 804.00000 0.00% - 10s
     0 0 804.00000 0 7 804.00000 804.00000 0.00% - 10s
60
   Cutting planes:
62
63
    Cover: 122
64
    Implied bound: 610
65
    Clique: 3
    MIR: 4
66
67
    StrongCG: 3
68
    GUB cover: 1
69
    Zero half: 2
70
    Relax-and-lift: 19
   Explored 1 nodes (13323 simplex iterations) in 10.13 seconds (15.78 work units)
   Thread count was 8 (of 8 available processors)
73
74
75
   Solution count 3: 804 1364 2244
76
   Optimal solution found (tolerance 1.00e-10)
77
   Best objective 8.040000000000e+02, best bound 8.04000000000e+02, gap 0.0000%
   Set parameter MIPGap to value 1e-08
```

```
80 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
 81
     CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
 82
 83
    Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
 85 Optimize a model with 252585 rows, 9618 columns and 522097 nonzeros
 86 Model fingerprint: 0x1148f118
 87 Variable types: 24 continuous, 9594 integer (5544 binary)
 88 Coefficient statistics:
     Matrix range [1e-01, 1e+10]
 89
     Objective range [6e-05, 5e+01]
 90
 91
      Bounds range [1e+00, 1e+00]
                    [8e-01, 1e+10]
     RHS range
     Warning: Model contains large matrix coefficients
 93
 94
     Warning: Model contains large rhs
          Consider reformulating model or setting NumericFocus parameter
 95
 96
          to avoid numerical issues.
 97 Presolve removed 250214 rows and 8762 columns
 98 Presolve time: 0.23s
    Presolved: 2371 rows, 856 columns, 6316 nonzeros
100 Variable types: 0 continuous, 856 integer (503 binary)
101 Found heuristic solution: objective 4207.6666667
102
103 Root relaxation: objective 5.149667e+03, 652 iterations, 0.00 seconds (0.01 work units)
104
105
       Nodes | Current Node | Objective Bounds | Work
    Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
106
107
108 * 0 0
                     0 5149.6666667 5149.66667 0.00% - 0s
109
110 Explored 1 nodes (652 simplex iterations) in 0.30 seconds (0.45 work units)
111 Thread count was 8 (of 8 available processors)
112
113 Solution count 2: 5149.67 4207.67
114
115 Optimal solution found (tolerance 1.00e-08)
116 Best objective 5.149666666667e+03, best bound 5.14966666667e+03, gap 0.0000%
117 SP is solved
118 SP's optimal solution is' ☐ 5149
119
120 Itr = 0
121 Collect LB = [804.0]
122 Collect_UB = [11103.33333333333336]
123 Collect_Hua = [0.0]
124 Collect_SPObjVal = [5149.66666666668]
125 Collect_MPObjValNHua = [804.0]
126
127
128 Set parameter MIPGap to value 1e-10
129 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
130
131 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
132 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
133
134 Optimize a model with 367234 rows, 137605 columns and 1009043 nonzeros
135 Model fingerprint: 0x484429d0
136 Variable types: 1 continuous, 137604 integer (137580 binary)
137 Coefficient statistics:
138
     Matrix range [1e+00, 1e+10]
139
     Objective range [1e+00, 2e+01]
     Bounds range [1e+00, 1e+00]
140
141
      RHS range
                    [1e+00, 2e+10]
142 Warning: Model contains large matrix coefficients
143 Warning: Model contains large rhs
144
          Consider reformulating model or setting NumericFocus parameter
145
          to avoid numerical issues.
146 Presolve removed 229129 rows and 122378 columns (presolve time = 5s) ...
147 Presolve removed 343024 rows and 131193 columns
148 Presolve time: 6.12s
149 Presolved: 24210 rows, 6412 columns, 85890 nonzeros
150 Variable types: 0 continuous, 6412 integer (6395 binary)
151
152 Root simplex log...
153
154 Iteration Objective
                          Primal Inf Dual Inf
                                                  Time
           6.0736667e+03 8.510000e+02 0.000000e+00
155
156
       2440 6.0736667e+03 0.000000e+00 0.000000e+00
157
Root relaxation: objective 6.073667e+03, 2440 iterations, 0.08 seconds (0.14 work units)
159
160
       Nodes | Current Node | Objective Bounds
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
161
162
           0 6073.66667 0 9
                                    - 6073.66667
163
```

```
164
           0 6073.66667 0 8
                                    - 6073.66667
165
           0 6073.66667 0 109
                                     - 6073.66667
                                                        - 7s
                          0.101
                                     - 6073.66667
166
       0
           0.6073.66667
                                                            7s
167
       0
           0 6073.66667 0 156
                                     - 6073.66667
                                                            7s
           0 6073.66667 0 146
                                     - 6073.66667
168
169
       0
           0 6073.66667 0 13
                                     - 6073.66667
                                                           8s
           0.6073.66667 \quad 0 \quad 20
170
       0
                                     - 6073.66667
                                                           8s
171
       0
           0 6073.66667 0 1
                                    - 6073.66667
                                                          9s
172
           0\ 6073.66667 0\ 13
       0
                                     - 6073.66667
                                                           9s
                                                           9s
           0 6073.66667 0 1
173
                                    - 6073.66667
       0
174
       0 0 6073.66667 0 1
                                    - 6073.66667
                                                          9s
175 H 0 0
                         6073.6666667 6073.66667 0.00% - 10s
176
        0 0 6073.66667 0 1 6073.66667 6073.66667 0.00% - 10s
177
178 Cutting planes:
179
     Gomory: 2
180
      Cover: 229
      Implied bound: 510
181
182
      Clique: 145
183
      MIR: 24
      StrongCG: 15
184
185
      GUB cover: 35
186
      RLT: 1
187
      Relax-and-lift: 11
188
189 Explored 1 nodes (17849 simplex iterations) in 10.20 seconds (13.47 work units)
190 Thread count was 8 (of 8 available processors)
191
192 Solution count 1: 6073.67
193
194 Optimal solution found (tolerance 1.00e-10)
195 Best objective 6.073666666667e+03, best bound 6.07366666667e+03, gap 0.0000%
196 Set parameter MIPGap to value 1e-08
197 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
198
199 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
200 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
201
202 Optimize a model with 252585 rows, 9618 columns and 522097 nonzeros
203 Model fingerprint: 0xe3457418
204 Variable types: 24 continuous, 9594 integer (5544 binary)
205 Coefficient statistics:
     Matrix range [1e-01, 1e+10]
206
207
     Objective range [6e-05, 5e+01]
     Bounds range [1e+00, 1e+00]
208
                    [8e-01, 1e+10]
209
     RHS range
210 Warning: Model contains large matrix coefficients
211 Warning: Model contains large rhs
212
          Consider reformulating model or setting NumericFocus parameter
213
          to avoid numerical issues.
214 Presolve removed 247302 rows and 7837 columns
215 Presolve time: 0.22s
216 Presolved: 5283 rows, 1781 columns, 14070 nonzeros
217 Variable types: 4 continuous, 1777 integer (1024 binary)
218 Found heuristic solution: objective 3689.6666667
219
220 Root relaxation: objective 5.402667e+03, 1412 iterations, 0.00 seconds (0.01 work units)
221
222
       Nodes | Current Node | Objective Bounds
223
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
224
225 H 0 0
                         5402.6666667 15700.0000 191% - 0s
226
                         5402.66667 5402.66667 0.00% - 0s
                  - 0
227
228 Explored 1 nodes (1853 simplex iterations) in 0.30 seconds (0.47 work units)
229 Thread count was 8 (of 8 available processors)
230
231 Solution count 2: 5402.67 3689.67
232
233 Optimal solution found (tolerance 1.00e-08)
234 Best objective 5.402666666667e+03, best bound 5.402666666667e+03, gap 0.0000%
235 SP is solved
236 SP's optimal solution is' ☐ 5402
237
238 Itr = 1
239 Collect LB = [804.0, 6073.66666666668]
240 Collect_UB = [11103.33333333336, 6326.66666666668]
241 Collect_Hua = [0.0, 5149.66666666668]
242 Collect_SPObjVal = [5149.66666666668, 5402.6666666668]
243 Collect MPObjValNHua = [804.0, 924.0]
244
245
246 Set parameter MIPGap to value 1e-10
247 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
```

```
248
249 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
250 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
251
252 Optimize a model with 367234 rows, 137605 columns and 1009043 nonzeros
253 Model fingerprint: 0xbf277ce8
254 Variable types: 1 continuous, 137604 integer (137580 binary)
255 Coefficient statistics:
     Matrix range [1e+00, 1e+10]
256
257
     Objective range [1e+00, 2e+01]
258
     Bounds range [1e+00, 1e+00]
259
      RHS range
                    [1e+00, 2e+10]
260 Warning: Model contains large matrix coefficients
261 Warning: Model contains large rhs
262
          Consider reformulating model or setting NumericFocus parameter
263
          to avoid numerical issues.
264 Presolve removed 229129 rows and 122378 columns (presolve time = 5s) ...
265 Presolve removed 343024 rows and 131193 columns
266 Presolve time: 6.17s
267 Presolved: 24210 rows, 6412 columns, 85890 nonzeros
268 Variable types: 0 continuous, 6412 integer (6395 binary)
269
270 Root simplex log...
271
272 Iteration Objective
                           Primal Inf. Dual Inf.
                                                  Time
         0 6.3266667e+03 8.510000e+02 0.000000e+00
273
274
       2440 6.3266667e+03 0.000000e+00 0.000000e+00
275
276 Root relaxation: objective 6.326667e+03, 2440 iterations, 0.08 seconds (0.14 work units)
277
278
       Nodes | Current Node | Objective Bounds
                                                          Work
279
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
280
                                    - 6326.66667
281
           0.6326.66667 \quad 0 \quad 9
                                                          6s
282
       0
           0 6326.66667 0 8
                                    - 6326.66667
                                                          6s
283
           0.6326.66667 0.109
                                     - 6326.66667
       0
                                                           7s
284
       0
           0 6326.66667
                          0 101
                                     - 6326.66667
                                                           7s
285
           0 6326.66667 0 156
                                     - 6326.66667
                                                           7s
                                     - 6326.66667
286
       0
           0.6326.66667 0.146
                                                           7s
287
       0
           0 6326.66667 0 13
                                     - 6326.66667
                                                          8s
288
           0 6326.66667 0 20
                                     - 6326.66667
289
       0
           0 6326.66667 0 1
                                    - 6326.66667
                                                       - 9s
           0.6326.66667 \quad 0 \quad 13
290
                                                      - 9s
       0
                                     - 6326.66667
291
       0
           0 6326.66667 0 1
                                    - 6326.66667
                                                   - - 9s
292
           0 6326.66667 0 1
       0
                                    - 6326.66667
293 H 0 0
                        6326.6666667 6326.66667 0.00% - 10s
294
       0 0 6326.66667 0 1 6326.66667 6326.66667 0.00%
295
296 Cutting planes:
297
      Gomory: 2
298
      Cover: 229
299
      Implied bound: 510
300
      Clique: 145
      MIR: 24
301
302
      StrongCG: 15
303
      GUB cover: 35
304
      RLT: 1
305
      Relax-and-lift: 11
306
307 Explored 1 nodes (17849 simplex iterations) in 10.32 seconds (13.47 work units)
308 Thread count was 8 (of 8 available processors)
309
310 Solution count 1: 6326.67
311
312 Optimal solution found (tolerance 1.00e-10)
313 Best objective 6.326666666667e+03, best bound 6.32666666667e+03, gap 0.0000%
314 Set parameter MIPGap to value 1e-08
315 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
316
317 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
318 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
319
320 Optimize a model with 252585 rows, 9618 columns and 522097 nonzeros
321 Model fingerprint: 0xe3457418
322 Variable types: 24 continuous, 9594 integer (5544 binary)
323 Coefficient statistics:
324 Matrix range [1e-01, 1e+10]
325
      Objective range [6e-05, 5e+01]
      Bounds range [1e+00, 1e+00]
326
                    [8e-01, 1e+10]
327
     RHS range
     Warning: Model contains large matrix coefficients
328
     Warning: Model contains large rhs
329
          Consider reformulating model or setting NumericFocus parameter
330
          to avoid numerical issues.
331
```

```
unknown
332 Presolve removed 247302 rows and 7837 columns
333 Presolve time: 0.20s
334 Presolved: 5283 rows, 1781 columns, 14070 nonzeros
335 Variable types: 4 continuous, 1777 integer (1024 binary)
336 Found heuristic solution: objective 3689.6666667
337
338 Root relaxation: objective 5.402667e+03, 1412 iterations, 0.00 seconds (0.01 work units)
339
340
       Nodes | Current Node | Objective Bounds
                                                      Work
      Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
341
342
343 H 0 0
                         5402.6666667 15700.0000 191% - 0s
                  - 0 5402.66667 5402.66667 0.00% - 0s
344
        0 0
345
346 Explored 1 nodes (1853 simplex iterations) in 0.31 seconds (0.47 work units)
347 Thread count was 8 (of 8 available processors)
348
349 Solution count 2: 5402.67 3689.67
350
351 Optimal solution found (tolerance 1.00e-08)
352 Best objective 5.402666666667e+03, best bound 5.40266666667e+03, gap 0.0000%
353 SP is solved
354 SP's optimal solution is' ☐ 5402
355
356 	ext{ Itr} = 2
357 Collect_LB = [804.0, 6073.66666666668, 6326.66666666668]
358 Collect_UB = [11103.33333333336, 6326.66666666668, 6326.66666666668]
359 Collect Hua = [0.0, 5149.6666666668, 5402.6666666668]
360 Collect_SPObjVal = [5149.66666666668, 5402.6666666668, 5402.6666666668]
361 Collect_MPObjValNHua = [804.0, 924.0, 924.0]
362
363
364
      Reach the termination conditions, stop iteration
365
      Values adopted from the Itr' th iteration, and Itr = \{2\}, judgeCount = \{2\}
366
                ~judge = 2, SPObj_SPF = 5402.6666666668
367
                  pi: 0-6, ai-di: 3-37, gi_SP-gpi_SP: 0.000000-0.000000, ai_SP-di: 3-37, taoi-deltai: 3-35, taoPi_SP-deltaPi_SP: 3-35, betaNi: 32
368 Vessel i: 0:
        bi: 32
                  pi: 6-13, ai-di: 17-33, gi_SP-gpi_SP: 0.000000-0.000000,
     Vessel i: 1:
                                                                                                 taoi-deltai: 17-31, taoPi SP-deltaPi SP: 17-31, betaNi
                                                                               ai_SP-di: 17-33,
            bi: 14
     : 14,
     Vessel i: 2:
                  pi: 13-19,
                              ai-di: 23-49,
                                             gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                ai_SP-di: 23-49,
                                                                                                  taoi-deltai: 23-47,
                                                                                                                      taoPi_SP-deltaPi_SP: 23-47,
     betaNi: 24,
                  bi: 24
                             ai-di: 41-57,
                                            gi_SP-gpi_SP: 0.000000-0.000000,
                                                                               ai_SP-di: 41-57,
                                                                                                 taoi-deltai: 41-55, taoPi_SP-deltaPi_SP: 41-55, betaNi
     Vessel i: 3:
                  pi: 7-13,
     : 14,
           bi: 14
     Vessel i: 4:
                  pi: 20-26,
                              ai-di: 50-74,
                                             gi_SP-gpi_SP: 0.200000-1.000000,
                                                                                ai_SP-di: 51-74,
                                                                                                  taoi-deltai: 51-73,
                                                                                                                      taoPi_SP-deltaPi_SP: 51-73,
                  bi: 22
     betaNi: 22.
373
     Vessel i: 5:
                   pi: 12-19,
                              ai-di: 51-75, gi_SP-gpi_SP: 1.000000-0.200000,
                                                                                ai_SP-di: 59-75,
                                                                                                  taoi-deltai: 59-81,
                                                                                                                     taoPi_SP-deltaPi_SP: 59-81,
     betaNi: 22,
                  bi: 22
374
375 round LB = [804, 6074, 6327]
376 round UB = [11103, 6327, 6327]
377 round Hua = [0, 5150, 5403]
378 round SPObjVal = [5150, 5403, 5403]
379 round MPObjValNHua = [804, 924, 924]
380
381 OptimalObj = 6326.66666666688
382 Time: 73.000000
383
384
385
386
```