```
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=56726
 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 0.001
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 398368 rows, 34789 columns and 1098502 nonzeros
19
   Model fingerprint: 0x917db14a
   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
27
   Warning: Model contains large rhs
28
        Consider reformulating model or setting NumericFocus parameter
29
        to avoid numerical issues.
30
   Presolve removed 191256 rows and 12027 columns (presolve time = 5s) ...
31
   Presolve removed 348926 rows and 21902 columns
   Presolve time: 8.09s
   Presolved: 49442 rows, 12887 columns, 199039 nonzeros
    Variable types: 0 continuous, 12887 integer (12869 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: 49438 rows, 12891 columns, 199027 nonzeros
40
41
42
   Root simplex log...
43
44
   Iteration Objective
                         Primal Inf. Dual Inf.
       0 8.9700000e+02 7.187500e+01 1.412650e+08
45
46
   Concurrent spin time: 0.03s
48
   Solved with dual simplex (primal model)
49
50
   Root relaxation: objective 8.970000e+02, 1913 iterations, 0.31 seconds (0.25 work units)
51
52
      Nodes | Current Node | Objective Bounds
                                                      Work
53
    Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
54
         0 897.00000 0 2
55
                                 - 897.00000
                      1737.0000000 897.00000 48.4% -
56
   H \quad 0 \quad 0
57
      0 0 897.00000 0 8 1737.00000 897.00000 48.4% - 10s
58 H 0 0
                       1057.0000000 897.00000 15.1% - 10s
59 H 0
                       957.0000000 897.00000 6.27% - 10s
60
   Explored 1 nodes (11312 simplex iterations) in 15.63 seconds (25.36 work units)
   Thread count was 8 (of 8 available processors)
62
63
64
   Solution count 3: 957 1057 1737
65
   Optimal solution found (tolerance 1.00e-03)
66
67
   Best objective 9.570000000000e+02, best bound 9.57000000000e+02, gap 0.0000%
    Set parameter MIPGap to value 1e-08
   Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
70
   CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
71
   Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
   Optimize a model with 252611 rows, 9618 columns and 522175 nonzeros
74
   Model fingerprint: 0x1a234adb
   Variable types: 24 continuous, 9594 integer (5544 binary)
   Coefficient statistics:
77
78
    Matrix range [1e-01, 1e+10]
    Objective range [6e-05, 5e+01]
79
```

```
Bounds range
                    [1e+00, 1e+00]
 80
 81
     RHS range
                    [8e-01, 1e+10]
    Warning: Model contains large matrix coefficients
 83
    Warning: Model contains large rhs
         Consider reformulating model or setting NumericFocus parameter
 85
         to avoid numerical issues.
 86 Presolve removed 247826 rows and 8144 columns
 87 Presolve time: 0.83s
    Presolved: 4785 rows, 1474 columns, 12785 nonzeros
    Variable types: 4 continuous, 1470 integer (840 binary)
 90 Found heuristic solution: objective 3668.6666667
    Found heuristic solution: objective 3808.6666667
 93 Root relaxation: objective 5.138792e+03, 1365 iterations, 0.08 seconds (0.03 work units)
 94
 95
       Nodes | Current Node | Objective Bounds
 96
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
 97
 98
       0 0 5138.79167 0 33 3808.66667 5138.79167 34.9%
 99 H 0 0
                        4760.1666667 5136.16667 7.90%
                                                          - 1s
       0 0 5136.16667 0 12 4760.16667 5136.16667 7.90% - 1s
100
                       5136.1666667 5136.16667 0.00% - 1s
101 H 0 0
       0 0 5136.16667 0 12 5136.16667 5136.16667 0.00% - 1s
102
103
104 Cutting planes:
105
     Gomory: 3
     Implied bound: 3
106
107
     Clique: 26
108
     MIR: 4
109
     Flow cover: 1
110
     Zero half: 1
     RLT: 1
111
112
     Relax-and-lift: 2
113
114 Explored 1 nodes (2790 simplex iterations) in 1.38 seconds (0.66 work units)
115 Thread count was 8 (of 8 available processors)
116
117 Solution count 4: 5136.17 4760.17 3808.67 3668.67
118
119 Optimal solution found (tolerance 1.00e-08)
120 Best objective 5.136166666667e+03, best bound 5.136166666667e+03, gap 0.0000%
121 SP is solved
122 SP's optimal solution is' ☐ 5136
123
124 	ext{ Itr} = 0
125 Collect LB = [957.0]
126 Collect_UB = [11229.333333333333333333
127 Collect_Hua = [0.0]
128 Collect SPObjVal = [5136.1666666666715]
129 Collect_MPObjValNHua = [957.0]
130
131
132 Set parameter MIPGap to value 0.05
133 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
134
135 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
136 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
137
138 Optimize a model with 403795 rows, 137605 columns and 1103944 nonzeros
139 Model fingerprint: 0x14abc000
140 Variable types: 1 continuous, 137604 integer (137580 binary)
141 Coefficient statistics:
142 Matrix range [1e+00, 1e+10]
     Objective range [1e+00, 2e+01]
143
     Bounds range [1e+00, 1e+00]
144
145
     RHS range
                   [1e+00, 2e+10]
146 Warning: Model contains large matrix coefficients
147 Warning: Model contains large rhs
148
          Consider reformulating model or setting NumericFocus parameter
149
         to avoid numerical issues.
150 Presolve removed 238372 rows and 120798 columns (presolve time = 5s) ...
151 Presolve removed 384612 rows and 130917 columns
152 Presolve time: 8.57s
153 Presolved: 19183 rows, 6688 columns, 85979 nonzeros
154 Variable types: 0 continuous, 6688 integer (6670 binary)
155
156 Root simplex log...
157
158 Iteration Objective
                          Primal Inf. Dual Inf.
                                                  Time
        0 6.0406667e+03 9.430000e+02 0.000000e+00
159
       4654 6.0406667e+03 0.000000e+00 0.000000e+00
160
161
162 Root relaxation: objective 6.040667e+03, 4654 iterations, 0.09 seconds (0.13 work units)
163
```

```
164
       Nodes | Current Node |
                                  Objective Bounds
                                                         Work
165
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
166
167
           0 6040.66667 0 16
                                    - 6040.66667
           0 6040.66667 0 67
                                    - 6040.66667
168
169
       0
           0 6040.66667
                         0 169
                                    - 6040.66667
                                                       - 10s
                                    - 6040.66667
                                                       - 14s
170
       0
           0.6040.66667 0.115
171
           0 6040.66667 0 494
                                     - 6040.66667
                                                       - 15s
172
       0
           0 6040.66667
                         0 489
                                     - 6040.66667
                                                       - 15s
                                                       - 19s
           0 6040.66667 0 154
                                     - 6040.66667
173
       0
           0 6040.66667 0 396
                                     - 6040.66667
174
       0
                                                       - 21s
                                                       - 23s
175
       0
           0 6040.66667 0 123
                                     - 6040.66667
176
       0
           0 6040.66667 0 123
                                     - 6040.66667
                                                    - - 24s
           2 6040.66667 0 117
177
                                     - 6040.66667
                                                    - - 26s
       0
178
       16
           11 6040.66667 6 376
                                      - 6040.66667
                                                   - 2591 30s
           32 6040.66667 13 275
179
       43
                                      - 6040.66667
                                                    - 2381 35s
180
      197 204 6040.66667 30 248
                                       - 6040.66667
                                                      - 736 40s
    * 235 204
                      67 6740.6666667 6040.66667 10.4% 620 40s
181
182
      396 230 6060.66667 54 382 6740.66667 6040.66667 10.4% 457 45s
183
      881 575 6060.66667 245 230 6740.66667 6040.66667 10.4% 233 50s
184 * 938 523
                      113 6540.6666667 6040.66667 7.64% 221 50s
                           6380.6666667\ 6040.66667\ 5.33\%\ 233\ 51s
185 H 969 390
186 H 996 279
                           6300.6666667 6040.66667 4.13% 231
                           6260.6666667 6040.66667 3.51% 231 52s
187 H 996 227
188
189 Cutting planes:
190
    Learned: 922
      Gomory: 1
191
192
      Cover: 588
193
      Implied bound: 289
194
      Clique: 173
195
      MIR: 204
196
      StrongCG: 94
197
      GUB cover: 6
198
      Zero half: 16
199
      RLT: 13
200
      Relax-and-lift: 64
201
202
203 Explored 1013 nodes (326652 simplex iterations) in 52.26 seconds (93.03 work units)
204 Thread count was 8 (of 8 available processors)
205
206 Solution count 5: 6260.67 6300.67 6380.67 ... 6740.67
207
208 Optimal solution found (tolerance 5.00e-02)
209 Best objective 6.260666666667e+03, best bound 6.04066666667e+03, gap 3.5140%
210 Set parameter MIPGap to value 1e-08
211 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
212
213 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
214 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
216 Optimize a model with 252611 rows, 9618 columns and 522175 nonzeros
217 Model fingerprint: 0x07d1d5c2
218 Variable types: 24 continuous, 9594 integer (5544 binary)
219 Coefficient statistics:
220 Matrix range [1e-01, 1e+10]
221
      Objective range [6e-05, 5e+01]
222
      Bounds range [1e+00, 1e+00]
                   [8e-01, 1e+10]
     RHS range
    Warning: Model contains large matrix coefficients
224
225
    Warning: Model contains large rhs
226
         Consider reformulating model or setting NumericFocus parameter
227
         to avoid numerical issues.
228 Presolve removed 246863 rows and 7848 columns
229 Presolve time: 0.23s
230 Presolved: 5748 rows, 1770 columns, 15223 nonzeros
231 Variable types: 4 continuous, 1766 integer (1017 binary)
232 Found heuristic solution: objective 3714.7551108
233
234 Root relaxation: objective 5.283667e+03, 1862 iterations, 0.02 seconds (0.02 work units)
235
236
       Nodes | Current Node | Objective Bounds
237
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
238
239 *
                     0 5283.6666667 5283.66667 0.00% - 0s
240
241 Explored 1 nodes (2851 simplex iterations) in 0.36 seconds (0.59 work units)
242 Thread count was 8 (of 8 available processors)
243
244 Solution count 2: 5283.67 3714.76
245
246 Optimal solution found (tolerance 1.00e-08)
247 Best objective 5.28366666667e+03, best bound 5.28366666667e+03, gap 0.0000%
```

```
248 SP is solved
249 SP's optimal solution is' 5283
250
251 Itr = 1
252 Collect LB = [957.0, 6260.6666666666715]
253 Collect UB = [11229.33333333343, 6408.16666666668]
254 Collect_Hua = [0.0, 5136.166666666715]
255 Collect_SPObjVal = [5136.1666666666715, 5283.66666666668]
256 Collect MPObjValNHua = [957.0, 1124.5]
257
258
259 Set parameter MIPGap to value 0.05
260 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
261
262 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
263 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
264
265 Optimize a model with 403795 rows, 137605 columns and 1103944 nonzeros
266 Model fingerprint: 0x3730fd1c
267
    Variable types: 1 continuous, 137604 integer (137580 binary)
268 Coefficient statistics:
      Matrix range [1e+00, 1e+10]
269
270
      Objective range [1e+00, 2e+01]
      Bounds range [1e+00, 1e+00]
271
     RHS range
                   [1e+00, 2e+10]
272
273
    Warning: Model contains large matrix coefficients
274 Warning: Model contains large rhs
          Consider reformulating model or setting NumericFocus parameter
275
276
         to avoid numerical issues.
277 Presolve removed 238307 rows and 120806 columns (presolve time = 5s) ...
278 Presolve removed 384613 rows and 130917 columns
279 Presolve time: 8.33s
280 Presolved: 19182 rows, 6688 columns, 85971 nonzeros
    Variable types: 0 continuous, 6688 integer (6670 binary)
281
282
283 Root simplex log...
284
285 Iteration Objective
                         Primal Inf. Dual Inf.
        0 6.1806667e+03 9.430000e+02 0.000000e+00
286
287
       4622 6.1806667e+03 0.000000e+00 0.000000e+00
288
289 Root relaxation: objective 6.180667e+03, 4622 iterations, 0.11 seconds (0.13 work units)
290
291
       Nodes | Current Node | Objective Bounds
292
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
293
294
           0.6180.66667 0 16
                                    - 6180.66667
295
           0 6180.66667 0 167
                                     - 6180.66667
296
           0 6180.66667 0 183
                                     - 6180.66667
                                                       - 10s
                                    - 6180.66667
297
           0.6180.66667 0.191
       0
                                                       - 10s
298
       0
           0 6180.66667 0 125
                                    - 6180.66667
                                                       - 10s
299
           0 6180.66667 0 191
                                     - 6180.66667
300
           0 6180.66667 0 170
                                    - 6180.66667
       0
                                                       - 16s
                                                      - 18s
           0 6180.66667 0 488
                                    - 6180,66667
301
       0
302
           0 6180.66667 0 185
                                     - 6180.66667
                                                       - 21s
       0
                                                       - 22s
303
           0 6180.66667 0 564
                                     - 6180.66667
           0 6180.66667 0 419
                                                   - - 26s
304
       0
                                    - 6180.66667
                                                   - - 27s
305
       0
           0 6180.66667 0 402
                                    - 6180.66667
306
       0
           2 6180.66667
                         0 374
                                     - 6180.66667
                                                       - 29s
                                     - 6180.66667 - 2930 31s
- 6180.66667 - 2279 35s
307
           6 6630.66667 3 177
                                     - 6180.66667
308
           23 6756.83688 8 382
       31
                         6920.6666667 6180.66667 10.7% 1809 37s
309 H 46 33
310 * 76 35
                      19 6900.6666667 6180.66667 10.4% 1764 39s
311
       77 41 cutoff 14
                            6900.66667 6180.66667 10.4% 1741 40s
312 H 165 124
                           6860.6666667 6180.66667 9.91% 921 41s
313 H 220 158
                           6780.6666667 6180.66667 8.85% 705 42s
314 H 262
            196
                           6700.6666667 6180.72116 7.76% 628 43s
                           6660.6666667 6180.72116 7.21% 598 43s
315 H 277
            196
316 H 284 196
                           6620.6666667 6180.72116 6.65% 584 43s
317 H 326 247
                           6580.6666667 6180.72116 6.08% 525 45s
318 H 354 247
                           6500.6666667 6180.72116 4.92% 485 45s
319
320 Cutting planes:
321
     Learned: 3
     Gomory: 8
322
323
      Cover: 614
324
      Implied bound: 312
325
      Clique: 174
326
      MIR: 177
327
      StrongCG: 109
      GUB cover: 66
328
      Zero half: 51
329
330
      RLT: 14
      Relax-and-lift: 223
331
```

```
332
      BOP: 2
333
334 Explored 368 nodes (268675 simplex iterations) in 45.17 seconds (78.08 work units)
335
    Thread count was 8 (of 8 available processors)
336
337 Solution count 9: 6500.67 6580.67 6620.67 ... 6920.67
338
339 Optimal solution found (tolerance 5.00e-02)
340 Best objective 6.500666666667e+03, best bound 6.20066666667e+03, gap 4.6149%
341 Set parameter MIPGap to value 1e-08
342 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
343
344 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
345 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
346
347 Optimize a model with 252611 rows, 9618 columns and 522175 nonzeros
348 Model fingerprint: 0x8b05bbc5
349 Variable types: 24 continuous, 9594 integer (5544 binary)
350 Coefficient statistics:
351
      Matrix range [1e-01, 1e+10]
      Objective range [6e-05, 5e+01]
352
353
      Bounds range [1e+00, 1e+00]
      RHS range
                    [8e-01, 1e+10]
354
355 Warning: Model contains large matrix coefficients
356 Warning: Model contains large rhs
357
          Consider reformulating model or setting NumericFocus parameter
358
          to avoid numerical issues.
359 Presolve removed 246724 rows and 7818 columns
360 Presolve time: 0.22s
361 Presolved: 5887 rows, 1800 columns, 15681 nonzeros
362
    Variable types: 4 continuous, 1796 integer (1036 binary)
363 Found heuristic solution: objective 971.8435550
364 Found heuristic solution: objective 3879.6666667
365
Root relaxation: objective 5.430667e+03, 1594 iterations, 0.02 seconds (0.03 work units)
367
368
       Nodes | Current Node | Objective Bounds
                                                          Work
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
369
370
                         5430.6666667 16108.0000 197% - 0s
371 H 0 0
                  - 0
                         5430.66667 5430.66667 0.00% - 0s
372
373
374 Explored 1 nodes (2365 simplex iterations) in 0.36 seconds (0.58 work units)
375 Thread count was 8 (of 8 available processors)
376
    Solution count 3: 5430.67 3879.67 971.844
377
378
379
    Optimal solution found (tolerance 1.00e-08)
380 Best objective 5.430666666667e+03, best bound 5.43066666667e+03, gap 0.0000%
381
    SP is solved
382 SP's optimal solution is' □ 5430
383
384 	ext{ Itr} = 2
385 Collect_LB = [957.0, 6260.6666666666715, 6500.66666666668]
386 Collect_UB = [11229.3333333333343, 6408.16666666668, 6408.16666666668]
387 Collect Hua = [0.0, 5136.1666666666715, 5283.66666666668]
388 Collect SPObjVal = [5136.16666666666715, 5283.66666666668, 5430.66666666668]
389 Collect_MPObjValNHua = [957.0, 1124.5, 1217.0]
390
391
392
      Ops, stop iteration
393
     Values adopted from the Itr-1' th iteration, and Itr = \{2\}, judgeCount = \{1\}
394
395
               ~~judgeCount = 1, SPObj_SPF = 5283.6666666668
                                         gi_SP-gpi_SP: 0.000000-0.000000,
396
    Vessel i: 0:
                  pi: 0-6,
                            ai-di: 4-12,
                                                                              ai_SP-di: 4-12, taoi-deltai: 4-10, taoPi_SP-deltaPi_SP: 4-7, betaNi: 6,
     bi: 6
                  pi: 0-7,
     Vessel i: 1:
                            ai-di: 20-54,
                                           gi SP-gpi SP: 0.000000-0.000000,
                                                                               ai SP-di: 20-54,
                                                                                                  taoi-deltai: 20-52,
                                                                                                                      taoPi SP-deltaPi SP: 22-52,
                                                                                                                                                   betaNi:
     32, bi: 32
                  pi: 7-14,
398
    Vessel i: 2:
                             ai-di: 24-60,
                                            gi SP-gpi SP: 0.000000-0.000000,
                                                                                 ai SP-di: 24-60,
                                                                                                   taoi-deltai: 24-58,
                                                                                                                       taoPi SP-deltaPi SP: 24-58,
                                                                                                                                                     betaNi
           bi: 34
      34,
                  pi: 27-34,
                                             gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                                                        taoPi_SP-deltaPi_SP: 31-53,
     Vessel i: 3:
                               ai-di: 31-55,
                                                                                 ai_SP-di: 31-55,
                                                                                                    taoi-deltai: 31-53.
     betaNi: 22,
                  bi: 22
     Vessel i: 4:
                  pi: 14-21,
                               ai-di: 30-68,
                                             gi_SP-gpi_SP: 0.200000-1.000000,
                                                                                  ai_SP-di: 31-68,
                                                                                                    taoi-deltai: 42-69,
                                                                                                                        taoPi SP-deltaPi SP: 42-69,
     betaNi: 27,
                  bi: 27
401
                  pi: 27-34.
                               ai-di: 50-68,
                                             gi_SP-gpi_SP: 1.000000-0.200000,
                                                                                 ai SP-di: 58-68,
                                                                                                                        taoPi SP-deltaPi SP: 58-65,
     Vessel i: 5:
                                                                                                    taoi-deltai: 57-65.
     betaNi: 8,
                 bi: 8
402
403 round LB = [957, 6261, 6501]
404 round UB = [11229, 6408, 6408]
405 round Hua = [0, 5136, 5284]
406 round SPObjVal = [5136, 5284, 5431]
407 round MPObjValNHua = [957, 1124, 1217]
408
409
    OptimalObj = 6500.6666666668
```

unknown

410	Time: 169.000000
411	Time. 109.000000
412	
412 413	
414	
1	
1	
1	
1	
1	
1	
1	