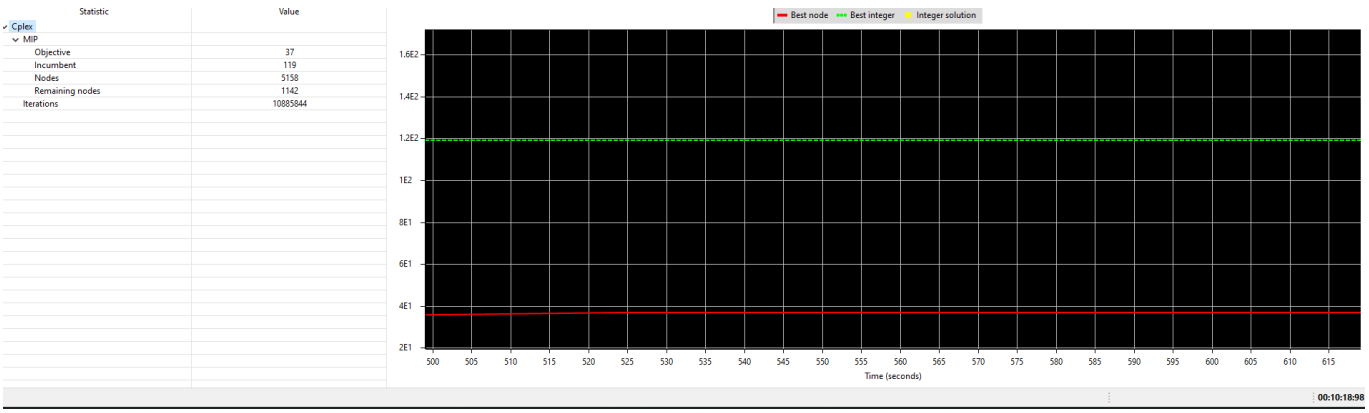
1) Corran su heurística sobre la instancia. Registren el resultado obtenido.
   Se llegó a un resultado de 11 tandas de lavado por heurística.
2) Prueben correr el código sin cambios, pueden detenerlo a los 10 minutos si no termina. Indicar en el informe todo lo que notan de esta corrida



Version identifier: 22.1.0.0 | 2022-03-09 | 1a383f8ce
Legacy callback pi
Tried aggregator 1 time.
MIP Presolve eliminated 120467 rows and 0 columns.
MIP Presolve modified 12013 coefficients.
Reduced MIP has 34783 rows, 19182 columns, and 121915 nonzeros.
Reduced MIP has 19044 binaries, 138 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.27 sec. (253.66 ticks)
Found incumbent of value 2760.000000 after 0.39 sec. (403.01 ticks)
Probing time = 0.11 sec. (13.80 ticks)
Tried aggregator 1 time.
Detecting symmetries...
Reduced MIP has 34783 rows, 19182 columns, and 121915 nonzeros.
Reduced MIP has 19044 binaries, 138 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.36 sec. (391.75 ticks)
Probing time = 0.11 sec. (13.12 ticks)
Clique table members: 15739.
MIP emphasis: balance optimality and feasibility.
MIP search method: dynamic search.
Parallel mode: deterministic, using up to 12 threads.
Root relaxation solution time = 0.55 sec. (488.70 ticks)

	Node	Nodes Left	Objective	IInf	Best Integer	Best Bound	Cuts/ ItCnt	Gap
*	0+	0			2760.0000	0.0000		100.00%
*	0+	0			1467.0000	0.0000		100.00%
*	0+	0			171.0000	0.0000		100.00%
	0	0	20.0000	4740	171.0000	20.0000	11	88.30%
*	0+	0			164.0000	20.0000		87.80%
	0	0	20.0000	1852	164.0000	Cuts: 131	9640	87.80%
	0	0	20.0000	2161	164.0000	Cuts: 1676	17368	87.80%
	0	0	20.0000	2068	164.0000	Cuts: 147	29708	87.80%
*	0+	0			154.0000	20.0000		87.01%

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*     0+    0                          152.0000       20.0000           86.84%
*     0+    0                          147.0000       20.0000           86.39%
*     0+    0                          144.0000       20.0000           86.11%
*     0+    0                          142.0000       20.0000           85.92%
      0     0  -1.00000e+75     0      142.0000       20.0000    29708   85.92%
      0     0       20.0000  1919      142.0000    Cuts: 1709    36509   85.92%
      0     0       20.0000  1618      142.0000     Cuts: 156    42826   85.92%
      0     0       20.0000  2048      142.0000    Cuts: 1546    50451   85.92%
Heuristic still looking.
      0     2       20.0000   940      142.0000       20.0000    50451   85.92%
Elapsed time = 66.55 sec. (86093.18 ticks, tree = 0.02 MB, solutions = 9)
      1     3       37.0000  1017      142.0000       20.0000    56376   85.92%
      2     3       20.0000  1726      142.0000       20.0000    56094   85.92%
      3     4       37.0000  1275      142.0000       20.0000    59665   85.92%
      4     5       37.0000  1299      142.0000       20.0000    69897   85.92%
      5     6       37.0000  1130      142.0000       20.0000    69799   85.92%
      6     7       37.0000  1791      142.0000       20.0000    76012   85.92%
      7     4       46.2868  1233      142.0000       20.0000    74423   85.92%
      8     8       37.0000   813      142.0000       20.0000    80993   85.92%
      9    11       37.0000   686      142.0000       20.0000   105859   85.92%
     13    14       56.0000   896      142.0000       20.0000   125575   85.92%
Elapsed time = 82.72 sec. (96023.53 ticks, tree = 0.03 MB, solutions = 9)
     15    17       37.0000   729      142.0000       20.0000   141432   85.92%
     22    17       56.0000   798      142.0000       20.0000   141873   85.92%
     33     9       46.2868  1312      142.0000       20.0000    94279   85.92%
     45    26       50.0000   869      142.0000       20.0000   197609   85.92%
     57    29       56.0000  1011      142.0000       20.0000   246803   85.92%
     75     5       20.0000  2161      142.0000       20.0000    70292   85.92%
     95    76       59.0000   938      142.0000       20.0000   416416   85.92%
    113    82       59.1326   759      142.0000       20.0000   450823   85.92%
    137    93       69.0000   981      142.0000       20.0000   480492   85.92%
    165   124       66.1439   703      142.0000       21.3260   592441   84.98%
Elapsed time = 103.41 sec. (106256.61 ticks, tree = 2.87 MB, solutions = 9)
    203   155      110.0000   352      142.0000       21.9753   652623   84.52%
    250   140       95.0769   479      142.0000       21.9753   645769   84.52%
*   256+  175                          140.0000       21.9753           84.30%
    313   256      101.0000   473      140.0000       21.9753   868607   84.30%
*   374+  282                          136.0000       21.9753           83.84%
    377   261      101.0000   410      136.0000       21.9753   877427   83.84%
*   465+  350                          135.0000       21.9753           83.72%
*   472+  319                          124.0000       21.9753           82.28%
    504   382      120.0000   145      124.0000       21.9753   925974   82.28%
    601   377      121.0000   141      124.0000       21.9753  1055267   82.28%
*   617   396      integral     0      123.0000       21.9753  1097552   82.13%
*   652   400      integral     0      122.0000       21.9753  1106265   81.99%
    658   379       46.2868   904      122.0000       21.9753  1061607   81.99%
    679   392       46.2868   896      122.0000       21.9753  1168565   81.99%
    702   395       88.8299   786      122.0000       21.9753  1161078   81.99%
    736   417       56.0000   901      122.0000       21.9753  1253466   81.99%
Elapsed time = 123.13 sec. (116015.76 ticks, tree = 4.27 MB, solutions = 16)
    759   426       82.6004   925      122.0000       21.9753  1287965   81.99%
    787   457       78.0000   589      122.0000       21.9753  1359855   81.99%
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   809   505      97.0000   439      122.0000       21.9753  1513274   81.99%
   840   488     109.0000   263      122.0000       21.9753  1445407   81.99%
   878   515     106.0000   352      122.0000       21.9753  1529794   81.99%
   934   501      42.3984   895      122.0000       21.9753  1517078   81.99%
*  951   594      integral     0      121.0000       21.9753  1735291   81.84%
   975   581       cutoff            121.0000       21.9753  1703768   81.84%
   998   615      70.0000   722      121.0000       21.9753  1835706   81.84%
  1025   634      52.0000  1001      121.0000       21.9753  1854074   81.84%
*  1058+  660                        120.0000       21.9753           81.69%
  1074   674      71.7204   773      120.0000       21.9753  1954840   81.69%
Elapsed time = 144.23 sec. (125822.71 ticks, tree = 7.08 MB, solutions = 18)
  1095   676      73.0221  1009      120.0000       21.9753  1958451   81.69%
  1123   736      90.0491   480      120.0000       21.9753  2131096   81.69%
  1147   696      59.0000   694      120.0000       21.9753  2018663   81.69%
  1175   753      82.2400   784      120.0000       21.9753  2200722   81.69%
  1226   815     118.0000   117      120.0000       21.9753  2350470   81.69%
  1328   795     102.0000   634      120.0000       21.9753  2317970   81.69%
  1355   803       cutoff            120.0000       21.9753  2339812   81.69%
  1404   861      93.7641   618      120.0000       21.9753  2474997   81.69%
*  1423   810      integral     0      119.0000       21.9753  2331143   81.53%
  1439   861      78.0000   832      119.0000       21.9753  2460396   81.53%
  1458   874      24.3333   941      119.0000       24.3333  2553600   79.55%
Elapsed time = 166.09 sec. (135561.29 ticks, tree = 9.43 MB, solutions = 19)
  1484   890      51.0000   764      119.0000       24.3333  2576455   79.55%
  1507   875      24.4833  1277      119.0000       24.3333  2562314   79.55%
  1532   931      79.2925   394      119.0000       24.3333  2669145   79.55%
  1562  1012     103.0000   570      119.0000       24.4833  2907174   79.43%
  1603  1017      64.9095   797      119.0000       24.4833  2928676   79.43%
  1634   985      59.0000   922      119.0000       28.0000  2841470   76.47%
  1663  1073     117.0000   203      119.0000       28.0000  3049739   76.47%
  1687  1083      37.0000  1003      119.0000       28.0000  3098275   76.47%
  1710  1088      64.0000   945      119.0000       28.0000  3117595   76.47%
  1735  1151      57.0000   731      119.0000       28.0000  3288949   76.47%
Elapsed time = 188.14 sec. (145496.62 ticks, tree = 12.93 MB, solutions = 19)
  1758  1111     104.3636   591      119.0000       28.0000  3161484   76.47%
  1791  1118     111.0000   213      119.0000       28.0000  3170009   76.47%
  1827  1195      84.0000   591      119.0000       28.0000  3410712   76.47%
  1846  1227     101.0000   461      119.0000       28.0000  3507627   76.47%
  1874  1157      46.2868  1191      119.0000       28.0000  3293404   76.47%
  1902  1238      88.6839   606      119.0000       28.0000  3542320   76.47%
  1926  1235      46.2868  1143      119.0000       28.0000  3531022   76.47%
  1960  1303     113.9577   150      119.0000       28.0000  3694411   76.47%
  1988  1358      83.0000   753      119.0000       28.0000  3866111   76.47%
  2012  1366      89.0000   545      119.0000       28.0000  3891705   76.47%
Elapsed time = 212.01 sec. (155392.93 ticks, tree = 14.97 MB, solutions = 19)
  2040  1324     111.0000   194      119.0000       28.0000  3762450   76.47%
  2090  1363      95.0000   472      119.0000       28.0000  3880860   76.47%
  2110  1374     102.6462   504      119.0000       28.0000  3912727   76.47%
  2132  1448      37.0000  1093      119.0000       28.0000  4101132   76.47%
  2156  1376      65.0000  1128      119.0000       28.0000  3935627   76.47%
  2183  1509      74.0000   629      119.0000       28.0000  4269507   76.47%
  2199  1432      59.6156   521      119.0000       28.0000  4091085   76.47%
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  2221  1503       74.5122   909      119.0000       28.0000  4254124   76.47%
  2242  1506       85.0000   668      119.0000       28.0000  4261966   76.47%
  2269  1531       72.0000   616      119.0000       28.0000  4326175   76.47%
Elapsed time = 235.73 sec. (165405.92 ticks, tree = 16.99 MB, solutions = 19)
  2310  1614       91.2400   533      119.0000       28.0000  4601381   76.47%
  2336  1604       52.0000   916      119.0000       28.0000  4579989   76.47%
  2359  1635       81.0000   372      119.0000       28.0000  4674618   76.47%
  2383  1626       89.6835   540      119.0000       28.0000  4645627   76.47%
  2409  1677       73.9189   792      119.0000       28.0000  4823598   76.47%
  2442  1670       72.0000   646      119.0000       28.0000  4794167   76.47%
  2483  1668       93.7622   751      119.0000       28.0000  4785540   76.47%
  2532  1783      112.0000   417      119.0000       28.0000  5039850   76.47%
  2573  1789      117.0000   203      119.0000       28.0000  5046707   76.47%
  2607  1803      117.0000   429      119.0000       28.0000  5087224   76.47%
Elapsed time = 259.63 sec. (175250.28 ticks, tree = 21.09 MB, solutions = 19)
  2633  1840       96.0000   335      119.0000       28.0000  5207614   76.47%
  2671  1843      104.0000   303      119.0000       28.0000  5210722   76.47%
  2697  1910      109.0000   465      119.0000       28.0000  5361804   76.47%
  2739  1915      114.0000   281      119.0000       28.0000  5370234   76.47%
  2762  1994       59.0000  1391      119.0000       29.2868  5550677   75.39%
  2782  1918       46.2868  1103      119.0000       29.2868  5382630   75.39%
  2797  1972       50.0000   998      119.0000       29.2868  5488794   75.39%
  2819  1929       56.0000   803      119.0000       29.2868  5416055   75.39%
  2840  2010       77.1503   396      119.0000       29.2868  5592105   75.39%
  2967  2124      107.8115   200      119.0000       29.2868  5904577   75.39%
Elapsed time = 292.45 sec. (188264.32 ticks, tree = 31.71 MB, solutions = 19)
  3060  2184       70.9836   709      119.0000       29.2868  6095989   75.39%
  3192  2336        cutoff           119.0000       29.2868  6467741   75.39%
  3274  2348      103.0000   465      119.0000       29.2868  6525845   75.39%
  3373  2493       78.0000   422      119.0000       29.2868  6952898   75.39%
  3477  2558      104.0000   413      119.0000       29.2868  7141683   75.39%
  3597  2588       59.9613   813      119.0000       29.2868  7249962   75.39%
  3714  2755      111.0000   353      119.0000       29.2868  7685186   75.39%
  3834  2870      108.0000   412      119.0000       37.0000  8008495   68.91%
  3947  2835       76.6462   461      119.0000       37.0000  7906850   68.91%

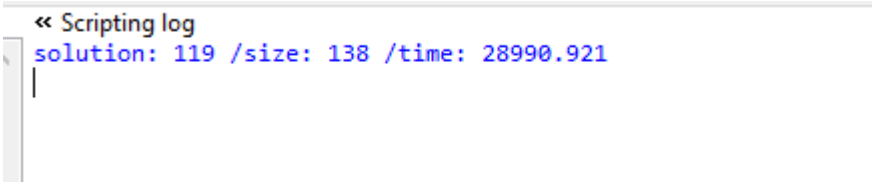
Performing restart 1

Repeating presolve.
Tried aggregator 1 time.
MIP Presolve eliminated 1108 rows and 552 columns.
Reduced MIP has 33675 rows, 18630 columns, and 119155 nonzeros.
Reduced MIP has 18492 binaries, 138 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.14 sec. (170.22 ticks)
Tried aggregator 1 time.
Reduced MIP has 33675 rows, 18630 columns, and 119155 nonzeros.
Reduced MIP has 18492 binaries, 138 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.11 sec. (167.19 ticks)
Represolve time = 0.55 sec. (463.04 ticks)
  3955     0       24.3014  1647      119.0000    Cuts: 1419  8517722   68.91%
  3955     0       25.0818  1876      119.0000    Cuts: 1248  8544132   68.91%
  3955     0       25.7176  1693      119.0000    Cuts: 1466  8568079   68.91%
```

```
  3955     0      26.0123  1660      119.0000    Cuts: 1524  8581982   68.91%
  3955     0      26.3608  1648      119.0000    Cuts: 1397  8595584   68.91%
  3955     0      26.5709  1513      119.0000    Cuts: 1388  8604907   68.91%
  3955     0      26.7651  1520      119.0000    Cuts: 1380  8616777   68.91%
  3955     0      26.9956  1305      119.0000    Cuts: 1209  8630128   68.91%
  3955     0      27.1337  1542      119.0000    Cuts: 1257  8643740   68.91%
  3955     2      27.1337  1507      119.0000      37.0000  8643740   68.91%
Elapsed time = 523.34 sec. (391324.29 ticks, tree = 0.02 MB, solutions = 19)
  3957     4      27.4151  1323      119.0000      37.0000  8656133   68.91%
  3960     6      39.0000   869      119.0000      37.0000  8669820   68.91%
  3965    12       77.0000   476      119.0000      37.0000  8708959   68.91%
  3998     5      30.7908  1046      119.0000      37.0000  8663788   68.91%
  4082    67       72.0000   414      119.0000      37.0000  8899697   68.91%
  4177   178       67.0062   462      119.0000      37.0000  9176848   68.91%
  4315   247       64.0000   912      119.0000      37.0000  9437096   68.91%
  4456   401      104.1000   241      119.0000      37.0000  9615180   68.91%
  4616   501       70.0000   493      119.0000      37.0000  9850251   68.91%
  4759   640       79.0606   620      119.0000      37.0000 10045312   68.91%
Elapsed time = 600.47 sec. (433338.45 ticks, tree = 8.51 MB, solutions = 19)
  4965   901       80.0000   377      119.0000      37.0000 10478358   68.91%
  5130  1038       81.5618   372      119.0000      37.0000 10726384   68.91%

Implied bound cuts applied:  1018
Flow cuts applied:  331
Mixed integer rounding cuts applied:  556
Zero-half cuts applied:  52
Gomory fractional cuts applied:  5

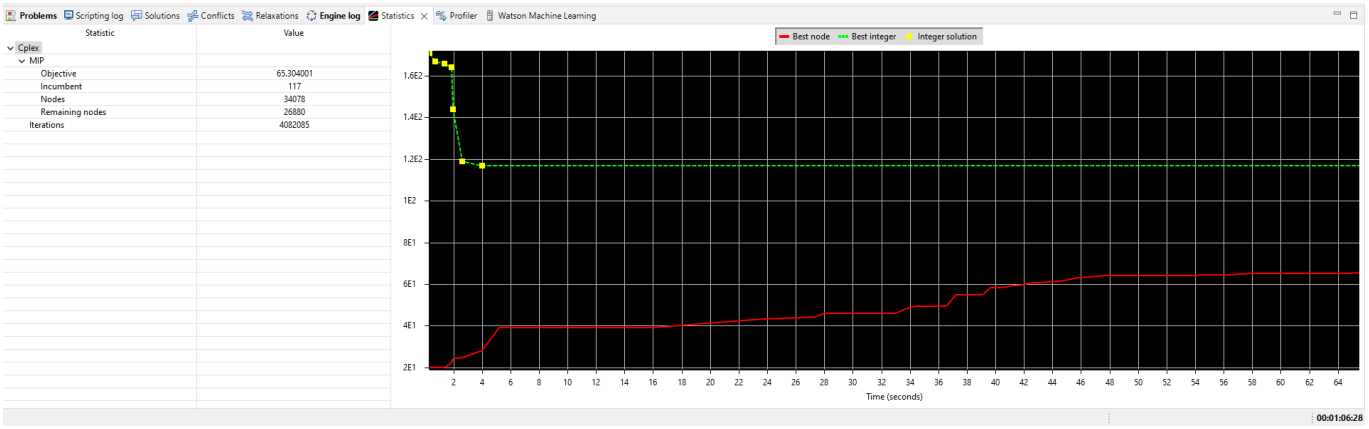
Root node processing (before b&c):
  Real time             =   66.31 sec. (85900.07 ticks)
Parallel b&c, 12 threads:
  Real time             =  550.86 sec. (356157.46 ticks)
  Sync time (average)   =   96.03 sec.
  Wait time (average)   =    0.05 sec.
                          ------------
Total (root+branch&cut) =  617.17 sec. (442057.54 ticks)
```



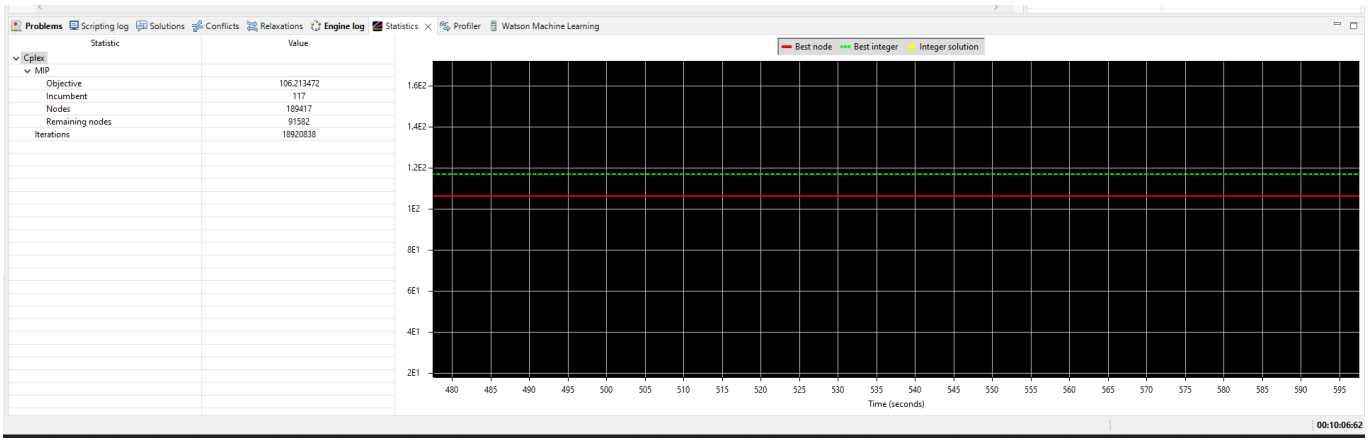
3) Sabiendo que existe una solución que usa 15 lavados (se obtuvo mediante una heurística) ver cómo acelerar reduciendo el modelo (cantidad de restricciones), pueden detenerlo a los 10 minutos si no termina. Indicar en el informe todo lo que notan de esta corrida

colocó el límite de colores a 15, de esta manera limitando la cantidad de tandas de lavados a 15, ya que sabemos que existe una solución menor por heurística, así acelerando la solución

En el primer minuto se muestra el grafico de la siguiente manera, donde se notan los Integer solutions, o al menos eso pienso porque soy medio daltonico y me cuesta diferenciar ver y ese amarillo, a los dos minutos ya no encuentra otro mejor integer solution entonces no se observa el amarillo.



a los minutos observamos que a diferencia al agregar el límite, llegamos a un punto más cercano a convergencia, pero no a una solución final en tiempo.



Version identifier: 22.1.0.0 | 2022-03-09 | 1a383f8ce
Legacy callback pi
Tried aggregator 1 time.
MIP Presolve eliminated 13053 rows and 0 columns.
MIP Presolve modified 1347 coefficients.
Reduced MIP has 3945 rows, 2085 columns, and 13532 nonzeros.
Reduced MIP has 2070 binaries, 15 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.01 sec. (23.27 ticks)
Found incumbent of value 300.000000 after 0.03 sec. (37.25 ticks)
Probing time = 0.02 sec. (4.04 ticks)
Tried aggregator 1 time.
Detecting symmetries...
Reduced MIP has 3945 rows, 2085 columns, and 13532 nonzeros.

Reduced MIP has 2070 binaries, 15 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.01 sec. (12.94 ticks)
Probing time = 0.02 sec. (4.04 ticks)
Clique table members: 1875.
MIP emphasis: balance optimality and feasibility.
MIP search method: dynamic search.
Parallel mode: deterministic, using up to 12 threads.
Root relaxation solution time = 0.11 sec. (148.88 ticks)

	Nodes				Cuts/			
	Node	Left	Objective	IInf	Best Integer	Best Bound	ItCnt	Gap
*	0+	0			300.0000	0.0000		100.00%
*	0+	0			171.0000	0.0000		100.00%
	0	0	20.0000	1121	171.0000	20.0000	1890	88.30%
*	0+	0			167.0000	20.0000		88.02%
	0	0	20.0000	1075	167.0000	Cuts: 466	3376	88.02%
*	0+	0			166.0000	20.0000		87.95%
	0	0	22.3129	1075	166.0000	Cuts: 1046	7555	86.56%
*	0+	0			164.0000	22.3129		86.39%
	0	0	24.4000	1000	164.0000	Cuts: 867	10779	85.12%
*	0+	0			162.0000	24.4000		84.94%
*	0+	0			146.0000	24.4000		83.29%
*	0+	0			144.0000	24.4000		83.06%
	0	0	-1.00000e+75	0	144.0000	24.4000	10779	83.06%
*	0+	0			119.0000	24.4000		79.50%
	0	0	24.4190	857	119.0000	Cuts: 685	15477	79.28%
	0	0	24.8376	978	119.0000	Cuts: 668	17933	78.71%
	0	0	25.1408	865	119.0000	Cuts: 705	19017	78.58%
	0	0	25.4164	983	119.0000	Cuts: 582	20016	78.38%
	0	0	25.6319	950	119.0000	Cuts: 570	21211	78.20%
	0	0	25.7120	922	119.0000	Cuts: 488	21877	78.13%
	0	0	25.7848	945	119.0000	Cuts: 466	22531	78.03%
	0	0	25.8287	1029	119.0000	Cuts: 425	23437	77.96%
	0	0	25.8736	1044	119.0000	Cuts: 490	24423	77.94%
*	0+	0			117.0000	26.2563		77.56%
	0	0	25.9381	996	117.0000	Cuts: 518	25444	76.15%
	0	0	26.0113	1037	117.0000	Cuts: 502	26842	76.15%
	0	0	26.0693	954	117.0000	Cuts: 363	27469	66.67%
	0	0	26.0946	959	117.0000	Cuts: 584	28238	66.67%
	0	2	26.0946	913	117.0000	39.0000	28238	66.67%

Elapsed time = 5.13 sec. (6438.90 ticks, tree = 0.02 MB, solutions = 10)

1	3	39.0062	814	117.0000	39.0000	30567	66.67%
5	5	39.0000	785	117.0000	39.0000	33164	66.67%
28	8	53.0788	661	117.0000	39.0000	36586	66.67%
74	30	77.0000	417	117.0000	39.0000	43701	66.67%
128	110	66.6943	515	117.0000	39.0000	77317	66.67%
198	171	97.5696	308	117.0000	39.0000	97840	66.67%
401	285	116.0000	54	117.0000	39.0000	119305	66.67%
511	303	65.0000	477	117.0000	39.0000	127138	66.67%
613	394	88.0000	466	117.0000	39.0000	146390	66.67%
997	716	77.4023	442	117.0000	39.0000	214046	66.67%

```
Elapsed time = 8.20 sec. (9612.98 ticks, tree = 19.09 MB, solutions = 10)
   1234   866      65.9951   524      117.0000       39.0000   265998   66.67%
   1544  1200      101.0000   262      117.0000       39.0000   354521   66.67%
   1817  1439      108.0000   219      117.0000       39.0000   445173   66.67%
   2109  1604      104.0000   272      117.0000       39.0000   492894   66.67%
   2394  1883       96.0000   330      117.0000       39.0000   568302   66.67%
   2693  2185       58.5645   522      117.0000       39.0000   668009   66.67%
   3135  2433       58.0000   628      117.0000       39.0000   733974   66.67%
   3491  2796       96.0000   398      117.0000       39.0000   833317   66.67%
   3985  3220      110.3227   202      117.0000       42.4738   902185   63.70%

Performing restart 1

Repeating presolve.
Tried aggregator 1 time.
MIP Presolve eliminated 124 rows and 60 columns.
Reduced MIP has 3821 rows, 2025 columns, and 13232 nonzeros.
Reduced MIP has 2010 binaries, 15 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.02 sec. (15.58 ticks)
Tried aggregator 1 time.
Reduced MIP has 3821 rows, 2025 columns, and 13232 nonzeros.
Reduced MIP has 2010 binaries, 15 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.02 sec. (12.70 ticks)
Represolve time = 0.11 sec. (51.62 ticks)
   4071     0       39.5345   798      117.0000     Cuts: 460   971441   63.09%
   4071     0       39.8751   767      117.0000     Cuts: 752   972478   63.09%
   4071     0       40.5657   760      117.0000     Cuts: 735   974220   63.09%
   4071     0       40.9261   741      117.0000     Cuts: 686   975608   63.09%
   4071     0       41.1446   706      117.0000     Cuts: 678   976329   63.09%
   4071     0       41.2539   741      117.0000     Cuts: 707   977153   63.09%
   4071     0       41.3371   640      117.0000     Cuts: 326   977710   63.09%
   4071     0       41.4488   700      117.0000     Cuts: 710   978587   63.09%
   4071     0       41.9487   657      117.0000     Cuts: 307   979395   63.09%
   4071     0       42.1170   689      117.0000     Cuts: 718   980450   63.09%
   4071     0       42.2478   636      117.0000     Cuts: 606   981242   63.09%
   4071     0       42.2889   638      117.0000     Cuts: 592   981711   63.09%
   4071     0       42.3819   645      117.0000     Cuts: 289   982270   63.09%
   4071     0       42.3927   650      117.0000     Cuts: 609   982625   63.09%
   4071     2       42.3927   637      117.0000       43.1847   982625   63.09%
Elapsed time = 23.45 sec. (25891.82 ticks, tree = 0.02 MB, solutions = 10)
   4074     4       42.8797   589      117.0000       43.2390   983693   63.04%
   4083     9       53.8117   557      117.0000       43.5019   988554   62.82%
   4102    23       64.3542   424      117.0000       43.6731   996519   62.67%
   4153    60       67.4816   459      117.0000       44.1324  1020918   62.28%
   4202    96       59.0096   483      117.0000       45.8211  1040980   60.84%
   4270   136       80.3230   426      117.0000       45.8211  1058518   60.84%
   4474    74       64.0000   485      117.0000       45.8211  1029562   60.84%
   4841   569       88.9032   359      117.0000       45.8211  1161631   60.84%
   5389   771       66.7537   480      117.0000       45.9526  1198600   60.72%
   6014  1392       77.9911   411      117.0000       45.9526  1292241   60.72%
Elapsed time = 32.97 sec. (35769.12 ticks, tree = 34.74 MB, solutions = 10)
   6631  1768       67.3378   446      117.0000       48.0558  1355895   58.93%
```

```
  7095  2365       96.3684   360      117.0000       49.3712  1445644   57.80%
  7869  3169      106.8503   215      117.0000       49.3712  1560438   57.80%
  8341  3577       96.0000   382      117.0000       49.3712  1615461   57.80%
  9243  4312      112.0000   263      117.0000       54.7537  1697546   53.20%
  9966  5182      102.5971   336      117.0000       54.7537  1785997   53.20%
 10801  5701      113.6500   233      117.0000       55.8132  1846083   52.30%
 11577  6546       75.3423   455      117.0000       58.6226  1927427   49.90%
 12288  7205        cutoff           117.0000       59.1081  2010684   49.48%
 13080  7621       91.5923   416      117.0000       59.8669  2051276   48.83%
Elapsed time = 42.05 sec. (45312.04 ticks, tree = 182.59 MB, solutions = 10)
 14130  8599      109.7500   255      117.0000       60.9152  2155631   47.94%
 15229  9366      106.0000   299      117.0000       61.0533  2212525   47.82%
 16289 10180      101.0000   326      117.0000       61.5115  2280194   47.43%
 17058 11565       96.5923   334      117.0000       62.9143  2400952   46.23%
 17946 11991      105.1053   295      117.0000       63.3267  2446355   45.87%
 18922 12775      101.9761   330      117.0000       63.8791  2526722   45.40%
 19837 13516       97.2536   359      117.0000       64.0000  2595439   45.30%
 20560 14415       97.5332   421      117.0000       64.0000  2670451   45.30%
 21261 15388      109.0000   323      117.0000       64.0000  2783709   45.30%
 22069 16086      101.0000   289      117.0000       64.0000  2856512   45.30%
Elapsed time = 51.39 sec. (54856.73 ticks, tree = 456.19 MB, solutions = 10)
 22817 16678       93.5153   338      117.0000       64.0000  2928452   45.30%
 23584 17577      106.0105   225      117.0000       64.0000  3019146   45.30%
 24524 18294       97.2704   296      117.0000       64.2963  3101214   45.05%
 25493 18752       74.5436   373      117.0000       64.3972  3136336   44.96%
 26570 20286      106.3486   309      117.0000       64.5127  3278159   44.86%
 27593 21147      116.0000   198      117.0000       64.7933  3362021   44.62%
 28347 22093       73.3221   432      117.0000       64.9927  3462744   44.45%
 29164 22477      101.0000   336      117.0000       65.0000  3502384   44.44%
 29815 22987      111.0000   154      117.0000       65.0000  3561187   44.44%
 30395 23647      101.0000   283      117.0000       65.0000  3643389   44.44%
Elapsed time = 60.91 sec. (64409.23 ticks, tree = 624.34 MB, solutions = 10)
 31157 24388      103.3118   345      117.0000       65.0000  3737888   44.44%
 32114 25314      109.4219   324      117.0000       65.0000  3836374   44.44%
 33021 26268       81.7049   430      117.0000       65.1964  3937652   44.28%
 33954 26944       97.6768   371      117.0000       65.2647  4000950   44.22%
 34613 27472       93.1548   406      117.0000       65.3040  4056932   44.18%
 35335 28201       96.7419   389      117.0000       65.4425  4146974   44.07%
 36209 28544       79.6863   381      117.0000       65.5679  4192859   43.96%
 37043 29487       98.7273   296      117.0000       65.6490  4312894   43.89%
 37770 30335      109.0000   286      117.0000       65.8577  4401602   43.71%
 38680 31126       97.5625   332      117.0000       65.8834  4482163   43.69%
Elapsed time = 70.72 sec. (73967.38 ticks, tree = 893.82 MB, solutions = 10)
 39381 31712       91.3684   414      117.0000       65.9791  4554824   43.61%
 40381 32990       93.1548   393      117.0000       66.1214  4708558   43.49%
 41059 32889      108.2677   332      117.0000       66.1214  4698372   43.49%
 42041 34024      107.4217   277      117.0000       66.2417  4826306   43.38%
 42870 34523      112.0000   159      117.0000       66.4753  4865502   43.18%
 43385 35865       97.5625   293      117.0000       66.5982  4983585   43.08%
 43954 36229       91.7347   421      117.0000       66.5982  5032607   43.08%
 44920 36426       93.1548   356      117.0000       66.7537  5054900   42.95%
 45791 37348      111.0000   281      117.0000       66.7961  5146181   42.91%
```

```
  46776 37776       96.6429   321      117.0000       66.8848  5187382   42.83%
Elapsed time = 83.66 sec. (83521.28 ticks, tree = 1124.25 MB, solutions = 10)
  47688 39016      116.0000   165      117.0000       67.0455  5309448   42.70%
  48440 39532       85.7991   379      117.0000       67.2072  5370641   42.56%
  49374 40511       93.1548   311      117.0000       67.4964  5453893   42.31%
  50469 41284      106.0000   298      117.0000       67.4976  5543458   42.31%
  51319 42096       93.7738   348      117.0000       67.6354  5625851   42.19%
  52272 42675       87.2785   432      117.0000       67.7837  5670264   42.07%
  53430 44387      104.6444   389      117.0000       67.9716  5831881   41.90%
  54280 44438       94.5813   341      117.0000       68.0795  5829463   41.81%
  55459 46128      107.2337   276      117.0000       68.2874  5981163   41.63%
  56423 47368      111.9519   273      117.0000       68.3511  6086784   41.58%
Elapsed time = 98.00 sec. (93073.05 ticks, tree = 1343.72 MB, solutions = 10)
  57444 47512      104.3027   262      117.0000       68.5955  6106187   41.37%
  58279 48286       91.7347   402      117.0000       68.6756  6172850   41.30%
  59415 49454      101.0043   337      117.0000       68.8825  6283519   41.13%
  60481 50303      101.0000   327      117.0000       69.2866  6362483   40.78%
  61712 50862      112.0000   210      117.0000       69.4579  6403004   40.63%
  62925 51636      101.7663   341      117.0000       69.5163  6471974   40.58%
  63995 53603       91.6863   372      117.0000       69.8149  6638020   40.33%
  64922 54998       96.5923   355      117.0000       70.0910  6740115   40.09%
  65754 55456       97.6569   347      117.0000       70.4877  6784570   39.75%
  69284 58836       78.8731   408      117.0000       70.7600  7123609   39.52%
Elapsed time = 128.20 sec. (105482.09 ticks, tree = 1718.18 MB, solutions = 10)
  72773 61430      116.0000   213      117.0000       70.9221  7356712   39.38%
  76147 65349      107.0000   334      117.0000       70.9221  7760539   39.38%
  79385 68586      106.3750   288      117.0000       71.0545  8092310   39.27%

Performing restart 2

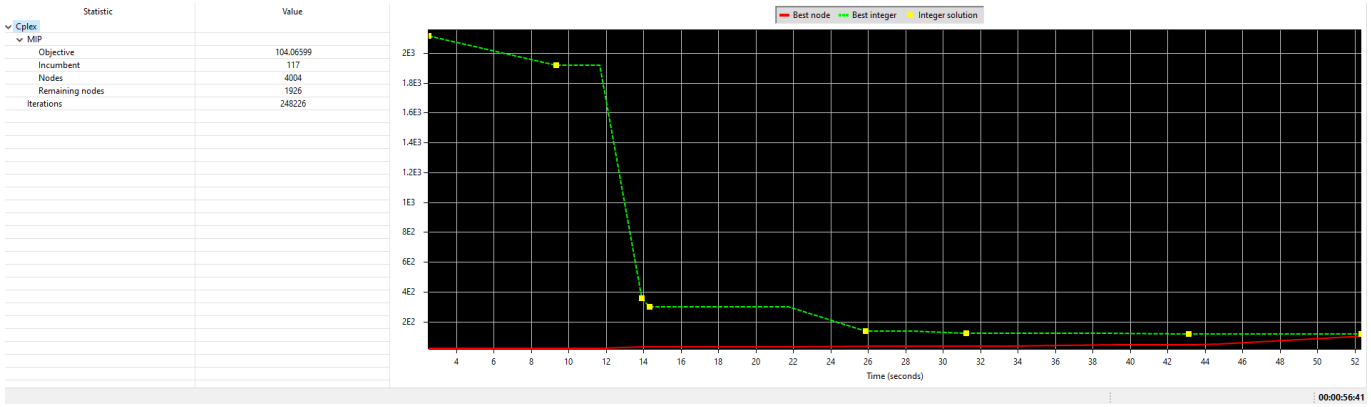
Repeating presolve.
Tried aggregator 1 time.
MIP Presolve eliminated 130 rows and 0 columns.
Reduced MIP has 3691 rows, 2025 columns, and 19179 nonzeros.
Reduced MIP has 2010 binaries, 15 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.05 sec. (19.74 ticks)
Tried aggregator 1 time.
Reduced MIP has 3691 rows, 2025 columns, and 19179 nonzeros.
Reduced MIP has 2010 binaries, 15 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.01 sec. (17.13 ticks)
Represolve time = 18.83 sec. (88.80 ticks)
  80576     0      104.0000   375      117.0000     Cuts: 289  8284026   11.11%
  80576     0      104.0000   434      117.0000     Cuts: 480  8284869   11.11%
  80576     0      104.0000   274      117.0000      Cuts: 57  8285181   11.11%
  80576     0      104.0000   345      117.0000     Cuts: 447  8285501   11.11%
  80576     0      104.0000   327      117.0000      Cuts: 35  8285933   11.11%
  80576     0      104.0000   409      117.0000     Cuts: 416  8286331   11.11%
  80576     0      104.0000   322      117.0000      Cuts: 96  8286693   11.11%
  80576     0      104.0000   358      117.0000     Cuts: 487  8287183   11.11%
  80576     0      104.0000   255      117.0000      Cuts: 81  8287376   11.11%
  80576     0      104.0000   345      117.0000     Cuts: 427  8287715   11.11%
  80576     0      104.0000   361      117.0000      Cuts: 75  8288167   11.11%
```

```
  80576     2      104.0000   232      117.0000      104.0000  8288167   11.11%
  80629    24      109.0000   269      117.0000      104.0000  8295783   11.11%
  81319   401      116.0000   139      117.0000      104.0000  8338560   11.11%
  84913  3295      108.5455   299      117.0000      104.0000  8570982   11.11%
  89388  7171      112.0000   269      117.0000      104.8207  8893738   10.41%
  92822 10249      105.4738   396      117.0000      105.0000  9182572   10.26%
  96234 13172      112.0000   267      117.0000      105.0000  9478987   10.26%
Elapsed time = 212.63 sec. (146266.40 ticks, tree = 300.91 MB, solutions = 10)
  99626 15712      107.0000   398      117.0000      105.0000  9735214   10.26%
 102579 18677      113.0000   347      117.0000      105.0000 10057500   10.26%
 105493 20570      112.0000   284      117.0000      105.0500 10310753   10.21%
 108696 23460      114.0000   253      117.0000      105.1468 10612992   10.13%
 112096 26111      116.0000   228      117.0000      105.3685 10869705    9.94%
 115211 28500      108.0000   326      117.0000      105.4653 11133068    9.86%
 118770 32225      114.0000   314      117.0000      105.6435 11515906    9.71%
 122185 34560      116.0000   286      117.0000      105.7073 11767840    9.65%
 125433 37689      109.3846   341      117.0000      105.8329 12080603    9.54%
 128713 40493      114.0000   276      117.0000      105.9303 12349429    9.46%
Elapsed time = 256.69 sec. (184427.22 ticks, tree = 1054.91 MB, solutions = 10)
 131153 42397      115.0000   310      117.0000      105.9794 12573972    9.42%
 134230 44765      114.0000   283      117.0000      106.0000 12811725    9.40%
 137015 47261      113.1429   343      117.0000      106.0000 13033657    9.40%
 139701 49220      110.8235   302      117.0000      106.0000 13253888    9.40%
 141881 51289      109.1250   340      117.0000      106.0000 13465693    9.40%
 143700 52709      108.3478   389      117.0000      106.0000 13682479    9.40%
 146004 55245      110.8889   340      117.0000      106.0000 13981229    9.40%
 147911 56666      113.0000   446      117.0000      106.0000 14147772    9.40%
 149470 58238      113.0000   338      117.0000      106.0000 14401979    9.40%
 151303 59539      110.0000   335      117.0000      106.0000 14603252    9.40%
Elapsed time = 323.55 sec. (222594.03 ticks, tree = 1715.82 MB, solutions = 10)
 153810 61203      114.7832   267      117.0000      106.0000 14780078    9.40%
 155582 63046      112.0000   373      117.0000      106.0000 15007751    9.40%
 157605 65082      114.0000   318      117.0000      106.0000 15280142    9.40%
 159637 66565      112.2238   311      117.0000      106.0000 15475176    9.40%
 161509 67862      112.6500   375      117.0000      106.0000 15651626    9.40%
 162880 69663      113.0000   404      117.0000      106.0000 15931457    9.40%
 164830 71452      112.0000   270      117.0000      106.0000 16143933    9.40%
 166177 72283      112.0000   339      117.0000      106.0000 16303408    9.40%
 167432 73430      112.0000   313      117.0000      106.0000 16509693    9.40%
 168974 74711      114.9625   376      117.0000      106.0000 16717036    9.40%
Elapsed time = 424.78 sec. (260766.59 ticks, tree = 2307.12 MB, solutions = 10)
Nodefile size = 253.90 MB (227.36 MB after compression)
 170576 76222      114.0000   377      117.0000      106.0000 16956124    9.40%
 172686 77017      106.6626   432      117.0000      106.0009 17059406    9.40%
 174664 78912      108.2885   407      117.0000      106.0294 17250687    9.38%
 176159 80614      115.0000   335      117.0000      106.0500 17456995    9.36%
 178210 81772      114.0000   363      117.0000      106.0500 17644212    9.36%
 180160 84340      112.0000   271      117.0000      106.0500 17929369    9.36%
 182146 85643      114.0000   313      117.0000      106.0714 18103230    9.34%
 184395 87553      116.0000   269      117.0000      106.1176 18321909    9.30%
 186432 88755      114.0000   293      117.0000      106.1176 18439799    9.30%
 188494 91312      114.1458   260      117.0000      106.1600 18760698    9.26%
```

Elapsed time = 583.76 sec. (298947.56 ticks, tree = 3014.22 MB, solutions = 10)
Nodefile size = 960.63 MB (862.84 MB after compression)
190655 92915 116.0000 215 117.0000 106.2777 18934197 9.16%
193065 94328 111.1429 355 117.0000 106.3122 19081200 9.13%

4) Volviendo al modelo original (sin el límite de 15 lavados), descomentar la restricción "simetría". Indicar en el informe todo lo que notan de esta corrida

   Activando la simetría llegamos a una solución bien rápido, agregando esta restricción se converge mucho más rápido.



Version identifier: 22.1.0.0 | 2022-03-09 | 1a383f8ce
Legacy callback pi
Tried aggregator 1 time.
MIP Presolve eliminated 120489 rows and 0 columns.
MIP Presolve modified 11991 coefficients.
Reduced MIP has 34898 rows, 19182 columns, and 122062 nonzeros.
Reduced MIP has 19044 binaries, 138 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.27 sec. (253.34 ticks)
Found incumbent of value 2760.000000 after 0.42 sec. (465.00 ticks)
Probing time = 0.13 sec. (13.81 ticks)
Tried aggregator 1 time.
Detecting symmetries...
Reduced MIP has 34898 rows, 19182 columns, and 122062 nonzeros.
Reduced MIP has 19044 binaries, 138 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.11 sec. (144.06 ticks)
Probing time = 0.11 sec. (13.14 ticks)
Clique table members: 15717.
MIP emphasis: balance optimality and feasibility.
MIP search method: dynamic search.
Parallel mode: deterministic, using up to 12 threads.
Root relaxation solution time = 1.19 sec. (1059.19 ticks)

	Node	Nodes Left	Objective	IInf	Best Integer	Cuts/ Best Bound	ItCnt	Gap
*	0+	0			2760.0000	0.0000		100.00%
*	0+	0			2631.0000	0.0000		100.00%
*	0+	0			2442.0000	0.0000		100.00%
*	0+	0			2298.0000	0.0000		100.00%

```
*    0+    0                         2201.0000        0.0000          100.00%
*    0+    0                         2126.0000        0.0000          100.00%
*    0+    0                         2116.0000        0.0000          100.00%
     0     0       20.0000 10405     2116.0000       20.0000       12   99.05%
*    0+    0                         2008.0000       20.0000           99.00%
*    0+    0                         1917.0000       20.0000           98.96%
     0     0       21.3171  9828     1917.0000    Cuts: 1915     2658   98.89%
     0     0       28.3807  8748     1917.0000    Cuts: 1470     8403   98.52%
*    0+    0                          356.0000       28.3807           92.03%
     0     0       30.2198  8195      356.0000    Cuts: 774     15372   91.51%
*    0+    0                          299.0000       30.2198           89.89%
     0     0  -1.00000e+75     0      299.0000       30.2198     15372   89.89%
*    0+    0                          178.0000       30.2198           83.02%
*    0+    0                          157.0000       30.2198           80.75%
*    0+    0                          144.0000       30.2198           79.01%
*    0+    0                          142.0000       30.2198           78.72%
*    0+    0                          140.0000       30.2198           78.41%
*    0+    0                          138.0000       30.2198           78.10%
*    0+    0                          136.0000       30.2198           77.78%
*    0+    0                          134.0000       30.2198           77.45%
     0     0  -1.00000e+75     0      134.0000       30.2198     35564   77.45%

Repeating presolve.
Tried aggregator 1 time.
MIP Presolve eliminated 11157 rows and 6359 columns.
MIP Presolve modified 1943 coefficients.
Reduced MIP has 23741 rows, 12823 columns, and 82137 nonzeros.
Reduced MIP has 12685 binaries, 138 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.08 sec. (95.74 ticks)
Probing time = 0.11 sec. (22.17 ticks)
Tried aggregator 1 time.
Detecting symmetries...
Reduced MIP has 23741 rows, 12823 columns, and 82137 nonzeros.
Reduced MIP has 12685 binaries, 138 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.08 sec. (90.72 ticks)
Represolve time = 0.36 sec. (422.29 ticks)
Probing time = 0.11 sec. (22.14 ticks)
Clique table members: 10922.
MIP emphasis: balance optimality and feasibility.
MIP search method: dynamic search.
Parallel mode: deterministic, using up to 12 threads.
Root relaxation solution time = 0.66 sec. (667.64 ticks)

        Nodes                                         Cuts/
   Node  Left     Objective  IInf  Best Integer    Best Bound    ItCnt     Gap

*    0+    0                          134.0000       30.2198           77.45%
     0     0       34.4425   778      134.0000       34.4425     35587   74.30%
*    0+    0                          121.0000       34.4425           71.54%
     0     0       36.2694   652      121.0000    Cuts: 254     57830   70.03%
     0     0       41.8592   638      121.0000    Cuts: 334     71873   64.85%
     0     0       42.1122   678      121.0000    Cuts: 201     73207   64.32%
```

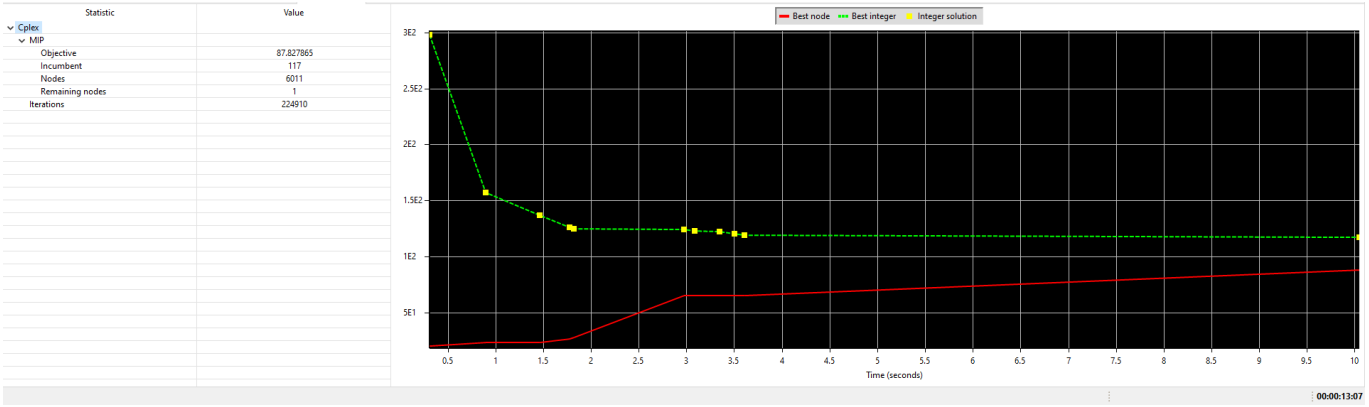
```
*     0+    0                    119.0000       43.1738           63.72%
*     0+    0                    118.0000       43.1738           63.41%
      0     0  -1.00000e+75     0      118.0000       43.1738    73207   63.41%
      0     0       42.4155   706      118.0000     Cuts: 268    74294   57.48%
      0     0       42.4666   607      118.0000      Cuts: 63    74515   57.48%
      0     0       42.5111   624      118.0000     Cuts: 179    74935   57.48%
Detecting symmetries...
      0     2       42.5586   491      118.0000       50.1699    74992   57.48%
Elapsed time = 44.47 sec. (54372.46 ticks, tree = 0.02 MB, solutions = 22)
      3     5       74.5338   346      118.0000       50.1699    77265   57.48%
     47    26      116.0000   112      118.0000       50.1699    84139   57.48%
    149    60      110.5308   135      118.0000       50.1699    98231   57.48%
    358   129      115.1023   127      118.0000       50.1699   104659   57.48%
    617   267      111.5455   120      118.0000       50.1699   118881   57.48%
    905   434      114.0000   179      118.0000       50.1699   132868   57.48%
   1056   620       92.5496   244      118.0000       50.1699   143310   57.48%
   1315   652      115.0000    39      118.0000       50.1699   150956   57.48%
   1646   821      105.6331   290      118.0000       80.0732   162189   32.14%
   2737  1365      113.4318   169      118.0000       96.9647   202292   17.83%
Elapsed time = 49.91 sec. (57518.28 ticks, tree = 9.49 MB, solutions = 22)
   3996  1942      117.0000    99      118.0000      103.9624   236801   11.90%
*  4003  1935      integral     0      117.0000      103.9624   243270   11.14%
   5387  1615    infeasible             117.0000      108.6405   297345    7.14%
   7204   843      115.0000   108      117.0000      113.1297   336454    3.31%

Clique cuts applied:  10
Implied bound cuts applied:  1436
Mixed integer rounding cuts applied:  5
Zero-half cuts applied:  35
Gomory fractional cuts applied:  24

Root node processing (before b&c):
  Real time             =   44.28 sec. (54096.14 ticks)
Parallel b&c, 12 threads:
  Real time             =   11.61 sec. (6593.63 ticks)
  Sync time (average)   =    3.11 sec.
  Wait time (average)   =    0.00 sec.
                          ------------
Total (root+branch&cut) =   55.89 sec. (60689.78 ticks)
```

5) Modificar el modelo del punto anterior para que aproveche el límite de 15 lavados. Indicar en el informe todo lo que notan de esta corrida

   Agregando el límite de colores, el modelo termina en 13 segundos, pero no llega a una convergencia.



Version identifier: 22.1.0.0 | 2022-03-09 | 1a383f8ce
Legacy callback pi
Tried aggregator 1 time.
MIP Presolve eliminated 13050 rows and 0 columns.
MIP Presolve modified 1350 coefficients.
Reduced MIP has 3962 rows, 2085 columns, and 13578 nonzeros.
Reduced MIP has 2070 binaries, 15 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.03 sec. (23.33 ticks)
Found incumbent of value 300.000000 after 0.06 sec. (53.08 ticks)
Probing time = 0.00 sec. (4.05 ticks)
Tried aggregator 1 time.
Detecting symmetries...
Reduced MIP has 3962 rows, 2085 columns, and 13578 nonzeros.
Reduced MIP has 2070 binaries, 15 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.00 sec. (12.66 ticks)
Probing time = 0.02 sec. (4.28 ticks)
Clique table members: 1878.
MIP emphasis: balance optimality and feasibility.
MIP search method: dynamic search.
Parallel mode: deterministic, using up to 12 threads.
Root relaxation solution time = 0.09 sec. (136.45 ticks)

	Nodes				Cuts/			
	Node	Left	Objective	IInf	Best Integer	Best Bound	ItCnt	Gap
*	0+	0			300.0000	0.0000		100.00%
*	0+	0			298.0000	0.0000		100.00%
	0	0	20.0000	1178	298.0000	20.0000	1809	93.29%
*	0+	0			157.0000	20.0000		87.26%
	0	0	22.1429	1150	157.0000	Cuts: 1090	5659	85.30%
*	0+	0			137.0000	23.0769		83.16%
	0	0	26.5726	918	137.0000	Cuts: 705	10322	80.60%
*	0+	0			126.0000	26.5726		78.91%
	0	0	27.6682	902	126.0000	Cuts: 604	12671	78.04%
*	0+	0			125.0000	27.6682		77.87%

```
      0     0  -1.00000e+75     0      125.0000       27.6682    12671   77.87%
      0     0       28.0912   906      125.0000     Cuts: 567    13906   54.93%
      0     0       28.4556   815      125.0000     Cuts: 306    14492   48.00%
      0     0       28.9110   874      125.0000     Cuts: 565    15764   48.00%
      0     2       29.9981   619      125.0000       65.0000    16210   48.00%
Elapsed time = 2.66 sec. (3166.91 ticks, tree = 0.02 MB, solutions = 6)
*    22+   10                    124.0000       65.0000           47.58%
*    25+    7                    123.0000       65.0000           47.15%
     30    20       84.8364   301      123.0000       65.0000    20448   47.15%
    515   192      110.3879   232      123.0000       65.0000    37140   47.15%
*   764+  263                    122.0000       65.0000           46.72%
*  1125   392      integral     0      121.0000       65.0000    52895   46.28%
*  1267   361      integral     0      120.0000       65.0000    57972   45.83%
*  1278   329      integral     0      119.0000       65.0000    58246   45.38%
   1373   235       cutoff          119.0000       65.0000    62284   45.38%
   1711    17       92.7725   256      119.0000       65.0000    76494   45.38%
   2214   125      113.5385   139      119.0000       65.0000    90055   45.38%
   2716   477       62.9690   426      119.0000       65.0000   111747   45.38%
   3319   758      110.2064   224      119.0000       65.0000   131798   45.38%
   4175  1406      115.0000   246      119.0000       65.0000   153823   45.38%
   4810  1954       94.6846   266      119.0000       70.5764   174133   40.69%
*  5834+ 2538                    117.0000       75.1879           35.74%

Performing restart 1

Repeating presolve.
Tried aggregator 1 time.
MIP Presolve eliminated 1093 rows and 592 columns.
MIP Presolve modified 122 coefficients.
Reduced MIP has 2869 rows, 1493 columns, and 9535 nonzeros.
Reduced MIP has 1478 binaries, 15 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.02 sec. (12.47 ticks)
Tried aggregator 1 time.
MIP Presolve eliminated 127 rows and 0 columns.
MIP Presolve modified 14 coefficients.
Reduced MIP has 2742 rows, 1493 columns, and 9281 nonzeros.
Reduced MIP has 1478 binaries, 15 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.02 sec. (8.67 ticks)
Represolve time = 0.09 sec. (68.77 ticks)
   6011     0       83.3611   384      117.0000     Cuts: 226   216479   28.75%
   6011     0       83.7192   386      117.0000     Cuts: 339   217694   28.45%
   6011     0       84.1301   380      117.0000     Cuts: 297   218130   28.09%
   6011     0       85.4408   368      117.0000     Cuts: 277   218663   26.97%
   6011     0       85.8902   371      117.0000     Cuts: 265   219023   26.59%
   6011     0       86.0056   385      117.0000     Cuts: 215   219309   26.49%
   6011     0       86.1345   387      117.0000     Cuts: 217   219574   26.38%
   6011     0       86.2274   382      117.0000     Cuts: 224   219829   26.30%
   6011     0       86.3203   385      117.0000     Cuts: 230   220132   26.22%
   6011     0       86.4033   393      117.0000     Cuts: 207   220377   26.15%
   6011     0       86.5503   394      117.0000     Cuts: 216   220691   26.03%
   6011     0       86.6590   408      117.0000     Cuts: 155   221000   25.93%
   6011     0       86.7251   415      117.0000     Cuts: 241   221220   25.88%
```

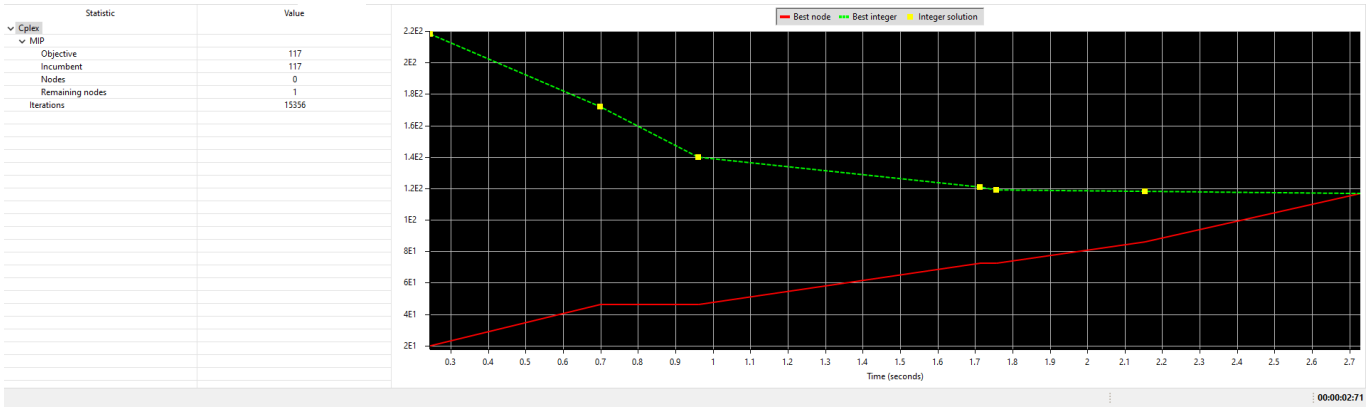
```
  6011     0       86.7960   411      117.0000     Cuts: 182   221375   25.82%
  6011     0       86.9215   431      117.0000     Cuts: 164   221663   25.71%
  6011     0       87.0714   438      117.0000     Cuts: 186   221929   25.58%
  6011     0       87.0972   431      117.0000     Cuts: 188   222069   25.56%
  6011     0       87.1701   432      117.0000     Cuts: 141   222246   25.50%
  6011     0       87.2328   436      117.0000     Cuts: 167   222376   25.44%
  6011     0       87.2713   427      117.0000     Cuts: 170   222546   25.41%
  6011     0       87.3032   415      117.0000     Cuts: 170   222709   25.38%
  6011     0       87.3783   422      117.0000     Cuts: 155   222951   25.32%
  6011     0       87.3970   425      117.0000     Cuts: 141   223079   25.30%
  6011     0       87.4549   419      117.0000     Cuts: 146   223215   25.25%
  6011     0       87.5229   406      117.0000     Cuts: 139   223389   25.19%
  6011     0       87.5467   410      117.0000     Cuts: 144   223567   25.17%
  6011     0       87.6425   411      117.0000     Cuts: 152   223753   25.09%
  6011     0       87.7290   414      117.0000     Cuts: 201   223941   25.02%
  6011     0       87.7677   400      117.0000     Cuts: 177   224109   24.98%
  6011     0       87.7722   418      117.0000     Cuts: 172   224252   24.98%
  6011     0       87.7984   386      117.0000      Cuts: 91   224383   24.96%
  6011     0       87.7984   399      117.0000     Cuts: 220   224518   24.96%
  6011     0       87.8034   403      117.0000      Cuts: 89   224617   24.95%
  6011     0       87.8172   366      117.0000     Cuts: 192   224795   24.94%
  6011     0       87.8279   402      117.0000     Cuts: 200   224910   24.93%
  6011     2       87.8279   391      117.0000      87.8279    224914   24.93%
Elapsed time = 9.97 sec. (9787.65 ticks, tree = 0.02 MB, solutions = 19)
  6031     7       88.6023   333      117.0000      88.2773    230887   24.55%
  6864   335       99.6157   314      117.0000      89.1219    296625   23.83%
  8280   527      114.0000   109      117.0000     109.8111    381184    6.14%

Clique cuts applied:  7
Implied bound cuts applied:  6
Flow cuts applied:  59
Mixed integer rounding cuts applied:  152
Zero-half cuts applied:  41
Lift and project cuts applied:  1
Gomory fractional cuts applied:  21

Root node processing (before b&c):
  Real time             =    2.61 sec. (3100.18 ticks)
Parallel b&c, 12 threads:
  Real time             =   10.38 sec. (9804.24 ticks)
  Sync time (average)   =    1.73 sec.
  Wait time (average)   =    0.01 sec.
                          ------------
Total (root+branch&cut) =   12.99 sec. (12904.41 ticks)
```

6) Comparar el paso 3 y el 5, repetir la prueba sabiendo que existe una solución de 11 lavados

Reducir a 11 colores en el límite, se llega a una convergencia en menos de 3 segundos



Version identifier: 22.1.0.0 | 2022-03-09 | 1a383f8ce
Legacy callback pi
Tried aggregator 1 time.
MIP Presolve eliminated 9577 rows and 0 columns.
MIP Presolve modified 983 coefficients.
Reduced MIP has 2935 rows, 1529 columns, and 9909 nonzeros.
Reduced MIP has 1518 binaries, 11 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.02 sec. (16.79 ticks)
Found incumbent of value 220.000000 after 0.05 sec. (50.34 ticks)
Probing time = 0.00 sec. (3.02 ticks)
Tried aggregator 1 time.
Detecting symmetries...
Reduced MIP has 2935 rows, 1529 columns, and 9909 nonzeros.
Reduced MIP has 1518 binaries, 11 generals, 0 SOSs, and 0 indicators.
Presolve time = 0.02 sec. (9.08 ticks)
Probing time = 0.00 sec. (3.06 ticks)
Clique table members: 1407.
MIP emphasis: balance optimality and feasibility.
MIP search method: dynamic search.
Parallel mode: deterministic, using up to 12 threads.
Root relaxation solution time = 0.06 sec. (98.28 ticks)

	Node	Nodes Left	Objective	IInf	Best Integer	Best Bound	Cuts/ ItCnt	Gap
*	0+	0			220.0000	0.0000		100.00%
*	0+	0			218.0000	0.0000		100.00%
	0	0	20.0000	914	218.0000	20.0000	1394	90.83%
*	0+	0			172.0000	20.0000		88.37%
	0	0	29.5206	794	172.0000	Cuts: 833	3326	73.09%
*	0+	0			140.0000	46.2868		66.94%
	0	0	37.0000	727	140.0000	Cuts: 564	4408	66.94%
*	0+	0			121.0000	46.2868		61.75%
	0	0	41.7808	657	121.0000	Cuts: 833	8851	40.20%
*	0+	0			119.0000	72.3584		39.19%
	0	0	-1.00000e+75	0	119.0000	72.3584	8851	39.19%
*	0+	0			118.0000	72.3584		38.68%

```
      0     0       49.9861   624      118.0000     Cuts: 833    11556   27.15%
*     0+    0                          117.0000       85.9632           26.53%
      0     0        cutoff            117.0000      117.0000    15356    0.00%
Elapsed time = 2.63 sec. (2556.18 ticks, tree = 0.01 MB, solutions = 8)

Clique cuts applied:  9
Implied bound cuts applied:  380
Mixed integer rounding cuts applied:  497
Zero-half cuts applied:  288
Multi commodity flow cuts applied:  24
Gomory fractional cuts applied:  1

Root node processing (before b&c):
  Real time             =    2.63 sec. (2556.36 ticks)
Parallel b&c, 12 threads:
  Real time             =    0.00 sec. (0.00 ticks)
  Sync time (average)   =    0.00 sec.
  Wait time (average)   =    0.00 sec.
                         ------------
Total (root+branch&cut) =    2.63 sec. (2556.36 ticks)
```

7) Comparar en el informe la heurística (paso 1) con la solución mediante programación lineal entera

Analizando el modelo utiliza el modelo estándar de coloreo igual al presentado en la anterior entrega, excepto por la restricción extra de simetría, el modelo normal como mi modelo heurístico es básicamente fuerza bruta, a diferencia que mi modelo llega en una solución mucho más rápido mediante el uso de más multi-threading (6 threads vs 100 threads), al agregar la simetría se obtiene una mucho mejor solucion de una forma mas acelerada.

En conclusión se muestra que mediante el uso de programación lineal entera, se puede obtener un modelo óptimo, pero usando un software pago, a diferencia de uso de algoritmos que lo hace de una forma más fácil, pero no tan óptima, y estudiando el tema de aproximaciones una mezcla de las dos herramientas puede ser el camino correcto.