```
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
 3
   import sys; print('Python %s on %s' % (sys.version, sys.platform))
 4
   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 455904 rows, 40692 columns and 1255082 nonzeros
19
   Model fingerprint: 0x0544b721
   Variable types: 1 continuous, 40691 integer (40663 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
27
   Warning: Model contains large rhs
28
        Consider reformulating model or setting NumericFocus parameter
29
        to avoid numerical issues.
   Presolve removed 302987 rows and 21615 columns (presolve time = 5s) ...
30
31
   Presolve removed 405682 rows and 29722 columns
   Presolve time: 6.58s
   Presolved: 50222 rows, 10970 columns, 163928 nonzeros
34
   Variable types: 0 continuous, 10970 integer (10949 binary)
35
   Deterministic concurrent LP optimizer: primal and dual simplex (primal and dual model)
37
   Showing first log only...
38
39
   Root relaxation presolved: 50219 rows, 10973 columns, 163919 nonzeros
40
41
42
   Root simplex log...
43
44
   Iteration Objective
                       Primal Inf. Dual Inf.
       0 5.3800000e+02 6.831250e+01 1.510929e+08
45
46
   Concurrent spin time: 0.01s
48
   Solved with dual simplex (primal model)
49
50
   Root relaxation: objective 5.380000e+02, 1854 iterations, 0.26 seconds (0.20 work units)
51
52
     Nodes | Current Node | Objective Bounds
                                                    Work
53
    Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
54
55
         0 538.00000 0 9
                               - 538.00000
                      1098.0000000 538.00000 51.0%
56
   H = 0 = 0
                                                       75
57
   Η
      0
          0
                      1058.0000000 538.00000 49.1%
                                                       8s
58
   H = 0
                      818.0000000 538.00000 34.2%
                                                      8s
59
                      618.0000000 538.00000 12.9%
   H = 0
          0
                                                      8s
60
   Η
                      538.0000000 538.00000 0.00%
         0 538.00000 0 42 538.00000 538.00000 0.00%
62
63
   Cutting planes:
64
    Gomory: 3
65
    Cover: 72
    Implied bound: 2
66
67
    Clique: 2
68
    MIR: 4
69
    StrongCG: 7
70
    GUB cover: 1
    Zero half: 1
    RLT: 2
73
    Relax-and-lift: 5
   Explored 1 nodes (8791 simplex iterations) in 8.46 seconds (13.23 work units)
76
   Thread count was 8 (of 8 available processors)
   Solution count 5: 538 618 818 ... 1098
78
79
```

```
80 Optimal solution found (tolerance 1.00e-10)
 81 Best objective 5.380000000000e+02, best bound 5.38000000000e+02, gap 0.0000%
    Set parameter MIPGap to value 1e-08
 83 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
 85 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
 86
 88 Optimize a model with 335541 rows, 11221 columns and 691168 nonzeros
 89 Model fingerprint: 0xd9af1d3a
 90 Variable types: 28 continuous, 11193 integer (6468 binary)
    Coefficient statistics:
     Matrix range [1e-01, 1e+10]
 93
     Objective range [6e-05, 5e+01]
 94
      Bounds range [1e+00, 1e+00]
                    [8e-01, 1e+10]
     RHS range
    Warning: Model contains large matrix coefficients
 96
    Warning: Model contains large rhs
 97
 98
          Consider reformulating model or setting NumericFocus parameter
          to avoid numerical issues.
100 Presolve removed 334584 rows and 10872 columns
101 Presolve time: 0.48s
102 Presolved: 957 rows, 349 columns, 2567 nonzeros
103 Variable types: 0 continuous, 349 integer (203 binary)
104 Found heuristic solution: objective 3293.6923132
105 Found heuristic solution: objective 3403.6923132
106
107 Root relaxation: objective 3.755692e+03, 245 iterations, 0.00 seconds (0.00 work units)
108
109
       Nodes | Current Node | Objective Bounds
110 Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
111
112 H 0 0
                         3755.6923132 5535.69231 47.4% - 0s
                  - 0
                         3755.69231 3755.69231 0.00% -
113
114
115 Explored 1 nodes (328 simplex iterations) in 0.57 seconds (0.57 work units)
116 Thread count was 8 (of 8 available processors)
117
118 Solution count 3: 3755.69 3403.69 3293.69
119
120 Optimal solution found (tolerance 1.00e-08)
121 Best objective 3.755692313203e+03, best bound 3.755692313203e+03, gap 0.0000%
122 SP is solved
123 SP's optimal solution is' □ 3755
124
125 Itr = 0
126 \quad Collect\_LB = [538.0]
127 Collect_UB = [8049.384626406991]
128 Collect_Hua = [0.0]
129 Collect SPObjVal = [3755.6923132034954]
130 Collect MPObjValNHua = [538.0]
131
132
133 Set parameter MIPGap to value 1e-10
134 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
135
136 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
137 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
138
139 Optimize a model with 459706 rows, 180636 columns and 1258905 nonzeros
140 Model fingerprint: 0x687d9101
141 Variable types: 1 continuous, 180635 integer (180607 binary)
142 Coefficient statistics:
143
     Matrix range [1e+00, 1e+10]
     Objective range [1e+00, 2e+01]
144
145
     Bounds range [1e+00, 1e+00]
146
     RHS range
                    [1e+00, 2e+10]
    Warning: Model contains large matrix coefficients
147
148 Warning: Model contains large rhs
149
          Consider reformulating model or setting NumericFocus parameter
          to avoid numerical issues.
150
151 Presolve removed 341195 rows and 166583 columns (presolve time = 5s) ...
152 Presolve removed 420684 rows and 174163 columns
153 Presolve time: 6.34s
154 Presolved: 39022 rows, 6473 columns, 100972 nonzeros
155 Variable types: 0 continuous, 6473 integer (6452 binary)
156 Root relaxation presolved: 6473 rows, 45495 columns, 107445 nonzeros
157
158
159 Root simplex log...
160
161 Iteration Objective Primal Inf. Dual Inf.
                                                   Time
162
            handle free variables
       4432
             4.2961923e+03 0.000000e+00 0.000000e+00
163
```

```
164
       4432 4.2961923e+03 0.000000e+00 0.000000e+00
165
Root relaxation: objective 4.296192e+03, 4432 iterations, 0.49 seconds (0.78 work units)
167
168
       Nodes | Current Node | Objective Bounds
169 Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
170
171
       0 \quad \  \  0.4296.19231 \quad \  0.16
                                    - 4296.19231
                        4436.1923132 4296.19231 3.16%
172 H 0 0
       0 0 4296.19231 0 25 4436.19231 4296.19231 3.16%
173
           0 4296.19231 0 40 4436.19231 4296.19231 3.16%
174
       Ω
175
       0
           0 4296.19231 0 29 4436.19231 4296.19231 3.16%
176 H 0 0
                       4416.1923132 4296.19231 2.72% - 8s
       0 0 4296.19231 0 83 4416.19231 4296.19231 2.72%
177
                                                                 88
178
       0
           0 4296.19231 0 5 4416.19231 4296.19231 2.72%
179 H 0 0
                        4396.1923132 4296.19231 2.27% - 9s
180 H 0 0
                        4316.1923132 4296.19231 0.46%
       0 0 4296.19231 0 68 4316.19231 4296.19231 0.46% - 9s
181
182
       0 0 4296.19231 0 17 4316.19231 4296.19231 0.46%
183
       0 0 4296.19231 0 29 4316.19231 4296.19231 0.46%
                                                                 9s
184 H 0 0
                        4296.1923132 4296.19231 0.00%
185
186 Cutting planes:
187
     Learned: 1
188
      Gomory: 17
189
      Cover: 87
     Implied bound: 4
191
      Clique: 15
192
      MIR: 57
193
      StrongCG: 38
194
      GUB cover: 2
195
      Zero half: 5
196
      RLT: 6
197
      Relax-and-lift: 9
198
199 Explored 1 nodes (12871 simplex iterations) in 9.50 seconds (14.56 work units)
200 Thread count was 8 (of 8 available processors)
201
202 Solution count 5: 4296.19 4316.19 4396.19 ... 4436.19
203
204 Optimal solution found (tolerance 1.00e-10)
205 Best objective 4.296192313203e+03, best bound 4.296192313203e+03, gap 0.0000%
206 Set parameter MIPGap to value 1e-08
207 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
208
209 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
210 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
212 Optimize a model with 335541 rows, 11221 columns and 691168 nonzeros
213 Model fingerprint: 0x434545db
214 Variable types: 28 continuous, 11193 integer (6468 binary)
215 Coefficient statistics:
216 Matrix range [1e-01, 1e+10]
     Objective range [6e-05, 5e+01]
217
218 Bounds range [1e+00, 1e+00]
                    [8e-01, 1e+10]
219
     RHS range
220 Warning: Model contains large matrix coefficients
221 Warning: Model contains large rhs
222
          Consider reformulating model or setting NumericFocus parameter
223
          to avoid numerical issues.
224 Presolve removed 334304 rows and 10788 columns
225 Presolve time: 0.45s
226 Presolved: 1237 rows, 433 columns, 3330 nonzeros
227 Variable types: 0 continuous, 433 integer (254 binary)
228 Found heuristic solution: objective 3569.2222222
229
230 Root relaxation: objective 4.125222e+03, 249 iterations, 0.00 seconds (0.00 work units)
231
232
       Nodes | Current Node | Objective Bounds
                                                         Work
233
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
234
235 *
                     0 4125.2222222 4125.22222 0.00% - 0s
236
237 Explored 1 nodes (249 simplex iterations) in 0.54 seconds (0.59 work units)
238 Thread count was 8 (of 8 available processors)
239
240 Solution count 2: 4125.22 3569.22
241
242 Optimal solution found (tolerance 1.00e-08)
243 Best objective 4.12522222222e+03, best bound 4.1252222222e+03, gap 0.0000%
244 SP is solved
245 SP's optimal solution is' □4125
246
247
     Itr = 1
```

```
248 Collect LB = [538.0, 4296.192313203495]
249 Collect UB = [8049.384626406991, 4665.722222222223]
250 Collect_Hua = [0.0, 3755.6923132034954]
251 Collect_SPObjVal = [3755.6923132034954, 4125.22222222223]
252 Collect MPObjValNHua = [538.0, 540.5]
253
254
255 Set parameter MIPGap to value 1e-10
256 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
257
258 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
259 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
260
261 Optimize a model with 459706 rows, 180636 columns and 1258905 nonzeros
262 Model fingerprint: 0x47fc47a8
263 Variable types: 1 continuous, 180635 integer (180607 binary)
264 Coefficient statistics:
     Matrix range [1e+00, 1e+10]
265
266
     Objective range [1e+00, 2e+01]
267
     Bounds range [1e+00, 1e+00]
                  [1e+00, 2e+10]
268
     RHS range
269 Warning: Model contains large matrix coefficients
270 Warning: Model contains large rhs
271
         Consider reformulating model or setting NumericFocus parameter
272
         to avoid numerical issues.
273 Presolve removed 341858 rows and 166624 columns (presolve time = 5s) ...
274 Presolve removed 421054 rows and 174215 columns
275 Presolve time: 6.26s
276 Presolved: 38652 rows, 6421 columns, 100028 nonzeros
277 Variable types: 0 continuous, 6421 integer (6400 binary)
278 Root relaxation presolved: 6421 rows, 45073 columns, 106449 nonzeros
279
280
281 Root simplex log...
282
283 Iteration Objective
                         Primal Inf. Dual Inf.
                                               Time
            handle free variables
284
       4859 4.6657222e+03 0.000000e+00 0.000000e+00
285
      4859 \quad 4.6657222e{+03} \quad 0.000000e{+00} \quad 0.000000e{+00}
286
287
288 Root relaxation: objective 4.665722e+03, 4859 iterations, 0.48 seconds (0.90 work units)
289
290
      Nodes | Current Node | Objective Bounds
                                                  Work
291
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
292
293
         0 4665.72222 0 10
                                  - 4665.72222
294
          0.4665.72222 \quad 0 \quad 27
       0
                                  - 4665.72222
          0.4665.72222 \quad 0 \quad 48
295
       0
                                  - 4665.72222
                       5145.7222222 4665.72222 9.33%
296 H 0 0
          297
       0
298
       0
           299
          0.4665.72222 \quad 0 \quad 47.5145.72222.4665.72222.9.33\%
300 H 0 0
                       4905.7222222 4665.72222 4.89%
                                                      - 9s
       0 0 4665.72222 0 18 4905.72222 4665.72222 4.89% -
301
302
          0 4665.72222 0 19 4905.72222 4665.72222 4.89%
           303
       0
          304
       0
          0\ 4665.72222\quad 0\ 103\ 4905.72222\ 4665.72222\ 4.89\%
305
306
       0
           0 4665.72222 0 9 4905.72222 4665.72222 4.89% - 10s
307
          0 4665.72222 0 66 4905.72222 4665.72222 4.89%
       0
                                                          - 11s
       0 0 4665.72222 0 178 4905.72222 4665.72222 4.89% - 11s
308
309 H 0 0
                       4665.7222222 4665.72222 0.00% - 11s
       0 0 4665.72222 0 6 4665.72222 4665.72222 0.00% - 11s
310
311
312 Cutting planes:
313
     Learned: 3
314
     Gomory: 54
315
     Cover: 237
316
     Implied bound: 19
317
     Clique: 101
318
     MIR: 84
319
     StrongCG: 60
320
     GUB cover: 6
321
     Zero half: 16
322
     RLT: 1
323
     Relax-and-lift: 48
324
325 Explored 1 nodes (27017 simplex iterations) in 11.59 seconds (17.14 work units)
326 Thread count was 8 (of 8 available processors)
327
328 Solution count 3: 4665.72 4905.72 5145.72
329
330 Optimal solution found (tolerance 1.00e-10)
331 Best objective 4.665722222222e+03, best bound 4.665722222222e+03, gap 0.0000%
```

```
Set parameter MIPGap to value 1e-08
332
333 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
334
335 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
336 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
337
338 Optimize a model with 335541 rows, 11221 columns and 691168 nonzeros
339 Model fingerprint: 0xb105b898
340 Variable types: 28 continuous, 11193 integer (6468 binary)
341 Coefficient statistics:
342
     Matrix range [1e-01, 1e+10]
343
      Objective range [6e-05, 5e+01]
344
      Bounds range [1e+00, 1e+00]
                    [8e-01, 1e+10]
345
     RHS range
346
     Warning: Model contains large matrix coefficients
347
    Warning: Model contains large rhs
348
          Consider reformulating model or setting NumericFocus parameter
349
          to avoid numerical issues.
350 Presolve removed 332391 rows and 10098 columns
351 Presolve time: 0.23s
352 Presolved: 3150 rows, 1123 columns, 8375 nonzeros
353 Variable types: 6 continuous, 1117 integer (656 binary)
354 Found heuristic solution: objective 2847.8034243
355
356 Root relaxation: objective 4.145222e+03, 935 iterations, 0.00 seconds (0.01 work units)
357
358
       Nodes | Current Node | Objective Bounds
359
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
360
           361
362 H 0 0
                         3572.5812021 4145.22222 16.0% - 0s
363 H 0 0
                         3604.2478688 4145.22222 15.0%
                                                           - 0s
364
       0 0 4140.09911 0 45 3604.24787 4140.09911 14.9%
                         4135.6923132 4140.09911 0.11% - 0s
365 H 0 0
366
       0 0 cutoff 0 4135.69231 4135.69231 0.00%
367
368 Cutting planes:
369
     Learned: 2
370
      Gomory: 2
371
      Cover: 10
      Clique: 25
373
      MIR: 1
374
      Zero half: 4
375
376 Explored 1 nodes (1463 simplex iterations) in 0.38 seconds (0.49 work units)
377 Thread count was 8 (of 8 available processors)
378
379 Solution count 4: 4135.69 3604.25 3572.58 2847.8
380
381 Optimal solution found (tolerance 1.00e-08)
382 Best objective 4.135692313203e+03, best bound 4.135692313203e+03, gap 0.0000%
383 SP is solved
384 SP's optimal solution is'□4135
385
386 	ext{ Itr} = 2
387 Collect LB = [538.0, 4296.192313203495, 4665.722222222223]
388 Collect UB = [8049.384626406991, 4665.72222222223, 4665.72222222223]
389 Collect_Hua = [0.0, 3755.6923132034954, 4125.22222222223]
390 Collect_SPObjVal = [3755.6923132034954, 4125.22222222223, 4135.6923132034935]
391 Collect_MPObjValNHua = [538.0, 540.5, 540.5]
392
393
394
      Reach the termination conditions, stop iteration
395
     Values adopted from the Itr-1' th iteration, and Itr = \{2\}, judgeCount = \{1\}
396
397
                ~judgeCount = 1, SPObj_SPF = 4125.22222222223
398
    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,
     . 6
399
    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
                  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,
     Vessel i: 3:
     betaNi: 16,
                  bi: 16
                  pi: 19-24.
                                                                                                                      taoPi_SP-deltaPi_SP: 24-33,
     Vessel i. 4.
                               ai-di: 20-45.
                                             gi_SP-gpi_SP: 0.375000-0.025000,
                                                                                ai_SP-di: 21-45,
                                                                                                  taoi-deltai: 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
404
                  pi: 21-26,
    Vessel i: 6:
                               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
405
406 round LB = [538, 4296, 4666]
407 round UB = [8049, 4666, 4666]
408 round Hua = [0, 3756, 4125]
```

unknown

409	round SPObjVal = [3756, 4125, 4136]
410	round SPObjVal = [3756, 4125, 4136] round MPObjValNHua = [538, 540, 540] OptimalObj = 4665.722222222222 Time: 83.000000
411	OntimalObi = 4665.722222222223
413	Time: 83.000000
1414	
415 416 417	
417	