```
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=1357
 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 375969 rows, 34789 columns and 1042007 nonzeros
19
     Model fingerprint: 0x36dd4b10
     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 326897 rows and 23704 columns (presolve time = 5s) ...
     Presolve removed 326897 rows and 23704 columns
31
     Presolve time: 5.14s
     Presolved: 49072 rows, 11085 columns, 174856 nonzeros
      Variable types: 0 continuous, 11085 integer (11070 binary)
34
35
     Deterministic concurrent LP optimizer: primal and dual simplex (primal and dual model)
     Showing first log only...
37
38
39
     Root relaxation presolved: 49072 rows, 11085 columns, 174856 nonzeros
40
41
     Concurrent spin time: 0.01s
42
43
     Solved with dual simplex (primal model)
44
45
     Root relaxation: objective 6.660000e+02, 1309 iterations, 0.20 seconds (0.16 work units)
46
47
         Nodes | Current Node | Objective Bounds
48
      Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
49
50
             0 666.00000 0 3
                                                  - 666.00000
                                   1106.0000000 666.00000 39.8% - 6s
51 H 0 0
52 H 0
                                   666,0000000 666,00000 0.00% - 6s
53
54
     Cutting planes:
55
      Gomory: 1
56
       Cover: 1
57
       StrongCG: 1
58
       GUB cover: 1
59
       RLT: 2
60
     Explored 1 nodes (2694 simplex iterations) in 6.34 seconds (10.09 work units)
     Thread count was 8 (of 8 available processors)
62
63
64
     Solution count 2: 666 1106
65
     Optimal solution found (tolerance 1.00e-10)
66
     67
      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 1153867 rows, 901813 columns and 7829844 nonzeros
74
     Model fingerprint: 0xc590e27d
      Variable types: 441325 continuous, 460488 integer (456438 binary)
     Coefficient statistics:
77
78
       Matrix range [1e-01, 1e+10]
       Objective range [6e-05, 5e+01]
79
```

```
Bounds range
                    [1e+00, 8e+01]
 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 1152440 rows and 901330 columns
 87 Presolve time: 2.64s
    Presolved: 1427 rows, 483 columns, 3802 nonzeros
    Variable types: 0 continuous, 483 integer (274 binary)
 90 Found heuristic solution: objective 2803.6666667
 92
    Root relaxation: objective 3.220667e+03, 293 iterations, 0.01 seconds (0.00 work units)
 93
 94
      Nodes | Current Node | Objective Bounds
                                                      Work
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
 95
 96
                         3220.6666667 6180.66667 91.9% - 3s
 97 H 0 0
 98
       0 0
                  - 0 3220.66667 3220.66667 0.00% - 3s
 99
100 Explored 1 nodes (445 simplex iterations) in 3.48 seconds (3.65 work units)
101 Thread count was 8 (of 8 available processors)
103 Solution count 2: 3220.67 2803.67
104
105 Optimal solution found (tolerance 1.00e-08)
106 Best objective 3.220666666667e+03, best bound 3.220666666667e+03, gap 0.0000%
107 SP is solved
108 SP's optimal solution is' \square 3220
109
110
     Itr = 0
111 Collect LB = [666.0]
112 Collect_UB = [7107.33333333333285]
113 Collect_Hua = [0.0]
114 Collect SPObjVal = [3220.666666666642]
115 Collect_MPObjValNHua = [666.0]
116
117
118 Set parameter TimeLimit to value 12000
119 Set parameter MIPGap to value 0.0005
120 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
121
122 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
123 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
124
125 Optimize a model with 382145 rows, 137605 columns and 1048210 nonzeros
126 Model fingerprint: 0xbadabcd3
127 Variable types: 1 continuous, 137604 integer (137580 binary)
128 Coefficient statistics:
     Matrix range [1e+00, 1e+10]
129
130
     Objective range [1e+00, 2e+01]
     Bounds range [1e+00, 1e+00]
                   [1e+00, 2e+10]
132
     RHS range
    Warning: Model contains large matrix coefficients
133
134
    Warning: Model contains large rhs
135
         Consider reformulating model or setting NumericFocus parameter
136
         to avoid numerical issues.
137 Presolve removed 355841 rows and 133024 columns
138
    Presolve time: 4.51s
139 Presolved: 26304 rows, 4581 columns, 69310 nonzeros
140 Variable types: 0 continuous, 4581 integer (4566 binary)
141
    Root relaxation presolved: 4581 rows, 30885 columns, 73891 nonzeros
142
143
144 Root relaxation: objective 4.066667e+03, 3466 iterations, 0.21 seconds (0.33 work units)
145
146
      Nodes | Current Node | Objective Bounds
                                                         Work
147
     Expl\ Unexpl\mid\ Obj\ \ Depth\ IntInf\ |\ Incumbent \quad BestBd\quad Gap\ |\ It/Node\ Time
148
149
           0\ 4066.66667\quad 0\quad 7
                                    - 4066.66667
150
       0 0 4066.66667 0 169
                                    - 4066.66667
151
       0 0 4066.66667 0 162
                                     - 4066.66667
152 H 0 0
                       4146.6666667 4066.66667 1.93% - 5s
       0 0 4066.66667 0 99 4146.66667 4066.66667 1.93% -
153
154
           0 4066.66667 0 102 4146.66667 4066.66667 1.93% - 5s
       0
155
           0 4066.66667 0 63 4146.66667 4066.66667 1.93% - 5s
       0
156 H 0 0
                        4066.6666667 4066.66667 0.00% - 6s
157
158 Cutting planes:
159
      Cover: 105
160
     Implied bound: 660
     Clique: 25
161
162
     MIR: 8
      StrongCG: 2
163
```

```
unknown
164
      GUB cover: 6
165
      Zero half: 3
166
      RLT: 1
167
      Relax-and-lift: 49
168
169 Explored 1 nodes (7800 simplex iterations) in 6.14 seconds (9.60 work units)
170 Thread count was 8 (of 8 available processors)
171
172 Solution count 2: 4066.67 4146.67
173
174 Optimal solution found (tolerance 5.00e-04)
175 Best objective 4.066666666667e+03, best bound 4.06666666667e+03, gap 0.0000%
176 Set parameter MIPGap to value 1e-08
177 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
178
179 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
180 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
181
182 Optimize a model with 1153867 rows, 901813 columns and 7829844 nonzeros
183 Model fingerprint: 0x1926e721
184 Variable types: 441325 continuous, 460488 integer (456438 binary)
185 Coefficient statistics:
      Matrix range [1e-01, 1e+10]
186
187
      Objective range [6e-05, 5e+01]
188
      Bounds range [1e+00, 8e+01]
189
      RHS range
                    [8e-01, 1e+10]
190 Warning: Model contains large matrix coefficients
191 Warning: Model contains large rhs
192
          Consider reformulating model or setting NumericFocus parameter
193
          to avoid numerical issues.
194 Presolve removed 1152286 rows and 901234 columns
195 Presolve time: 2.36s
196 Presolved: 1581 rows, 579 columns, 4212 nonzeros
197
     Variable types: 4 continuous, 575 integer (337 binary)
198 Found heuristic solution: objective 2624.3818887
199
200 Root relaxation: objective 3.444667e+03, 417 iterations, 0.00 seconds (0.00 work units)
201
202
       Nodes | Current Node | Objective Bounds

↓ Work

203 Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
204
205 H 0 0
                         3444.6666667 6522.00000 89.3% - 3s
206
        0 0
                  - 0 3444.66667 3444.66667 0.00% - 3s
207
208 Explored 1 nodes (569 simplex iterations) in 3.14 seconds (3.18 work units)
209 Thread count was 8 (of 8 available processors)
210
211 Solution count 2: 3444.67 2624.38
212
213 Optimal solution found (tolerance 1.00e-08)
214 Best objective 3.444666666667e+03, best bound 3.44466666667e+03, gap 0.0000%
215 SP is solved
216 SP's optimal solution is' □ 3444
217
218 	ext{ Itr} = 1
219 Collect LB = [666.0, 4066.666666666642]
220 Collect_UB = [7107.3333333333285, 4290.666666666664]
221 Collect_Hua = [0.0, 3220.666666666642]
222 Collect_SPObjVal = [3220.66666666642, 3444.666666666642]
223 Collect MPObjValNHua = [666.0, 846.0]
224
225
226 Set parameter TimeLimit to value 12000
227 Set parameter MIPGap to value 0.0005
228 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
229
230 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
231 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
232
233 Optimize a model with 382146 rows, 137605 columns and 1048223 nonzeros
234 Model fingerprint: 0x66aa3021
235 Variable types: 1 continuous, 137604 integer (137580 binary)
236 Coefficient statistics:
237 Matrix range [1e+00, 1e+10]
      Objective range [1e+00, 2e+01]
238
239
      Bounds range [1e+00, 1e+00]
240 RHS range
                    [1e+00, 2e+10]
241 Warning: Model contains large matrix coefficients
242 Warning: Model contains large rhs
243
          Consider reformulating model or setting NumericFocus parameter
244
          to avoid numerical issues.
245 Presolve removed 355842 rows and 133024 columns
246 Presolve time: 4.48s
247 Presolved: 26304 rows, 4581 columns, 69310 nonzeros
```

```
248 Variable types: 0 continuous, 4581 integer (4566 binary)
249 Root relaxation presolved: 4581 rows, 30885 columns, 73891 nonzeros
250
251
252 Root relaxation: objective 4.290667e+03, 3466 iterations, 0.21 seconds (0.33 work units)
253
254
       Nodes | Current Node | Objective Bounds | Work
255
     Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
256
257
          0 4290.66667 0 7
                                    - 4290.66667
258
       0 0 4290.66667 0 169
                                     - 4290.66667 - - 5s
- 4290.66667 - - 5s
                                     - 4290.66667
259
       0
           0 4290.66667 0 162
260 H 0 0
                        4370.6666667 4290.66667 1.83% - 5s
       0 0 4290.66667 0 99 4370.66667 4290.66667 1.83% - 5s
261
       0 \quad 0 \; 4290.66667 \quad 0 \; 102 \; 4370.66667 \; 4290.66667 \; 1.83\% \quad \text{-}
262
       0 0 4290.66667 0 63 4370.66667 4290.66667 1.83% - 5s
263
264 H 0 0
                        4290.6666667 4290.66667 0.00% - 5s
265
266 Cutting planes:
267
      Cover: 105
      Implied bound: 660
268
269
      Clique: 25
270
      MIR: 8
271
      StrongCG: 2
272
      GUB cover: 6
273
      Zero half: 3
274
      RLT: 1
      Relax-and-lift: 49
275
276
277 Explored 1 nodes (7800 simplex iterations) in 5.98 seconds (9.60 work units)
278 Thread count was 8 (of 8 available processors)
279
280 Solution count 2: 4290.67 4370.67
281
282 Optimal solution found (tolerance 5.00e-04)
283 Best objective 4.290666666667e+03, best bound 4.290666666667e+03, gap 0.0000%
284 Set parameter MIPGap to value 1e-08
285 Gurobi Optimizer version 10.0.2 build v10.0.2rc0 (win64)
286
287 CPU model: 11th Gen Intel(R) Core(TM) i7-11370H @ 3.30GHz, instruction set [SSE2|AVX|AVX2|AVX512]
288 Thread count: 4 physical cores, 8 logical processors, using up to 8 threads
289
290 Optimize a model with 1153867 rows, 901813 columns and 7829844 nonzeros
291 Model fingerprint: 0x1926e721
292 Variable types: 441325 continuous, 460488 integer (456438 binary)
293 Coefficient statistics:
294 Matrix range [1e-01, 1e+10]
295
      Objective range [6e-05, 5e+01]
296 Bounds range [1e+00, 8e+01]
297
                    [8e-01, 1e+10]
      RHS range
298 Warning: Model contains large matrix coefficients
299 Warning: Model contains large rhs
300
          Consider reformulating model or setting NumericFocus parameter
301
          to avoid numerical issues.
302 Presolve removed 1152286 rows and 901234 columns
303 Presolve time: 2.33s
304 Presolved: 1581 rows, 579 columns, 4212 nonzeros
305 Variable types: 4 continuous, 575 integer (337 binary)
306 Found heuristic solution: objective 2624.3818887
307
308 Root relaxation: objective 3.444667e+03, 417 iterations, 0.00 seconds (0.00 work units)
309
310
       Nodes | Current Node | Objective Bounds
311 Expl Unexpl | Obj Depth IntInf | Incumbent BestBd Gap | It/Node Time
312
313 H 0 0
                         3444.6666667 6522.00000 89.3% - 2s
314
                  - 0 3444.66667 3444.66667 0.00% - 2s
315
316 Explored 1 nodes (569 simplex iterations) in 3.12 seconds (3.18 work units)
317 Thread count was 8 (of 8 available processors)
318
319 Solution count 2: 3444.67 2624.38
320
321 Optimal solution found (tolerance 1.00e-08)
322 Best objective 3.44466666667e+03, best bound 3.44466666667e+03, gap 0.0000%
323 SP is solved
324 SP's optimal solution is'□3444
325
326 	ext{ Itr} = 2
327 Collect LB = [666.0, 4066.66666666642, 4290.66666666664]
328 Collect_UB = [7107.3333333333285, 4290.66666666664, 4290.66666666664]
329 Collect_Hua = [0.0, 3220.666666666642, 3444.666666666642]
330 Collect_SPObjVal = [3220.666666666642, 3444.66666666642, 3444.66666666642]
331 Collect_MPObjValNHua = [666.0, 846.0, 846.0]
```

```
unknown
332
333
334
       Reach the termination conditions, stop iteration
335
      Values adopted from the Itr' th iteration, and Itr = \{2\}, judgeCount = \{2\}
336
337
                 ~judge = 2, SPObj SPF = 3444.666666666642
338 Vessel i: 0:
                    pi: 0\text{-}6, \quad ai\text{-}di: 2\text{-}23, \quad gi\_SP\text{-}gpi\_SP: 0.0000000\text{-}0.0000000, \\
                                                                                  ai_SP-di: 2-23, taoi-deltai: 2-25, taoPi_SP-deltaPi_SP: 2-21, betaNi: 23
          bi: 23
339
     Vessel i: 1:
                    pi: 6-13,
                                             gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                                     taoi-deltai: 8-16,
                                                                                                                         taoPi_SP-deltaPi_SP: 8-16, betaNi: 8
                               ai-di: 8-17,
                                                                                    ai_SP-di: 8-17,
         bi: 8
     Vessel i: 2:
                                               gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                                                             taoPi_SP-deltaPi_SP: 34-39,
                    pi: 3-10,
                                ai-di: 34-42,
                                                                                     ai_SP-di: 34-42,
                                                                                                        taoi-deltai: 34-41,
                                                                                                                                                            betaNi
      : 7, bi: 7
341 Vessel i: 3:
                    pi: 12-19,
                                 ai-di: 40-58,
                                                gi_SP-gpi_SP: 0.000000-0.000000,
                                                                                      ai_SP-di: 40-58,
                                                                                                         taoi-deltai: 40-56,
                                                                                                                              taoPi_SP-deltaPi_SP: 40-56,
      betaNi: 16,
                    bi: 16
342
      Vessel i: 4:
                    pi: 6-12,
                                ai-di: 47-59,
                                               gi_SP-gpi_SP: 0.200000-1.000000,
                                                                                     ai_SP-di: 48-59,
                                                                                                        taoi-deltai: 48-61,
                                                                                                                             taoPi_SP-deltaPi_SP: 48-61,
                                                                                                                                                            betaNi
      : 13, bi: 13
                    pi: 27-34,
                                                                                      ai_SP-di: 58-67,
      Vessel i: 5:
                                 ai-di: 50-67,
                                                gi_SP-gpi_SP: 1.000000-0.200000,
                                                                                                                              taoPi SP-deltaPi SP: 58-77,
                                                                                                         taoi-deltai: 58-77,
                    bi: 19
      betaNi: 19,
344
345 round LB = [666, 4067, 4291]
346 round UB = [7107, 4291, 4291]
347 round Hua = [0, 3221, 3445]
348 round SPObjVal = [3221, 3445, 3445]
349 round MPObjValNHua = [666, 846, 846]
350
351 OptimalObj = 4290.66666666664
352 Time: 248.000000
353
354
355
356
```