```
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=31087
   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 646413 rows, 64824 columns and 1832833 nonzeros
19
   Model fingerprint: 0x2872db6c
   Variable types: 1 continuous, 64823 integer (64779 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 395742 rows and 31115 columns (presolve time = 5s) ...
31
   Presolve removed 542577 rows and 42602 columns
   Presolve time: 9.36s
   Presolved: 103836 rows, 22222 columns, 338252 nonzeros
   Variable types: 0 continuous, 22222 integer (22193 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: 22222 rows, 126058 columns, 360474 nonzeros
40
41
42
   Root simplex log...
43
44
   Iteration Objective
                       Primal Inf. Dual Inf.
       0 1.0160000e+03 0.000000e+00 1.256000e+03
45
                                                    10s
46
      364 1.0162009e+03 0.000000e+00 8.070676e+03
47
   Concurrent spin time: 0.02s
48
49
   Solved with dual simplex (primal model)
50
51
   Root relaxation: objective 1.016000e+03, 2750 iterations, 0.42 seconds (0.47 work units)
52
53
     Nodes | Current Node | Objective Bounds
                                               Work
54
    Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
55
56
      0
         0 1016.00000 0 10
                                - 1016.00000
                                              - - 11s
57
      0
         0 1016.00000 0 27
                                - 1016.00000
                                                 - 12s
                                - 1016.00000
58
         0 1016.00000 0 20
59
   H 0 0
                     5096.0000000 1016.00000 80.1% - 13s
60
     0 0 1016.00000 0 18 5096.00000 1016.00000 80.1%
   H = 0
                     1416.0000000 1016.00000 28.2% - 14s
61
         62
63
         0
64 H 0
                     1336.0000000 1016.00000 24.0% - 17s
         2 1016.00000 0 51 1336.00000 1016.00000 24.0%
65
         4 1016.00000 1 38 1336.00000 1016.00000 24.0% 1768 20s
66
67
     54 55 1016.00000 9 98 1336.00000 1016.00000 24.0% 313 25s
68
   H 164 112
                       1176.0000000 1016.00000 13.6% 323 29s
    166 117 1016.00000 30 81 1176.00000 1016.00000 13.6% 349 31s
70 H 206 134
                       1136.0000000 1016.00000 10.6% 373 33s
    230 155 1016.00000 35 251 1136.00000 1016.00000 10.6% 386 35s
   H 275 167
                       1016.0000000 1016.00000 0.00% 364 38s
73
74
   Cutting planes:
    Cover: 299
76
    Implied bound: 1222
77
    Clique: 4
78
    MIR: 39
    StrongCG: 64
79
```

```
GUB cover: 6
 80
 81
      RLT: 3
      Relax-and-lift: 422
 82
 83
 84 Explored 319 nodes (151515 simplex iterations) in 38.42 seconds (80.32 work units)
 85 Thread count was 8 (of 8 available processors)
 86
 87 Solution count 6: 1016 1136 1176 ... 5096
 88
 89 Optimal solution found (tolerance 1.00e-10)
 90 Best objective 1.016000000000e+03, best bound 1.01600000000e+03, gap 0.0000%
 91
     Set parameter MIPGap to value 1e-08
    Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
 93
 94 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
 95 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
 96
 97 Optimize a model with 783600 rows, 17633 columns and 1599413 nonzeros
 98 Model fingerprint: 0xea826290
    Variable types: 44 continuous, 17589 integer (10164 binary)
100 Coefficient statistics:
101
     Matrix range [1e-01, 1e+10]
      Objective range [6e-05, 5e+01]
102
     Bounds range [1e+00, 1e+00]
103
                    [8e-01, 1e+10]
104
     RHS range
105 Warning: Model contains large matrix coefficients
106 Warning: Model contains large rhs
          Consider reformulating model or setting NumericFocus parameter
107
108
          to avoid numerical issues.
109 Presolve removed 778935 rows and 16036 columns
110 Presolve time: 0.53s
111 Presolved: 4665 rows, 1597 columns, 12489 nonzeros
112 Variable types: 9 continuous, 1588 integer (931 binary)
113 Found heuristic solution: objective 4116.7031603
114
Root relaxation: objective 6.543431e+03, 1418 iterations, 0.03 seconds (0.02 work units)
116
117
       Nodes | Current Node | Objective Bounds
118 \quad Expl \ Unexpl \ | \ Obj \ Depth \ IntInf \ | \ Incumbent \quad BestBd \quad Gap \ | \ It/Node \ Time
119
120
       0 \quad 0.6543.43142 \quad 0.154.4116.70316.6543.43142.58.9\%
121 H 0 0
                         6490.8160331 6543.43142 0.81% - 0s
122 H 0 0
                         6530.8160331 6543.43142 0.19% - 0s
123
124 Cutting planes:
125 Learned: 50
126
     Gomory: 14
127
      Cover: 5
     Implied bound: 24
128
129
      Clique: 7
130
      MIR: 3
131
     Flow cover: 2
      Zero half: 1
132
133
      Network: 3
134
135 Explored 1 nodes (2278 simplex iterations) in 0.78 seconds (1.13 work units)
136 Thread count was 8 (of 8 available processors)
137
138 Solution count 3: 6530.82 6490.82 4116.7
139
140 Optimal solution found (tolerance 1.00e-08)
141 Best objective 6.530816033068e+03, best bound 6.530816033068e+03, gap 0.0000%
142 SP is solved
143 SP's optimal solution is' ☐ 6530
144
145 Itr = 0
146 Collect LB = [1016.0]
147 Collect_UB = [14077.632066136313]
148 Collect_Hua = [0.0]
149 Collect_SPObjVal = [6530.816033068157]
150 Collect_MPObjValNHua = [1016.0]
151
152
153 Set parameter MIPGap to value 1e-10
154 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
155
156 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
157 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
158
159 Optimize a model with 658039 rows, 410400 columns and 1844514 nonzeros
160 Model fingerprint: 0x9d7f1390
161 Variable types: 1 continuous, 410399 integer (410355 binary)
162 Coefficient statistics:
     Matrix range [1e+00, 1e+10]
163
```

```
Objective range [1e+00, 2e+01]
164
165
      Bounds range [1e+00, 1e+00]
                   [1e+00, 2e+10]
166
     RHS range
167
     Warning: Model contains large matrix coefficients
    Warning: Model contains large rhs
         Consider reformulating model or setting NumericFocus parameter
169
170
         to avoid numerical issues.
171 Presolve removed 494184 rows and 390193 columns (presolve time = 5s) ...
    Presolve removed 606382 rows and 401131 columns
    Presolve time: 9.30s
173
    Presolved: 51657 rows, 9269 columns, 133938 nonzeros
174
    Variable types: 0 continuous, 9269 integer (9242 binary)
176 Root relaxation presolved: 9269 rows, 60926 columns, 143207 nonzeros
177
178
179
    Root simplex log...
180
181
    Iteration Objective
                          Primal Inf. Dual Inf.
                                                Time
182
            handle free variables
                                            10s
183
       4281
             9.2575497e+03 1.601634e+04 0.0000000e+00
                                                          10s
             7.9628160e+03 0.000000e+00 0.000000e+00
184
       8105
                                                          11s
185
       8105
            7.9628160e+03 0.000000e+00 0.000000e+00
                                                          11s
186
187
    Root relaxation: objective 7.962816e+03, 8105 iterations, 0.98 seconds (1.69 work units)
188
189
       Nodes | Current Node | Objective Bounds | Work
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
190
191
192
                                   - 7962.81603
           0 7962.81603 0 38
                                                 - - 11s
193
           0 7962.81603 0 103
                                    - 7962.81603
194
       0
           0 7962.81603
                         0 38
                                   - 7962.81603
                                                     - 11s
195
           0.7962.81603
                         0.311
                                   - 7962.81603
                                                     - 12s
       0
196
       0
           0 7962.81603
                         0 278
                                    - 7962.81603
                                                      - 12s
197
       0
           0 7962.81603
                         0 381
                                    - 7962.81603
198
           0 7962.81603
                         0 325
                                    - 7962.81603
                                                     - 13s
       0
199
                                    - 7962.81603
           0.7962.81603
                         0.300
                                                      - 13s
200
       0
           0 7962.81603
                         0 136
                                    - 7962.81603
                                                     - 15s
201
           0 7962.81603
                         0 249
                                    - 7962.81603
                                                      - 16s
202
           0 7962.81603
                                    - 7962.81603
       0
                         0 212
                                                     - 17s
203
       0
           0 7962.81603
                         0 196
                                    - 7962.81603
                                                     - 18s
204
           0 7962.81603
                                    - 7962.81603
                         0 433
205
           0 7962.81603
                         0 59
                                   - 7962.81603
                                                     - 20s
       0
                                                     - 20s
206
                         0 42
                                   - 7962 81603
       0
           0.7962.81603
207
       0
           0 7962.81603
                         0 343
                                    - 7962.81603
                                                     - 21s
208
       0
           0 7962.81603
                         0 340
                                    - 7962.81603
                                                        21s
209
       0
           0 7962.81603 0 470
                                    - 7962.81603
                                                     - 21s
210
           0 7962.81603
                         0 470
                                    - 7962.81603
                                                        21s
211
       0
           0 7962.81603
                         0 120
                                    - 7962.81603
212
           0 7962.81603
                         0 429
                                    - 7962.81603
                                                      - 25s
213
                                    - 7962.81603
       0
           0 7962.81603
                         0 426
                                                     - 25s
214
       0
           0 7962.81603
                         0 259
                                    - 7962.81603
                                                     - 27s
215
           0 7962.81603
                         0 338
                                    - 7962.81603
           0 7962.81603 0 296
216
       0
                                    - 7962.81603
                                                  - - 27s
217
       0
           2 7962.81603
                         0 296
                                    - 7962.81603
                                                      - 29s
218
           5 7962.81603 1 317
                                    - 7962.81603
                                                  - 2656 30s
219
       35
           46 7980.01298 7 918
                                     - 7962.81603
                                                   - 2592
220
      176
          214 8022.81603 25 605
                                      - 7962.81603 - 1231 40s
221
      563 590 8362.81603 21 393
                                      - 7962.81603
                                                     - 588 45s
222
      1069
           791 8522.81603 225 433
                                        - 7962.81603
                                                     - 389 64s
223
           792 8714.39498 43 37
                                      - 7962.81603
      1071
                                                     - 388 67s
224
      1073
           794 9222.81603 30 795
                                       - 7962.81603
                                                     - 387 73s
225
      1074
           794 8122.81603 162 517
                                       - 7962.81603
                                                      - 387
                                                             80s
226
      1076 796 8202.81603 206 320
                                       - 7962.81603
                                                     - 386 87s
227
           796 7962.81603 4 631
                                      - 7962.81603
                                                     - 386 91s
      1077
228
      1078 797 8442.81603 198 350
                                       - 7962.81603
                                                     - 385 96s
229
      1079 798 8462.81603 52 719
                                       - 7962.81603
                                                     - 385 100s
230
      1080
           798 8022.81603 32 552
                                       - 7962.81603
                                                      - 385 106s
231
      1082 800 8162.81603 159 752
                                       - 7962 81603
                                                     - 384 114s
232
      1083
           800 8042.81603 196 859
                                       - 7962.81603
                                                      - 384 117s
233
                                                      - 383 122s
      1084
           801 8112.81603 104 496
                                       - 7962.81603
234
      1085 802 8222.81603 151 868
                                       - 7962.81603
                                                      - 383 126s
235
           802 8162.81603 134 502
      1086
                                       - 7962.81603
                                                      - 383 132s
236
      1087
           803 8714.39498 41 1004
                                       - 7962.81603
                                                      - 382 135s
237
                                                      - 382 141s
      1088 804 8142.81603 164 663
                                       - 7962.81603
238
      1089 804 8262 81603 109 989
                                       - 7962 81603
                                                      - 381 145s
239
      1091 806 8062.81603 56 478
                                       - 7962.81603
                                                      - 381 153s
240
      1092
           806 8602.81603 195 478
                                       - 7962.81603
                                                     - 380 157s
                                                     - 575 161s
241
      1093
           810 7962.81603 10 465
                                       - 7962.81603
      1095 813 7962.81603 11 446
                                                      - 585 165s
242
                                       - 7962.81603
243 H 1099 775
                          8202.8160331 7962.81603 2.93% 601 168s
244 H 1103
            737
                          8162.8160331 7962.81603 2.45% 619 174s
                          8042.8160331 7962.81603 0.99% 619 174s
245 H 1103 700
     1107 698 7962.81603 13 643 8042.81603 7962.81603 0.99% 700 176s
246
247 H 1133 650
                          7982.8160331 7962.81603 0.25% 728 180s
```

```
248 H 1138 614
                            7962.8160331 7962.81603 0.00% 727 180s
249
250 Cutting planes:
251
     Learned: 2
252
     Gomory: 5
253
      Cover: 171
254
     Implied bound: 38
255
     Clique: 31
256
      MIR: 45
      StrongCG: 26
257
258
     Flow cover: 26
259
      GUB cover: 30
260
      Zero half: 14
261
      RLT: 18
262
      Relax-and-lift: 60
263
      BOP: 13
264
265 Explored 1139 nodes (878518 simplex iterations) in 180.50 seconds (326.79 work units)
266 Thread count was 8 (of 8 available processors)
267
268 Solution count 5: 7962.82 7982.82 8042.82 ... 8202.82
269
270 Optimal solution found (tolerance 1.00e-10)
271 Best objective 7.962816033068e+03, best bound 7.962816033068e+03, gap 0.0000%
272 Set parameter MIPGap to value 1e-08
273 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
274
275 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
276 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
277
278 Optimize a model with 783600 rows, 17633 columns and 1599413 nonzeros
279 Model fingerprint: 0x9202f5f4
280 Variable types: 44 continuous, 17589 integer (10164 binary)
281 Coefficient statistics:
282 Matrix range [1e-01, 1e+10]
     Objective range [6e-05, 5e+01]
283
284
      Bounds range [1e+00, 1e+00]
                    [8e-01, 1e+10]
285
     RHS range
    Warning: Model contains large matrix coefficients
286
287
     Warning: Model contains large rhs
288
          Consider reformulating model or setting NumericFocus parameter
289
          to avoid numerical issues.
290 Presolve removed 776211 rows and 15274 columns
291 Presolve time: 0.56s
292 Presolved: 7389 rows, 2359 columns, 19792 nonzeros
293 Variable types: 10 continuous, 2349 integer (1343 binary)
294
295 Root relaxation: objective 7.317111e+03, 2159 iterations, 0.03 seconds (0.03 work units)
296
297
       Nodes | Current Node | Objective Bounds

↓ Work

298
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
299
300
       0 0 7317.11111 0 48
                                     - 7317.11111
                         7296.4444444 7317.11111 0.28%
301 H 0 0
302 H 0 0
                         7301.1111111 7317.11111 0.22%
303 H 0
                         7314.4444444 7317.11111 0.04%
304
305 Cutting planes:
306
307
308 Explored 1 nodes (2933 simplex iterations) in 0.84 seconds (1.30 work units)
309 Thread count was 8 (of 8 available processors)
310
311 Solution count 3: 7314.44 7301.11 7296.44
312
313 Optimal solution found (tolerance 1.00e-08)
314 Best objective 7.31444444444e+03, best bound 7.3144444444e+03, gap 0.0000%
315 SP is solved
316 SP's optimal solution is' ☐ 7314
317
318 	ext{ Itr} = 1
319 Collect_LB = [1016.0, 7962.816033068157]
320 Collect_UB = [14077.632066136313, 8746.44444444445]
321 Collect Hua = [0.0, 6530.816033068157]
322 Collect SPObjVal = [6530.816033068157, 7314.444444444445]
323 Collect MPObjValNHua = [1016.0, 1432.0]
324
325
326 Set parameter MIPGap to value 1e-10
327 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
328
329 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
330 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
331
```

```
332 Optimize a model with 658039 rows, 410400 columns and 1844514 nonzeros
333 Model fingerprint: 0xc171d781
    Variable types: 1 continuous, 410399 integer (410355 binary)
334
335 Coefficient statistics:
     Matrix range [1e+00, 1e+10]
336
337
      Objective range [1e+00, 2e+01]
338
      Bounds range [1e+00, 1e+00]
339
     RHS range
                   [1e+00, 2e+10]
340
    Warning: Model contains large matrix coefficients
341
    Warning: Model contains large rhs
342
          Consider reformulating model or setting NumericFocus parameter
343
          to avoid numerical issues.
344 Presolve removed 495171 rows and 390316 columns (presolve time = 5s) ...
345 Presolve removed 606591 rows and 401179 columns
346 Presolve time: 9.21s
347 Presolved: 51448 rows, 9221 columns, 133168 nonzeros
    Variable types: 0 continuous, 9221 integer (9195 binary)
348
349 Root relaxation presolved: 9221 rows, 60669 columns, 142389 nonzeros
350
351
352 Root simplex log...
353
354 Iteration Objective
                          Primal Inf. Dual Inf.
355
            handle free variables
                                             10s
             9.0919336e+03 1.441587e+03 0.000000e+00
356
       5693
                                                           10s
357
       7699
             8.7964444e{+03} \quad 0.000000e{+00} \quad 0.000000e{+00}
                                                           10s
       7699 \quad 8.7964444e + 03 \quad 0.000000e + 00 \quad 0.000000e + 00
358
359
360 Root relaxation: objective 8.796444e+03, 7699 iterations, 0.89 seconds (1.64 work units)
361
362
       Nodes | Current Node | Objective Bounds
                                                         Work
363
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
364
           0\ 8796.44444\ 0\ 37
                                    - 8796.44444
365
366
       0
           0 8796.44444 0 163
                                    - 8796.44444
                                                   - - 12s
367
           0.8796.44444
                                    - 8796,44444
                         0.352
                                                       - 12s
368
       0
           0 8796.44444
                         0 201
                                    - 8796.44444
                                                       - 12s
369
           0 8796.44444
                         0 162
                                    - 8796.44444
                                                       - 12s
           0 8796.44444
                                    - 8796.44444
370
       0
                         0 529
                                                       - 13s
371
       0
           0 8796.44444
                         0 496
                                    - 8796.44444
                                                       - 13s
           0 8796.44444
                                    - 8796.44444
372
                         0 158
373
           0 8796.44444
                         0 654
                                    - 8796.44444
       0
                                                       - 16s
           0 8796 44444
                                                       - 17s
374
                         0.558
                                    - 8796,44444
       0
375
       0
           0 8796.44444
                         0 245
                                    - 8796.44444
                                                       - 19s
           0 8796.44444
376
       0
                         0 289
                                    - 8796.44444
           0 8796.44444 0 329
                                    - 8796.44444
                                                   - - 20s
377
       0
           0 8796.44444
                                    - 8796.44444
378
                         0 189
                                                       - 22s
379
       0
           0 8796.44444
                         0 209
                                    - 8796.44444
380
           0 8796.44444 0 344
                                    - 8796.44444
                                                       - 23s
381
           0.8796.44444 0.301
                                    - 8796,44444
       0
                                                       - 23s
382
       0
           0 8796.44444 0 369
                                    - 8796.44444
                                                      - 25s
           0\ 8796.44444\ \ 0\ 369
                                    - 8796.44444
383
384
           2 8796.44444 0 365
                                    - 8796.44444
       0
                                                       - 27s
           12 8876.44444 3 551
                                                   - 2404 30s
385
       7
                                     - 8796.44444
386
       39
           52 8896.44444 8 753
                                     - 8796.44444
                                                    - 1647 36s
          103 8896.44444 23 430
387
       69
                                       - 8796.44444
                                                      - 1927 43s
388
      139
           196 9256.44444 49 233
                                       - 8796,44444
                                                     - 1342 47s
389
      266\ \ 289\ 9256.44444\ \ 96\ \ 170
                                       - 8796.44444
                                                      - 839 50s
390 H 285 289
                          9256.4444444 8796.44444 4.97% 793 50s
391
      491 266 8796.44444 12 770 9256.44444 8796.44444 4.97% 575
                          9236.4444444 8796.44444 4.76% 590 55s
392 H 499 263
      679\ \ 453\ 8856.44444\ \ 29\ \ 787\ 9236.44444\ \ 8796.44444\ \ 4.76\%\ \ \ 496
393
      888 487 8856.90486 56 757 9236.44444 8796.44444 4.76% 439 65s
394
395
      1144 636 9096.44444 28 369 9236.44444 8796.44444 4.76% 387 82s
      1147 638 9196.44444 120 367 9236.44444 8796.44444 4.76% 386 86s
396
397
      1149 639 9176.44444 117 372 9236.44444 8796.44444 4.76% 385 92s
398 H 1150 607
                           8896.4444444 8796.44444 1.12% 385 98s
      1152 608 8896.44444 58 789 8896.44444 8796.44444 1.12% 384 100s
399
      1157 613 8816.44444 125 75 8896.44444 8796.44444 1.12% 428 105s
400
      1160 615 8896.44444 105 404 8896.44444 8796.44444 1.12% 426 112s
401
      1162 617 8896.44444 166 414 8896.44444 8796.44444 1.12% 426 117s
402
                           8876.4444444 8796.44444 0.90% 425 121s
403 H 1163 586
404 H 1164 557
                           8816.4444444 8799.77778 0.19% 425 122s
405
406 Cutting planes:
407
      Gomory: 9
408
      Cover: 207
409
      Implied bound: 78
410
      Projected implied bound: 23
411
      Clique: 12
      MIR: 48
412
      StrongCG: 27
413
414
      Flow cover: 59
      GUB cover: 57
415
```

```
416
      Zero half: 10
417
      RLT: 26
418
      Relax-and-lift: 40
419
      BOP: 5
420
421
     Explored 1164 nodes (636181 simplex iterations) in 122.10 seconds (234.81 work units)
422 Thread count was 8 (of 8 available processors)
423
424 Solution count 5: 8816.44 8876.44 8896.44 ... 9256.44
425
426 Optimal solution found (tolerance 1.00e-10)
427 Best objective 8.81644444444e+03, best bound 8.8164444444e+03, gap 0.0000%
428 Set parameter MIPGap to value 1e-08
429 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
430
431 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
432 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
433
434 Optimize a model with 783600 rows, 17633 columns and 1599413 nonzeros
435 Model fingerprint: 0x4689685f
436 Variable types: 44 continuous, 17589 integer (10164 binary)
437 Coefficient statistics:
      Matrix range [1e-01, 1e+10]
438
439
      Objective range [6e-05, 5e+01]
440
      Bounds range [1e+00, 1e+00]
441
      RHS range
                    [8e-01, 1e+10]
442 Warning: Model contains large matrix coefficients
443 Warning: Model contains large rhs
444
          Consider reformulating model or setting NumericFocus parameter
445
          to avoid numerical issues.
446 Presolve removed 776672 rows and 15408 columns
447 Presolve time: 0.55s
448 Presolved: 6928 rows, 2225 columns, 18620 nonzeros
449 Variable types: 10 continuous, 2215 integer (1270 binary)
450 Found heuristic solution: objective 5258.2267544
451
452 Root relaxation: objective 7.303159e+03, 2105 iterations, 0.03 seconds (0.03 work units)
453
454
       Nodes | Current Node | Objective Bounds

↓ Work

455
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
456
457
        0 0 7303.15873 0 8 5258.22675 7303.15873 38.9%
                         6869.1587302 7303.15873 6.32%
458 H 0 0
                                                          - 0s
459 H 0 0
                         7256.1587302 7303.15873 0.65%
                                                           - 0s
460 H 0 0
                         7303.1587302 7303.15873 0.00%
461
        0 0 7303.15873 0 4 7303.15873 7303.15873 0.00%
462
463 Cutting planes:
464
     Gomory: 2
465
      Cover: 13
466
      Implied bound: 4
467
      Clique: 2
      Zero half: 2
468
469
      RLT: 1
470
471 Explored 1 nodes (2921 simplex iterations) in 0.83 seconds (1.28 work units)
472 Thread count was 8 (of 8 available processors)
473
474 Solution count 4: 7303.16 7256.16 6869.16 5258.23
475
476 Optimal solution found (tolerance 1.00e-08)
477 Best objective 7.303158730159e+03, best bound 7.303158730159e+03, gap 0.0000%
478 SP is solved
479 SP's optimal solution is' ☐ 7303
480
481 Itr = 2
482 Collect LB = [1016.0, 7962.816033068157, 8816.44444444445]
483 Collect UB = [14077.632066136313, 8746.4444444445, 8746.4444444445]
484 Collect Hua = [0.0, 6530.816033068157, 7314.44444444445]
485 Collect_SPObjVal = [6530.816033068157, 7314.44444444445, 7303.158730158728]
486 Collect_MPObjValNHua = [1016.0, 1432.0, 1502.0]
487
488
489
      Ops, stop iteration
490
     Values adopted from the Itr-1' th iteration, and Itr = \{2\}, judgeCount = \{1\}
491
492
                ~judgeCount = 1, SPObj SPF = 7314.444444444445
493
    Vessel i: 0:
                  pi: 0-5, ai-di: 72-81, gi_SP-gpi_SP: 0.000000-0.000000,
                                                                               ai SP-di: 72-81.
                                                                                                 taoi-deltai: 72-77, taoPi SP-deltaPi SP: 72-77,
                                                                                                                                                betaNi:
     5 hi 5
494 Vessel i: 1:
                  pi: 12-18, ai-di: 2-15,
                                           gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                ai SP-di: 2-15,
                                                                                                 taoi-deltai: 2-15, taoPi SP-deltaPi SP: 2-15, betaNi: 13
        bi: 13
     Vessel i: 2:
                                            gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                ai SP-di: 14-36,
                                                                                                                     taoPi SP-deltaPi SP: 14-37,
                                                                                                                                                   betaNi
                  pi: 6-12,
                             ai-di: 14-36.
                                                                                                  taoi-deltai: 14-37,
     : 23,
           bi: 23
                  pi: 18-25,
                               ai-di: 14-25,
                                             gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                 ai SP-di: 14-25,
                                                                                                   taoi-deltai: 14-21,
                                                                                                                       taoPi SP-deltaPi SP: 14-21,
496 Vessel i: 3:
```

```
unknown
496 betaNi: 7,
                   bi: 7
                    pi: 12-17,
                                                                                        ai_SP-di: 20-44,
497
      Vessel i: 4:
                                  ai-di: 20-44,
                                                  gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                                            taoi-deltai: 20-41,
                                                                                                                                 taoPi_SP-deltaPi_SP: 20-41,
      betaNi: 21,
                    bi: 21
                                                  gi\_SP\text{-}gpi\_SP\text{: }0.000000\text{-}0.000000,
498
      Vessel i: 5:
                    pi: 18-25,
                                  ai-di: 24-30,
                                                                                        ai_SP-di: 24-30,
                                                                                                            taoi-deltai: 24-29,
                                                                                                                                 taoPi_SP-deltaPi_SP: 24-29,
      betaNi: 5,
                   bi: 5
                    pi: 17-23,
      Vessel i: 6:
                                  ai-di: 29-48,
                                                  gi_SP-gpi_SP: 0.500000-1.000000,
                                                                                        ai_SP-di: 31-48,
                                                                                                            taoi-deltai: 32-50,
                                                                                                                                 taoPi_SP-deltaPi_SP: 32-50,
                    bi: 18
      betaNi: 18,
500
     Vessel i: 7:
                    pi: 9-15,
                                 ai-di: 34-63,
                                                gi_SP-gpi_SP: 1.000000-0.389633,
                                                                                       ai_SP-di: 42-63,
                                                                                                           taoi-deltai: 42-71,
                                                                                                                                taoPi_SP-deltaPi_SP: 42-71,
                                                                                                                                                                betaNi
      : 29, bi: 29
      Vessel i: 8:
                                                  gi_SP-gpi_SP: 0.900000-0.610367,
501
                    pi: 28-34,
                                                                                                                                 taoPi_SP-deltaPi_SP: 43-46,
                                  ai-di: 34-43,
                                                                                        ai_SP-di: 43-43,
                                                                                                            taoi-deltai: 39-46,
      betaNi: 7,
                   bi: 7
502
      Vessel i: 9:
                    pi: 15-21,
                                  ai-di: 47-66,
                                                  gi_SP-gpi_SP: 0.600000-1.000000,
                                                                                        ai_SP-di: 51-66,
                                                                                                            taoi-deltai: 54-74,
                                                                                                                                 taoPi_SP-deltaPi_SP: 54-74,
      betaNi: 20,
                    bi: 20
503
                     pi: 28-34,
                                                   gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                         ai_SP-di: 50-68,
                                                                                                                                  taoPi_SP-deltaPi_SP: 50-67,
      Vessel i: 10:
                                   ai-di: 50-68,
                                                                                                             taoi-deltai: 50-67,
      betaNi: 17,
                    bi: 17
504
505 round LB = [1016, 7963, 8816]
506 round UB = [14078, 8746, 8746]
507 round Hua = [0, 6531, 7314]
508 round SPObjVal = [6531, 7314, 7303]
509 round MPObjValNHua = [1016, 1432, 1502]
510
511 OptimalObj = 8816.44444444445
512 Time: 427.000000
513
514
515
516
```