```
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=1268
 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 00000/1 00000/1 00000/1 LW_000/4 000/3 python_code/9 Code for this paper/main_RO_BDC.py', wdir='E:/1 0000/3 0000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 000000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 000000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00000/1 00
     this paper'
    Backend TkAgg is interactive backend. Turning interactive mode on.
     Waiting 5s.....
     Set parameter MIPGap to value 1e-10
     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 361160 rows, 34789 columns and 995570 nonzeros
     Model fingerprint: 0xd26ac180
     Variable types: 1 continuous, 34788 integer (34764 binary)
20
21
     Coefficient statistics:
      Matrix range [1e+00, 1e+10]
       Objective range [1e+00, 2e+01]
23
       Bounds range [1e+00, 1e+00]
24
                            [1e+00, 2e+10]
      RHS range
26
      Warning: Model contains large matrix coefficients
27
     Warning: Model contains large rhs
28
             Consider reformulating model or setting NumericFocus parameter
29
             to avoid numerical issues.
30
     Presolve removed 320138 rows and 23992 columns
31
     Presolve time: 5.00s
     Presolved: 41022 rows, 10797 columns, 146176 nonzeros
33
     Variable types: 0 continuous, 10797 integer (10782 binary)
34
35
     Deterministic concurrent LP optimizer: primal and dual simplex (primal and dual model)
     Showing first log only...
37
     Root relaxation presolved: 41022 rows, 10797 columns, 146176 nonzeros
38
39
40
     Concurrent spin time: 0.00s
41
42
     Solved with dual simplex (primal model)
43
44
     Root relaxation: objective 6.820000e+02, 1686 iterations, 0.16 seconds (0.15 work units)
45
46
        Nodes | Current Node | Objective Bounds | Work
47
      Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
48
         0 \quad \  \  0 \ \ 682.00000 \quad \  \  0 \quad \  \  8
49
                                                    - 682.00000
50
    H \quad 0 \quad 0
                                   1622.0000000 682.00000 58.0% - 5s
              0 682.00000 0 133 1622.00000 682.00000 58.0% -
51
                                                                                                 6s
              0 682.00000 0 132 1622.00000 682.00000 58.0% -
52
         0
                                                                                                 6s
                                   1202.0000000 682.00000 43.3% - 6s
53 H 0 0
54
     H = 0
                                    682.0000000 682.00000 0.00%
55
56
     Cutting planes:
57
       Gomory: 1
       Cover: 23
59
       Implied bound: 474
60
       Clique: 1
       MIR: 7
62
       GUB cover: 4
63
       RLT-1
64
       Relax-and-lift: 4
65
66
67
     Explored 1 nodes (4505 simplex iterations) in 7.17 seconds (11.33 work units)
68
     Thread count was 8 (of 8 available processors)
69
70
     Solution count 3: 682 1202 1622
     Optimal solution found (tolerance 1.00e-10)
73
     Best objective 6.82000000000e+02, best bound 6.82000000000e+02, gap 0.0000%
     Set parameter MIPGap to value 1e-08
74
75
     Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
     CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
77
78
    Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
```

```
80 Optimize a model with 1153935 rows, 901813 columns and 7830116 nonzeros
 81 Model fingerprint: 0x30e6b2a7
    Variable types: 441325 continuous, 460488 integer (456438 binary)
 83 Coefficient statistics:
     Matrix range [1e-01, 1e+10]
 85
      Objective range [6e-05, 5e+01]
      Bounds range [1e+00, 8e+01]
 86
 87
     RHS range
                   [8e-01, 1e+10]
     Warning: Model contains large matrix coefficients
     Warning: Model contains large rhs
 89
          Consider reformulating model or setting NumericFocus parameter
 90
 91
          to avoid numerical issues.
 92 Presolve removed 1151486 rows and 900916 columns
    Presolve time: 2.91s
 93
 94
    Presolved: 2449 rows, 897 columns, 6631 nonzeros
    Variable types: 0 continuous, 897 integer (507 binary)
    Found heuristic solution: objective 3134.6666667
 97
    Found heuristic solution: objective 3194.6666667
 98
 99
    Root relaxation: objective 4.522667e+03, 799 iterations, 0.01 seconds (0.01 work units)
100
                                                       Work
101
       Nodes | Current Node | Objective Bounds
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
102
103
                         4522.6666667 9482.66667 110% - 3s
104 H 0 0
105
       0 0
                  - 0 4522.66667 4522.66667 0.00% - 3s
106
107 Explored 1 nodes (1042 simplex iterations) in 3.78 seconds (3.47 work units)
108 Thread count was 8 (of 8 available processors)
109
110 Solution count 3: 4522.67 3194.67 3134.67
111
112 Optimal solution found (tolerance 1.00e-08)
113 Best objective 4.522666666667e+03, best bound 4.522666666667e+03, gap 0.0000%
114 SP is solved
115 SP's optimal solution is' □4522
116
117
     Itr = 0
118 Collect_LB = [682.0]
119 Collect_UB = [9727.333333333333]
120 Collect_Hua = [0.0]
121 Collect SPObjVal = [4522.66666666666]
122 Collect MPObjValNHua = [682.0]
123
124
125 Set parameter TimeLimit to value 12000
126 Set parameter MIPGap to value 0.0005
127 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
128
129 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
130 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
131
132 Optimize a model with 365024 rows, 137605 columns and 999461 nonzeros
133 Model fingerprint: 0x57dda685
134 Variable types: 1 continuous, 137604 integer (137580 binary)
135 Coefficient statistics:
136 Matrix range [1e+00, 1e+10]
      Objective range [1e+00, 2e+01]
137
138
      Bounds range [1e+00, 1e+00]
                   [1e+00, 2e+10]
139
     RHS range
140 Warning: Model contains large matrix coefficients
141
     Warning: Model contains large rhs
          Consider reformulating model or setting NumericFocus parameter
142
143
          to avoid numerical issues.
144 Presolve removed 253026 rows and 123425 columns (presolve time = 5s) ...
145 Presolve removed 346407 rows and 131233 columns
146 Presolve time: 6.48s
147 Presolved: 18617 rows, 6372 columns, 76982 nonzeros
148 Variable types: 0 continuous, 6372 integer (6358 binary)
149
150 Root simplex log...
151
152 Iteration Objective
                           Primal Inf. Dual Inf.
        0 5.3396667e+03 6.250000e+02 0.000000e+00
153
154
       2302 5.3396667e+03 0.000000e+00 0.000000e+00
155
156 Root relaxation: objective 5.339667e+03, 2302 iterations, 0.06 seconds (0.07 work units)
157
       Nodes | Current Node | Objective Bounds
158

↓ Work

159
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
160
           0 5339.66667 0 15
                                     - 5339.66667
161
           0.5339.66667 0.133
                                     - 5339.66667
                                                    - - 7s
162
       0
       0
           0 5339.66667 0 129
                                     - 5339.66667
                                                           7s
163
```

```
unknown
164
        0 0 5339.66667 0 65
                                     - 5339.66667
165 H 0 0
                         5339.6666667 5339.66667 0.00%
        0 \quad 0.5339.66667 \quad 0 \quad 9.5339.66667 \quad 5339.66667 \quad 0.00\%
166
167
168 Cutting planes:
169
      Learned: 4
170
      Gomory: 7
171
      Cover: 47
172
      Implied bound: 367
173
      Clique: 572
174
      MIR: 133
175
      StrongCG: 94
176
      GUB cover: 2
      Zero half: 9
177
178
      RLT: 8
179
      Relax-and-lift: 18
180
181 Explored 1 nodes (8532 simplex iterations) in 8.88 seconds (11.02 work units)
182 Thread count was 8 (of 8 available processors)
183
184 Solution count 1: 5339.67
185
186 Optimal solution found (tolerance 5.00e-04)
187 Best objective 5.339666666667e+03, best bound 5.339666666667e+03, gap 0.0000%
188 Set parameter MIPGap to value 1e-08
189 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
190
     CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
191
192
     Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
193
194 Optimize a model with 1153935 rows, 901813 columns and 7830116 nonzeros
195 Model fingerprint: 0xe360a0c9
196 Variable types: 441325 continuous, 460488 integer (456438 binary)
197 Coefficient statistics:
198
      Matrix range [1e-01, 1e+10]
199
      Objective range [6e-05, 5e+01]
200
      Bounds range [1e+00, 8e+01]
                    [8e-01, 1e+10]
201
      RHS range
     Warning: Model contains large matrix coefficients
202
203 Warning: Model contains large rhs
204
          Consider reformulating model or setting NumericFocus parameter
205
          to avoid numerical issues.
206 Presolve removed 1151122 rows and 900850 columns
207 Presolve time: 2.49s
208 Presolved: 2813 rows, 963 columns, 7625 nonzeros
209 Variable types: 0 continuous, 963 integer (547 binary)
210
211 Root relaxation: objective 4.752667e+03, 918 iterations, 0.01 seconds (0.01 work units)
212
213
       Nodes | Current Node | Objective Bounds

↓ Work

214
      Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
        0 0 4752.66667 0 4
                                    - 4752.66667
216
                         4752.6666667 4752.66667 0.00%
217 H 0 0
218
219 Explored 1 nodes (1447 simplex iterations) in 3.31 seconds (3.38 work units)
220 Thread count was 8 (of 8 available processors)
221
222 Solution count 1: 4752.67
223
224 Optimal solution found (tolerance 1.00e-08)
225 Best objective 4.752666666667e+03, best bound 4.752666666667e+03, gap 0.0000%
226 SP is solved
227 SP's optimal solution is' \square 4752
228
229 Itr = 1
230 Collect LB = [682.0, 5339.66666666666]
231 Collect UB = [9727.33333333332, 5569.666666666666]
232 Collect_Hua = [0.0, 4522.66666666666]
233 Collect_SPObjVal = [4522.66666666666, 4752.666666666666]
234 Collect_MPObjValNHua = [682.0, 817.0]
235
236
237 Set parameter TimeLimit to value 12000
238 Set parameter MIPGap to value 0.0005
239 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
240
241 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
242 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
243
244 Optimize a model with 365025 rows, 137605 columns and 999474 nonzeros
245 Model fingerprint: 0xb3039aa5
246 Variable types: 1 continuous, 137604 integer (137580 binary)
247 Coefficient statistics:
```

```
248
      Matrix range [1e+00, 1e+10]
249
      Objective range [1e+00, 2e+01]
      Bounds range [1e+00, 1e+00]
250
251
      RHS range
                   [1e+00, 2e+10]
252 Warning: Model contains large matrix coefficients
253 Warning: Model contains large rhs
254
         Consider reformulating model or setting NumericFocus parameter
255
         to avoid numerical issues.
256 Presolve removed 252853 rows and 123411 columns (presolve time = 5s) ...
257 Presolve removed 346401 rows and 131231 columns
258 Presolve time: 6.23s
259 Presolved: 18624 rows, 6374 columns, 77004 nonzeros
260 Variable types: 0 continuous, 6374 integer (6359 binary)
261
262 Root simplex log...
263
264 Iteration Objective
                          Primal Inf. Dual Inf.
                                                 Time
        0 5.5946667e+03 6.260000e+02 0.000000e+00
265
266
       2260 5.5946667e+03 0.000000e+00 0.000000e+00
267
268 Root relaxation: objective 5.594667e+03, 2260 iterations, 0.06 seconds (0.06 work units)
269
270
       Nodes | Current Node | Objective Bounds | Work
271
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
272
273
       0 0 5594.66667 0 6
                                   - 5594.66667
                       7294.6666667 5594.66667 23.3% -
274 H 0 0
       0 0 5594.66667 0 166 7294.66667 5594.66667 23.3%
275
276
       0 0 5594.66667 0 124 7294.66667 5594.66667 23.3% -
277 H 0 0
                       6814.6666667 5594.66667 17.9% - 7s
278
       0 0 5594.66667 0 104 6814.66667 5594.66667 17.9% - 7s
                5594.6666667 5594.66667 0.00% - 8s
279 H 0 0
       0 0 5594.66667 0 3 5594.66667 5594.66667 0.00% -
280
281
282 Cutting planes:
283
     Learned: 1
284
      Gomory: 4
285
      Cover: 190
      Implied bound: 401
286
287
      Clique: 261
288
      MIR: 112
289
      StrongCG: 98
290
      GUB cover: 2
291
      Zero half: 14
292
      RLT: 3
293
      Relax-and-lift: 7
294
295 Explored 1 nodes (14662 simplex iterations) in 8.99 seconds (11.06 work units)
296 Thread count was 8 (of 8 available processors)
297
298 Solution count 3: 5594.67 6814.67 7294.67
299
300 Optimal solution found (tolerance 5.00e-04)
301 Best objective 5.594666666667e+03, best bound 5.59466666667e+03, gap 0.0000%
302
    Set parameter MIPGap to value 1e-08
303 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
304
305 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
306
    Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
307
308 Optimize a model with 1153935 rows, 901813 columns and 7830116 nonzeros
309 Model fingerprint: 0xbedf6f2f
310 Variable types: 441325 continuous, 460488 integer (456438 binary)
311 Coefficient statistics:
     Matrix range [1e-01, 1e+10]
312
313 Objective range [6e-05, 5e+01]
314
     Bounds range [1e+00, 8e+01]
                    [8e-01, 1e+10]
315
     RHS range
316 Warning: Model contains large matrix coefficients
317 Warning: Model contains large rhs
         Consider reformulating model or setting NumericFocus parameter
318
319
         to avoid numerical issues.
320 Presolve removed 1151375 rows and 900926 columns
321 Presolve time: 2.68s
322 Presolved: 2560 rows, 887 columns, 6934 nonzeros
323 Variable types: 0 continuous, 887 integer (512 binary)
324
325 Root relaxation: objective 4.582667e+03, 831 iterations, 0.01 seconds (0.01 work units)
326
327
       Nodes | Current Node | Objective Bounds
328 Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
329
330 H 0 0
                        4582.6666667 9662.66667 111% - 3s
                  - 0 4582.66667 4582.66667 0.00% - 3s
331
```

```
unknown
332
333 Explored 1 nodes (1127 simplex iterations) in 3.49 seconds (3.44 work units)
334 Thread count was 8 (of 8 available processors)
335
336 Solution count 1: 4582.67
337
338 Optimal solution found (tolerance 1.00e-08)
339 Best objective 4.58266666667e+03, best bound 4.58266666667e+03, gap 0.0000%
340 SP is solved
341 SP's optimal solution is' □4582
342
343 	ext{ Itr} = 2
344 Collect LB = [682.0, 5339.66666666666, 5594.66666666666]
345 Collect_UB = [9727.33333333333, 5569.66666666666, 5424.66666666666]
346 Collect_Hua = [0.0, 4522.66666666666, 4752.66666666666]
347 Collect SPObjVal = [4522.666666666666, 4752.66666666666, 4582.666666666666]
348 Collect MPObjValNHua = [682.0, 817.0, 842.0]
349
350
351
      Ops, stop iteration
      Values adopted from the Itr-1' th iteration, and Itr = \{2\}, judgeCount = \{1\}
352
353
354
                 ~judgeCount = 1, SPObj_SPF = 4752.66666666666
355 Vessel i: 0:
                  pi: 0-5, ai-di: 1-37,
                                          gi_SP-gpi_SP: 0.000000-0.000000,
                                                                               ai SP-di: 1-37, taoi-deltai: 1-34, taoPi SP-deltaPi SP: 1-34, betaNi: 33
         bi: 33
356
     Vessel i: 1:
                   pi: 5-11, ai-di: 10-30,
                                             gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                 ai_SP-di: 10-30,
                                                                                                   taoi-deltai: 10-32,
                                                                                                                       taoPi_SP-deltaPi_SP: 10-32,
                                                                                                                                                     betaNi
     : 22, bi: 22
                   pi: 16-21,
                                                                                  ai_SP-di: 11-24,
     Vessel i: 2:
                               ai-di: 11-24,
                                              gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                                    taoi-deltai: 11-27,
                                                                                                                        taoPi_SP-deltaPi_SP: 11-27,
     betaNi: 16,
                   bi: 16
     Vessel i: 3:
                   pi: 11-16,
                               ai-di: 13-26,
                                              gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                  ai_SP-di: 13-26,
                                                                                                    taoi-deltai: 13-22,
                                                                                                                        taoPi_SP-deltaPi_SP: 13-22,
     betaNi: 9,
                  bi: 9
                   pi: 14-19,
                                              gi_SP-gpi_SP: 0.200000-1.000000,
                                                                                                    taoi-deltai: 41-63,
                                                                                                                        taoPi_SP-deltaPi_SP: 41-63,
     Vessel i: 4:
                               ai-di: 38-63,
                                                                                  ai_SP-di: 39-63,
     betaNi: 22,
                   bi: 22
     Vessel i: 5:
                              ai-di: 40-50,
                                            gi_SP-gpi_SP: 1.000000-0.200000,
                                                                                                                       taoPi_SP-deltaPi_SP: 48-56,
                   pi: 8-13,
                                                                                 ai_SP-di: 47-50,
                                                                                                    taoi-deltai: 46-56,
                                                                                                                                                     betaNi
     : 10, bi: 10
361
362 round LB = [682, 5340, 5595]
363 round UB = [9727, 5570, 5425]
364 round Hua = [0, 4523, 4753]
365 round SPObjVal = [4523, 4753, 4583]
366 round MPObjValNHua = [682, 817, 842]
367
368 OptimalObj = 5594.66666666666
369 Time: 272.000000
370
371
372
373
```