```
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=9450
 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
12
     Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
13
15
     CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
     Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
16
17
     Optimize a model with 360923 rows, 34789 columns and 1002717 nonzeros
19
     Model fingerprint: 0xa61a2c1f
     Variable types: 1 continuous, 34788 integer (34764 binary)
20
21
     Coefficient statistics:
      Matrix range [1e+00, 1e+10]
       Objective range [1e+00, 2e+01]
23
24
       Bounds range [1e+00, 1e+00]
                            [1e+00, 2e+10]
       RHS range
26
      Warning: Model contains large matrix coefficients
27
     Warning: Model contains large rhs
28
             Consider reformulating model or setting NumericFocus parameter
29
             to avoid numerical issues.
30
     Presolve removed 176910 rows and 12747 columns (presolve time = 5s) ...
31
     Presolve removed 307571 rows and 21407 columns
     Presolve time: 6.26s
     Presolved: 53352 rows, 13382 columns, 204541 nonzeros
34
     Variable types: 0 continuous, 13382 integer (13364 binary)
35
     Deterministic concurrent LP optimizer: primal and dual simplex (primal and dual model)
     Showing first log only...
37
38
39
     Root relaxation presolved: 53351 rows, 13383 columns, 204538 nonzeros
40
41
42
     Root simplex log...
43
44
     Iteration Objective
                                       Primal Inf. Dual Inf.
           0 1.1240000e+03 9.687500e+01 1.931714e+08
45
46
     Concurrent spin time: 0.01s
48
     Solved with dual simplex (primal model)
49
50
     Root relaxation: objective 8.040000e+02, 1859 iterations, 0.27 seconds (0.23 work units)
51
52
         Nodes | Current Node | Objective Bounds
                                                                               Work
53
      Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
54
55
          0 0 804.00000 0 2
                                                    - 804.00000
                                   2244.0000000 804.00000 64.2% -
56 H 0 0
57
     Η
          0 0
                                   1364.0000000 804.00000 41.1%
         0 0 804.00000 0 19 1364.00000 804.00000 41.1%
59 H 0 0
                                    804.0000000 804.00000 0.00% - 9s
         0 0 804.00000 0 7 804.00000 804.00000 0.00%
60
     Cutting planes:
62
63
       Cover: 122
64
       Implied bound: 610
65
       Clique: 3
       MIR: 4
66
67
       StrongCG: 3
68
       GUB cover: 1
69
       Zero half: 2
70
       Relax-and-lift: 19
     Explored 1 nodes (13323 simplex iterations) in 9.39 seconds (15.78 work units)
     Thread count was 8 (of 8 available processors)
73
74
75
     Solution count 3: 804 1364 2244
76
     Optimal solution found (tolerance 1.00e-10)
77
     Best objective 8.040000000000e+02, best bound 8.04000000000e+02, gap 0.0000%
     Set parameter MIPGap to value 1e-08
```

```
80 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
 81
    CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
 82
 83
    Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
 85 Optimize a model with 1153863 rows, 901813 columns and 7829828 nonzeros
 86 Model fingerprint: 0xf22978a3
 87 Variable types: 441325 continuous, 460488 integer (456438 binary)
 88 Coefficient statistics:
     Matrix range [1e-01, 1e+10]
 90
     Objective range [6e-05, 5e+01]
 91
     Bounds range [1e+00, 8e+01]
     RHS range
                    [8e-01, 1e+10]
    Warning: Model contains large matrix coefficients
 93
 94
    Warning: Model contains large rhs
          Consider reformulating model or setting NumericFocus parameter
 95
 96
          to avoid numerical issues.
 97 Presolve removed 1151492 rows and 900957 columns
 98 Presolve time: 2.54s
    Presolved: 2371 rows, 856 columns, 6316 nonzeros
100 Variable types: 0 continuous, 856 integer (503 binary)
101 Found heuristic solution: objective 4207.6666667
103 Root relaxation: objective 5.149667e+03, 652 iterations, 0.01 seconds (0.01 work units)
104
105
       Nodes | Current Node | Objective Bounds
                                                      Work
    Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
106
107
108 * 0 0
                     0 5149.6666667 5149.66667 0.00% - 3s
109
110 Explored 1 nodes (652 simplex iterations) in 3.28 seconds (3.48 work units)
111 Thread count was 8 (of 8 available processors)
112
113 Solution count 2: 5149.67 4207.67
114
115 Optimal solution found (tolerance 1.00e-08)
116 Best objective 5.14966666667e+03, best bound 5.14966666667e+03, gap 0.0000%
117 SP is solved
118 SP's optimal solution is'□5149
119
120 Itr = 0
121 Collect LB = [804.0]
122 Collect_UB = [11103.33333333333333
123 Collect_Hua = [0.0]
124 Collect_SPObjVal = [5149.66666666668]
125 Collect_MPObjValNHua = [804.0]
126
127
128 Set parameter TimeLimit to value 12000
129 Set parameter MIPGap to value 0.0005
130 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
132 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
133 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
134
135 Optimize a model with 367235 rows, 137605 columns and 1009056 nonzeros
136 Model fingerprint: 0x970e3d5f
137 Variable types: 1 continuous, 137604 integer (137580 binary)
138 Coefficient statistics:
     Matrix range [1e+00, 1e+10]
139
140
     Objective range [1e+00, 2e+01]
141
     Bounds range [1e+00, 1e+00]
                    [1e+00, 2e+10]
     RHS range
143 Warning: Model contains large matrix coefficients
144 Warning: Model contains large rhs
145
          Consider reformulating model or setting NumericFocus parameter
146
          to avoid numerical issues.
147 Presolve removed 229130 rows and 122378 columns (presolve time = 5s) ...
148 Presolve removed 343025 rows and 131193 columns
149 Presolve time: 6.11s
150 Presolved: 24210 rows, 6412 columns, 85890 nonzeros
151
    Variable types: 0 continuous, 6412 integer (6395 binary)
152
153 Root simplex log...
154
155 Iteration Objective
                           Primal Inf. Dual Inf.
156
           6.0736667e+03 8.510000e+02 0.000000e+00
157
       2440 6.0736667e+03 0.000000e+00 0.000000e+00
158
159 Root relaxation: objective 6.073667e+03, 2440 iterations, 0.07 seconds (0.14 work units)
160
       Nodes | Current Node | Objective Bounds
                                                          Work
161
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
162
163
```

```
164
           0 6073.66667 0 9
                                    - 6073.66667
                                                          6s
165
           0 6073.66667
                          0 8
                                    - 6073.66667
                                                          6s
                          0 109
166
           0.6073.66667
                                     - 6073.66667
                                                           7s
167
       0
           0 6073.66667
                          0.101
                                     - 6073.66667
                                                           7s
           0 6073.66667 0 156
                                     - 6073.66667
168
169
       0
           0 6073.66667 0 146
                                     - 6073.66667
                                                           7s
170
           0 6073.66667 0 13
                                     - 6073.66667
       0
                                                          7s
                                                          8s
171
           0.6073.66667 \quad 0 \quad 20
                                     - 6073.66667
172
       0
           0 6073.66667 0 1
                                    - 6073.66667
                                                          8s
           0 6073.66667 0 13
173
                                    - 6073.66667
       0
                                                          8s
           0 6073.66667 0 1
174
       0
                                    - 6073.66667
                                                          88
175
       0
           0 6073.66667 0 1
                                    - 6073.66667
176 H 0 0
                        6073.6666667 6073.66667 0.00%
       0 \quad 0.6073.66667 \quad 0 \quad 1.6073.66667 \quad 6073.66667 \quad 0.00\%
177
178
179 Cutting planes:
180
     Gomory: 2
      Cover: 229
181
182
      Implied bound: 510
183
      Clique: 145
      MIR: 24
184
      StrongCG: 15
185
      GUB cover: 35
186
187
      RLT: 1
188
      Relax-and-lift: 11
189
190 Explored 1 nodes (17849 simplex iterations) in 9.27 seconds (13.47 work units)
191 Thread count was 8 (of 8 available processors)
192
193 Solution count 1: 6073.67
194
195 Optimal solution found (tolerance 5.00e-04)
196 Best objective 6.073666666667e+03, best bound 6.07366666667e+03, gap 0.0000%
197
     Set parameter MIPGap to value 1e-08
198 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
199
200 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
201 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
202
203 Optimize a model with 1153863 rows, 901813 columns and 7829828 nonzeros
204 Model fingerprint: 0xf3ef7702
205 Variable types: 441325 continuous, 460488 integer (456438 binary)
206 Coefficient statistics:
207
     Matrix range [1e-01, 1e+10]
208
      Objective range [6e-05, 5e+01]
     Bounds range [1e+00, 8e+01]
209
                   [8e-01, 1e+10]
210
     RHS range
211
     Warning: Model contains large matrix coefficients
212 Warning: Model contains large rhs
213
          Consider reformulating model or setting NumericFocus parameter
214
          to avoid numerical issues.
215 Presolve removed 1148580 rows and 900032 columns
216 Presolve time: 2.30s
217 Presolved: 5283 rows, 1781 columns, 14070 nonzeros
218 Variable types: 4 continuous, 1777 integer (1024 binary)
219 Found heuristic solution: objective 3689.6666667
220
221 Root relaxation: objective 5.402667e+03, 1412 iterations, 0.02 seconds (0.01 work units)
222
223
       Nodes | Current Node | Objective Bounds
224
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
225
226 H 0 0
                         5402.6666667 15700.0000 191% - 2s
227
                  - 0
                         5402.66667 5402.66667 0.00% - 2s
228
229 Explored 1 nodes (1853 simplex iterations) in 3.03 seconds (3.27 work units)
230 Thread count was 8 (of 8 available processors)
231
232 Solution count 2: 5402.67 3689.67
233
234 Optimal solution found (tolerance 1.00e-08)
235 Best objective 5.402666666667e+03, best bound 5.402666666667e+03, gap 0.0000%
236 SP is solved
237 SP's optimal solution is' ☐ 5402
238
239 Itr = 1
240 Collect_LB = [804.0, 6073.66666666668]
241 Collect_UB = [11103.33333333336, 6326.66666666668]
242 Collect Hua = [0.0, 5149.66666666668]
243 Collect SPObjVal = [5149.6666666668, 5402.6666666668]
244 Collect MPObjValNHua = [804.0, 924.0]
245
246
247 Set parameter TimeLimit to value 12000
```

```
248 Set parameter MIPGap to value 0.0005
249 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
250
251 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
252 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
253
254 Optimize a model with 367236 rows, 137605 columns and 1009069 nonzeros
255 Model fingerprint: 0x2ce99282
256 Variable types: 1 continuous, 137604 integer (137580 binary)
257 Coefficient statistics:
258
     Matrix range [1e+00, 1e+10]
259
      Objective range [1e+00, 2e+01]
260
     Bounds range [1e+00, 1e+00]
                   [1e+00, 2e+10]
     RHS range
261
262
     Warning: Model contains large matrix coefficients
263 Warning: Model contains large rhs
          Consider reformulating model or setting NumericFocus parameter
264
265
          to avoid numerical issues.
266 Presolve removed 229131 rows and 122378 columns (presolve time = 5s) ...
267 Presolve removed 343026 rows and 131193 columns
268 Presolve time: 6.03s
269 Presolved: 24210 rows, 6412 columns, 85890 nonzeros
270
    Variable types: 0 continuous, 6412 integer (6395 binary)
271
272 Root simplex log...
273
274 Iteration Objective
                           Primal Inf. Dual Inf.
        0 6.3266667e+03 8.510000e+02 0.000000e+00
275
276
       2440 6.3266667e+03 0.000000e+00 0.000000e+00
277
278 Root relaxation: objective 6.326667e+03, 2440 iterations, 0.08 seconds (0.14 work units)
279
280
       Nodes | Current Node | Objective Bounds
                                                      | Work
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
281
282
283
                                    - 6326.66667
           0.6326.66667 0 9
284
       0
           0 6326.66667 0 8
                                    - 6326.66667
285
       0
           0 6326.66667 0 109
                                    - 6326.66667
                                                      - 7s
286
           0.6326.66667 0.101
                                     - 6326,66667
       0
                                                           7s
287
       0
           0 6326.66667 0 156
                                     - 6326.66667
                                                           7s
288
           0 6326.66667 0 146
                                     - 6326.66667
289
       0
           0 6326.66667 0 13
                                    - 6326.66667
                                                          7s
           0 6326.66667 0 20
290
                                    - 6326.66667
       0
                                                          8s
                                                      - 8s
291
       0
           0 6326.66667 0 1
                                    - 6326.66667
292
           0 6326.66667 0 13
       0
                                    - 6326.66667
                                                          8s
293
           0 6326.66667 0 1
       0
                                    - 6326,66667
                                                          9s
294
       0
           0 6326.66667 0 1
                                    - 6326.66667
                                                         9s
295 H 0 0
                       6326.6666667 6326.66667 0.00%
296
           0 6326.66667 0 1 6326.66667 6326.66667 0.00%
297
298 Cutting planes:
299
     Gomory: 2
300
      Cover: 229
301
      Implied bound: 510
302
      Clique: 145
303
      MIR: 24
304
      StrongCG: 15
305
      GUB cover: 35
306
      RLT: 1
307
      Relax-and-lift: 11
308
309 Explored 1 nodes (17849 simplex iterations) in 9.30 seconds (13.47 work units)
310 Thread count was 8 (of 8 available processors)
311
312 Solution count 1: 6326.67
313
314 Optimal solution found (tolerance 5.00e-04)
315 Best objective 6.326666666667e+03, best bound 6.32666666667e+03, gap 0.0000%
316 Set parameter MIPGap to value 1e-08
317 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
318
319 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
320 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
321
322 Optimize a model with 1153863 rows, 901813 columns and 7829828 nonzeros
323 Model fingerprint: 0xf3ef7702
324 Variable types: 441325 continuous, 460488 integer (456438 binary)
325 Coefficient statistics:
     Matrix range [1e-01, 1e+10]
326
327
      Objective range [6e-05, 5e+01]
328
      Bounds range [1e+00, 8e+01]
329
     RHS range
                   [8e-01, 1e+10]
330 Warning: Model contains large matrix coefficients
     Warning: Model contains large rhs
331
```

```
332
          Consider reformulating model or setting NumericFocus parameter
333
          to avoid numerical issues.
334 Presolve removed 1148580 rows and 900032 columns
335 Presolve time: 3.47s
336 Presolved: 5283 rows, 1781 columns, 14070 nonzeros
337
     Variable types: 4 continuous, 1777 integer (1024 binary)
338 Found heuristic solution: objective 3689.6666667
339
340 Root simplex log...
341
                           Primal Inf. Dual Inf.
342 Iteration Objective
                                                  Time
343
        0 1.1952000e+04 5.715525e+03 0.000000e+00
       1412 5.4026667e+03 0.000000e+00 0.000000e+00
344
345
Root relaxation: objective 5.402667e+03, 1412 iterations, 0.01 seconds (0.01 work units)
347
348
       Nodes | Current Node | Objective Bounds

↓ Work

349
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
350
351 H 0 0
                         5402.6666667 15700.0000 191% - 5s
       0 0
                  - 0 5402.66667 5402.66667 0.00% - 5s
352
353
354 Explored 1 nodes (1853 simplex iterations) in 5.92 seconds (3.27 work units)
355 Thread count was 8 (of 8 available processors)
356
357 Solution count 2: 5402.67 3689.67
358
359 Optimal solution found (tolerance 1.00e-08)
360 Best objective 5.402666666667e+03, best bound 5.40266666667e+03, gap 0.0000%
361 SP is solved
362 SP's optimal solution is' ☐ 5402
363
364 	ext{ Itr} = 2
365 Collect_LB = [804.0, 6073.66666666668, 6326.66666666668]
366 Collect UB = [11103.33333333336, 6326.66666666668, 6326.6666666668]
367 Collect Hua = [0.0, 5149.6666666668, 5402.6666666668]
368 Collect SPObjVal = [5149.66666666668, 5402.6666666668, 5402.6666666668]
369 Collect MPObjValNHua = [804.0, 924.0, 924.0]
370
371
      Reach the termination conditions, stop iteration
372
373
     Values adopted from the Itr' th iteration, and Itr = \{2\}, judgeCount = \{2\}
374
375 ~~
          ----judge = 2, SPObj SPF = 5402.6666666668
376 Vessel i: 0:
                 pi: 0-6, ai-di: 3-37, gi SP-gpi SP: 0.000000-0.000000, ai SP-di: 3-37, taoi-deltai: 3-35, taoPi SP-deltaPi SP: 3-35, betaNi: 32
        bi: 32
                  pi: 6-13, ai-di: 17-33, gi_SP-gpi_SP: 0.000000-0.000000,
377
    Vessel i: 1:
                                                                              ai_SP-di: 17-33, taoi-deltai: 17-31, taoPi_SP-deltaPi_SP: 17-31,
                                                                                                                                                 betaNi
     : 14, bi: 14
     Vessel i: 2: pi: 13-19,
                              ai-di: 23-49,
                                            gi_SP-gpi_SP: 0.000000-0.000000,
                                                                               ai SP-di: 23-49,
                                                                                                  taoi-deltai: 23-47,
                                                                                                                     taoPi SP-deltaPi SP: 23-47,
     betaNi: 24.
                  bi: 24
     Vessel i: 3:
                  pi: 7-13,
                             ai-di: 41-57, gi SP-gpi SP: 0.000000-0.000000,
                                                                               ai SP-di: 41-57,
                                                                                                taoi-deltai: 41-55,
                                                                                                                    taoPi SP-deltaPi SP: 41-55, betaNi
     : 14, bi: 14
                  pi: 20-26,
                                            gi SP-gpi SP: 0.200000-1.000000,
                                                                                                                     taoPi SP-deltaPi SP: 51-73,
     Vessel i: 4:
                              ai-di: 50-74.
                                                                               ai SP-di: 51-74,
                                                                                                 taoi-deltai: 51-73.
     betaNi: 22,
                  bi: 22
381
     Vessel i: 5:
                  pi: 12-19,
                              ai-di: 51-75, gi_SP-gpi_SP: 1.000000-0.200000,
                                                                               ai_SP-di: 58-75,
                                                                                                  taoi-deltai: 59-81,
                                                                                                                     taoPi SP-deltaPi SP: 59-81,
     betaNi: 22,
                  bi: 22
382
383 round LB = [804, 6074, 6327]
384 round UB = [11103, 6327, 6327]
385 round Hua = [0, 5150, 5403]
386 round SPObjVal = [5150, 5403, 5403]
387 round MPObjValNHua = [804, 924, 924]
388
389 OptimalObj = 6326.66666666688
390 Time: 249.000000
391
392
393
394
```