

Using Google OR Tools for Knapsack Problems: Don't work hard, more and more computers!

Quan Hoang Ngoc - 22521178

March 2024

In this project, we conducted some experiments to measure and evaluate the solution and performance of OR Tools for Knapsack problems. Thus, we also learn how to use OR-Tools and install them for practical purposes. To set up the experiments, we need to clone the test-case set, read files, and get data from the clone folder. Besides, how to operate the experiments automatic and efficient is a challenge that we must face.

1 How to set up the experiments

To set up the experiments firstly, we install the or-tools module and clone the folder that contains the test-case set for experiments. We use guidelines from the home page to implement a solver for Knapsack problems. Besides, we also need to get all files from the repository and read and convert data from them. But, there are too many files in the repository, so with a leaf folder we will get a file. In total, we have **2x8x13** files as test cases for these experiments.

We want to operate the experiments automatic, so we abstracted all the above steps as functions of the pipeline: *get files from folder – get data from file – solve with or-tools and write results to backup and log file* in experiments process takes places.

Although we have a limited number of test cases and a set time limit for the solver is **180 seconds**, the number of test cases is also too large and we can spend up to 10 hours (not including wasted time) for experiments. This is a challenge that we must overcome.

The idea for this challenge is that we recognize each test-case group is independent and we can use more computers to run them parallel and then synthesize them together. Based on Kaggle's policy, We used 3 Kaggle sessions for running work with the experiments.

Finally, we use computer programs to create report tables automatically.

2 Statistics and Evaluation

Testcase: the name of files that contain the test case.

Nitems: the number of items in the test case.

Value: the total profit of the solution found.

Weight: the total weight of items in the solution found.

Time (second): the run time of solver programs.

Optimal: True, if it is an optimal solution. If False, it may not be an optimal solution.

The computers used for experiments are **Kaggle CPUs**.

Table 1: Statistics

| testcase | Nitems | value | weight | time | optimal |
|--|--------|----------|----------|------|---------|
| /00Uncorrelated/n01000/R10000/s009.kp | 1000 | 3932453 | 2555088 | 0 | True |
| /00Uncorrelated/n01000/R01000/s009.kp | 1000 | 393483 | 255729 | 0 | True |
| /00Uncorrelated/n02000/R10000/s009.kp | 2000 | 8160372 | 4851150 | 0 | True |
| /00Uncorrelated/n02000/R01000/s009.kp | 2000 | 816516 | 485559 | 0 | True |
| /00Uncorrelated/n00100/R10000/s009.kp | 100 | 364266 | 242347 | 0 | True |
| /00Uncorrelated/n00100/R01000/s009.kp | 100 | 36459 | 24262 | 0 | True |
| /00Uncorrelated/n10000/R10000/s009.kp | 10000 | 40249903 | 24771994 | 0 | True |
| /00Uncorrelated/n10000/R01000/s009.kp | 10000 | 4027410 | 2479420 | 0 | True |
| /00Uncorrelated/n05000/R10000/s009.kp | 5000 | 20128686 | 12220642 | 0 | True |
| /00Uncorrelated/n05000/R01000/s009.kp | 5000 | 2014059 | 1223184 | 0 | True |
| /00Uncorrelated/n00200/R10000/s009.kp | 200 | 784545 | 482744 | 0 | True |
| /00Uncorrelated/n00200/R01000/s009.kp | 200 | 78515 | 48331 | 0 | True |
| /00Uncorrelated/n00050/R10000/s009.kp | 50 | 183147 | 114430 | 0 | True |
| /00Uncorrelated/n00050/R01000/s009.kp | 50 | 18331 | 11457 | 0 | True |
| /00Uncorrelated/n00500/R10000/s009.kp | 500 | 1990637 | 1194207 | 0 | True |
| /00Uncorrelated/n00500/R01000/s009.kp | 500 | 199181 | 119530 | 0 | True |
| /01WeaklyCorrelated/n01000/R10000/s009.kp | 1000 | 2666130 | 2392259 | 0 | True |
| /01WeaklyCorrelated/n01000/R01000/s009.kp | 1000 | 266964 | 239451 | 0 | True |
| /01WeaklyCorrelated/n02000/R10000/s009.kp | 2000 | 5453334 | 4947358 | 0 | True |
| /01WeaklyCorrelated/n02000/R01000/s009.kp | 2000 | 546000 | 495187 | 0 | True |
| /01WeaklyCorrelated/n00100/R10000/s009.kp | 100 | 248539 | 222984 | 0 | True |
| /01WeaklyCorrelated/n00100/R01000/s009.kp | 100 | 24885 | 22316 | 0 | True |
| /01WeaklyCorrelated/n10000/R10000/s009.kp | 10000 | 27132774 | 24528449 | 0 | True |
| /01WeaklyCorrelated/n10000/R01000/s009.kp | 10000 | 2716776 | 2455079 | 0 | True |
| /01WeaklyCorrelated/n05000/R10000/s009.kp | 5000 | 13579520 | 12307795 | 0 | True |
| /01WeaklyCorrelated/n05000/R01000/s009.kp | 5000 | 1359652 | 1231894 | 0 | True |
| /01WeaklyCorrelated/n00200/R10000/s009.kp | 200 | 517905 | 465529 | 0 | True |
| /01WeaklyCorrelated/n00200/R01000/s009.kp | 200 | 51864 | 46603 | 0 | True |
| /01WeaklyCorrelated/n00050/R10000/s009.kp | 50 | 119733 | 108238 | 0 | True |
| /01WeaklyCorrelated/n00050/R01000/s009.kp | 50 | 11991 | 10836 | 0 | True |
| /01WeaklyCorrelated/n00500/R10000/s009.kp | 500 | 1323913 | 1198027 | 0 | True |
| /01WeaklyCorrelated/n00500/R01000/s009.kp | 500 | 132582 | 119918 | 0 | True |
| /02StronglyCorrelated/n01000/R10000/s009.kp | 1000 | 3100924 | 2388924 | 180 | False |
| /02StronglyCorrelated/n01000/R01000/s009.kp | 1000 | 310426 | 239226 | 180 | False |
| /02StronglyCorrelated/n02000/R10000/s009.kp | 2000 | 6349888 | 4942888 | 180 | False |
| /02StronglyCorrelated/n02000/R01000/s009.kp | 2000 | 635490 | 494790 | 180 | False |
| /02StronglyCorrelated/n00100/R10000/s009.kp | 100 | 294990 | 222990 | 2 | True |
| /02StronglyCorrelated/n00100/R01000/s009.kp | 100 | 29523 | 22323 | 1 | True |
| /02StronglyCorrelated/n10000/R10000/s009.kp | 10000 | 31577966 | 24523966 | 180 | False |
| /02StronglyCorrelated/n10000/R01000/s009.kp | 10000 | 3160178 | 2454878 | 180 | False |
| /02StronglyCorrelated/n05000/R10000/s009.kp | 5000 | 15829300 | 12303300 | 180 | False |
| /02StronglyCorrelated/n05000/R01000/s009.kp | 5000 | 1584494 | 1231894 | 180 | False |
| /02StronglyCorrelated/n00200/R10000/s009.kp | 200 | 608588 | 465588 | 37 | True |
| /02StronglyCorrelated/n00200/R01000/s009.kp | 200 | 60904 | 46604 | 9 | True |
| /02StronglyCorrelated/n00050/R10000/s009.kp | 50 | 144240 | 108240 | 0 | True |
| /02StronglyCorrelated/n00050/R01000/s009.kp | 50 | 14436 | 10836 | 0 | True |
| /02StronglyCorrelated/n00500/R10000/s009.kp | 500 | 1556033 | 1198033 | 180 | False |
| /02StronglyCorrelated/n00500/R01000/s009.kp | 500 | 155718 | 119918 | 180 | False |
| /03InverseStronglyCorrelated/n01000/R10000/s009.kp | 1000 | 2575844 | 2882844 | 180 | False |
| /03InverseStronglyCorrelated/n01000/R01000/s009.kp | 1000 | 258156 | 288956 | 180 | False |

Continued on next page

| test case | Nitems | value | weight | time | optimal |
|---|--------|----------|----------|------|---------|
| /03InverseStronglyCorrelated/n02000/R10000/s009.kp | 2000 | 5303326 | 5932326 | 180 | False |
| /03InverseStronglyCorrelated/n02000/R01000/s009.kp | 2000 | 531197 | 594197 | 180 | False |
| /03InverseStronglyCorrelated/n00100/R10000/s009.kp | 100 | 242494 | 272494 | 0 | True |
| /03InverseStronglyCorrelated/n00100/R01000/s009.kp | 100 | 24273 | 27273 | 0 | True |
| /03InverseStronglyCorrelated/n10000/R10000/s009.kp | 10000 | 26336830 | 29472830 | 180 | False |
| /03InverseStronglyCorrelated/n10000/R01000/s009.kp | 10000 | 2635794 | 2949494 | 180 | False |
| /03InverseStronglyCorrelated/n05000/R10000/s009.kp | 5000 | 13213919 | 14781919 | 180 | False |
| /03InverseStronglyCorrelated/n05000/R01000/s009.kp | 5000 | 1322116 | 1478916 | 180 | False |
| /03InverseStronglyCorrelated/n00200/R10000/s009.kp | 200 | 503570 | 564570 | 0 | True |
| /03InverseStronglyCorrelated/n00200/R01000/s009.kp | 200 | 50392 | 56492 | 0 | True |
| /03InverseStronglyCorrelated/n00050/R10000/s009.kp | 50 | 117989 | 132989 | 0 | True |
| /03InverseStronglyCorrelated/n00050/R01000/s009.kp | 50 | 11811 | 13311 | 0 | True |
| /03InverseStronglyCorrelated/n00500/R10000/s009.kp | 500 | 1292641 | 1444641 | 180 | False |
| /03InverseStronglyCorrelated/n00500/R01000/s009.kp | 500 | 129332 | 144532 | 180 | False |
| /04AlmostStronglyCorrelated/n00200/R10000/s097.kp | 200 | 654568 | 514576 | 0 | True |
| /04AlmostStronglyCorrelated/n00200/R01000/s097.kp | 200 | 65504 | 51501 | 0 | True |
| /04AlmostStronglyCorrelated/n00050/R10000/s097.kp | 50 | 151198 | 115092 | 0 | True |
| /04AlmostStronglyCorrelated/n00050/R01000/s097.kp | 50 | 15134 | 11519 | 0 | True |
| /04AlmostStronglyCorrelated/n05000/R10000/s097.kp | 5000 | 15871795 | 12367138 | 180 | False |
| /04AlmostStronglyCorrelated/n05000/R01000/s097.kp | 5000 | 1588106 | 1237716 | 180 | False |
| /04AlmostStronglyCorrelated/n01000/R10000/s097.kp | 1000 | 3188355 | 2484141 | 180 | False |
| /04AlmostStronglyCorrelated/n01000/R01000/s097.kp | 1000 | 319110 | 248678 | 180 | False |
| /04AlmostStronglyCorrelated/n02000/R10000/s097.kp | 2000 | 6363284 | 4963083 | 0 | True |
| /04AlmostStronglyCorrelated/n02000/R01000/s097.kp | 2000 | 636399 | 496434 | 180 | False |
| /04AlmostStronglyCorrelated/n00500/R10000/s097.kp | 500 | 1611108 | 1260301 | 180 | False |
| /04AlmostStronglyCorrelated/n00500/R01000/s097.kp | 500 | 161217 | 126139 | 180 | False |
| /04AlmostStronglyCorrelated/n00100/R10000/s097.kp | 100 | 319490 | 249272 | 0 | True |
| /04AlmostStronglyCorrelated/n00100/R01000/s097.kp | 100 | 31979 | 24950 | 0 | True |
| /04AlmostStronglyCorrelated/n10000/R10000/s097.kp | 10000 | 31799634 | 24775458 | 180 | False |
| /04AlmostStronglyCorrelated/n10000/R01000/s097.kp | 10000 | 3182496 | 2480115 | 11 | True |
| /05SubsetSum/n01000/R01000/s084.kp | 1000 | 254029 | 254029 | 0 | True |
| /05SubsetSum/n01000/R10000/s084.kp | 1000 | 2538064 | 2538064 | 0 | True |
| /05SubsetSum/n00200/R01000/s084.kp | 200 | 51896 | 51896 | 0 | True |
| /05SubsetSum/n00200/R10000/s084.kp | 200 | 518499 | 518499 | 0 | True |
| /05SubsetSum/n00100/R01000/s084.kp | 100 | 25500 | 25500 | 0 | True |
| /05SubsetSum/n00100/R10000/s084.kp | 100 | 254769 | 254769 | 0 | True |
| /05SubsetSum/n10000/R01000/s084.kp | 10000 | 2498215 | 2498215 | 0 | True |
| /05SubsetSum/n10000/R10000/s084.kp | 10000 | 24959783 | 24959783 | 0 | True |
| /05SubsetSum/n00500/R01000/s084.kp | 500 | 128452 | 128452 | 0 | True |
| /05SubsetSum/n00500/R10000/s084.kp | 500 | 1283388 | 1283388 | 0 | True |
| /05SubsetSum/n00050/R01000/s084.kp | 50 | 11705 | 11705 | 0 | True |
| /05SubsetSum/n00050/R10000/s084.kp | 50 | 116934 | 116934 | 0 | True |
| /05SubsetSum/n02000/R01000/s084.kp | 2000 | 495050 | 495050 | 0 | True |
| /05SubsetSum/n02000/R10000/s084.kp | 2000 | 4946057 | 4946057 | 0 | True |
| /05SubsetSum/n05000/R01000/s084.kp | 5000 | 1254329 | 1254329 | 0 | True |
| /05SubsetSum/n05000/R10000/s084.kp | 5000 | 12532088 | 12532088 | 0 | True |
| /06UncorrelatedWithSimilarWeights/n01000/R10000/s009.kp | 1000 | 367586 | 49525849 | 0 | True |
| /06UncorrelatedWithSimilarWeights/n01000/R01000/s009.kp | 1000 | 367586 | 49525849 | 0 | True |
| /06UncorrelatedWithSimilarWeights/n02000/R10000/s009.kp | 2000 | 746070 | 99047618 | 180 | False |
| /06UncorrelatedWithSimilarWeights/n02000/R01000/s009.kp | 2000 | 746070 | 99047618 | 180 | False |
| /06UncorrelatedWithSimilarWeights/n00100/R10000/s009.kp | 100 | 34671 | 4902529 | 0 | True |
| /06UncorrelatedWithSimilarWeights/n00100/R01000/s009.kp | 100 | 34671 | 4902529 | 0 | True |

Continued on next page

| test case | Nitems | value | weight | time | optimal |
|---|--------|----------|-----------|------|---------|
| /06UncorrelatedWithSimilarWeights/n10000/R10000/s009.kp | 10000 | 3708622 | 495246594 | 180 | False |
| /06UncorrelatedWithSimilarWeights/n10000/R01000/s009.kp | 10000 | 3708622 | 495246594 | 180 | False |
| /06UncorrelatedWithSimilarWeights/n05000/R10000/s009.kp | 5000 | 1861639 | 247623037 | 180 | False |
| /06UncorrelatedWithSimilarWeights/n05000/R01000/s009.kp | 5000 | 1861639 | 247623037 | 180 | False |
| /06UncorrelatedWithSimilarWeights/n00200/R10000/s009.kp | 200 | 72026 | 9904722 | 0 | True |
| /06UncorrelatedWithSimilarWeights/n00200/R01000/s009.kp | 200 | 72026 | 9904722 | 0 | True |
| /06UncorrelatedWithSimilarWeights/n00050/R10000/s009.kp | 50 | 16781 | 2401092 | 0 | True |
| /06UncorrelatedWithSimilarWeights/n00050/R01000/s009.kp | 50 | 16781 | 2401092 | 0 | True |
| /06UncorrelatedWithSimilarWeights/n00500/R10000/s009.kp | 500 | 184485 | 24712110 | 180 | False |
| /06UncorrelatedWithSimilarWeights/n00500/R01000/s009.kp | 500 | 184485 | 24712110 | 180 | False |
| /07SpannerUncorrelated/n00200/R10000/s039.kp | 200 | 141320 | 135868 | 180 | False |
| /07SpannerUncorrelated/n00200/R01000/s039.kp | 200 | 14307 | 13424 | 180 | False |
| /07SpannerUncorrelated/n00050/R10000/s039.kp | 50 | 36080 | 35094 | 180 | False |
| /07SpannerUncorrelated/n00050/R01000/s039.kp | 50 | 3662 | 3492 | 1 | True |
| /07SpannerUncorrelated/n10000/R10000/s039.kp | 10000 | 7628020 | 7325730 | 180 | False |
| /07SpannerUncorrelated/n10000/R01000/s039.kp | 10000 | 773057 | 724280 | 180 | False |
| /07SpannerUncorrelated/n05000/R10000/s039.kp | 5000 | 3779510 | 3632933 | 180 | False |
| /07SpannerUncorrelated/n05000/R01000/s039.kp | 5000 | 382981 | 359254 | 180 | False |
| /07SpannerUncorrelated/n01000/R10000/s039.kp | 1000 | 724750 | 692591 | 180 | False |
| /07SpannerUncorrelated/n01000/R01000/s039.kp | 1000 | 73503 | 68389 | 180 | False |
| /07SpannerUncorrelated/n00500/R10000/s039.kp | 500 | 373290 | 358457 | 180 | False |
| /07SpannerUncorrelated/n00500/R01000/s039.kp | 500 | 37832 | 35447 | 180 | False |
| /07SpannerUncorrelated/n00100/R10000/s039.kp | 100 | 67980 | 65042 | 180 | False |
| /07SpannerUncorrelated/n00100/R01000/s039.kp | 100 | 6868 | 6398 | 180 | False |
| /07SpannerUncorrelated/n02000/R10000/s039.kp | 2000 | 1502400 | 1443556 | 180 | False |
| /07SpannerUncorrelated/n02000/R01000/s039.kp | 2000 | 152251 | 142745 | 180 | False |
| /08SpannerWeaklyCorrelated/n00200/R10000/s053.kp | 200 | 593307 | 372949 | 180 | False |
| /08SpannerWeaklyCorrelated/n00200/R01000/s053.kp | 200 | 59370 | 37322 | 180 | False |
| /08SpannerWeaklyCorrelated/n02000/R10000/s053.kp | 2000 | 5996133 | 3769131 | 180 | False |
| /08SpannerWeaklyCorrelated/n02000/R01000/s053.kp | 2000 | 600237 | 376893 | 180 | False |
| /08SpannerWeaklyCorrelated/n00500/R10000/s053.kp | 500 | 1491633 | 937631 | 180 | False |
| /08SpannerWeaklyCorrelated/n00500/R01000/s053.kp | 500 | 149382 | 93798 | 180 | False |
| /08SpannerWeaklyCorrelated/n05000/R10000/s053.kp | 5000 | 14906034 | 9369838 | 180 | False |
| /08SpannerWeaklyCorrelated/n05000/R01000/s053.kp | 5000 | 1492272 | 937008 | 180 | False |
| /08SpannerWeaklyCorrelated/n00100/R10000/s053.kp | 100 | 291001 | 183147 | 180 | False |
| /08SpannerWeaklyCorrelated/n00100/R01000/s053.kp | 100 | 29154 | 18306 | 180 | False |
| /08SpannerWeaklyCorrelated/n10000/R10000/s053.kp | 10000 | 29934333 | 18816531 | 180 | False |
| /08SpannerWeaklyCorrelated/n10000/R01000/s053.kp | 10000 | 2996799 | 1881711 | 180 | False |
| /08SpannerWeaklyCorrelated/n01000/R10000/s053.kp | 1000 | 3021876 | 1899532 | 180 | False |
| /08SpannerWeaklyCorrelated/n01000/R01000/s053.kp | 1000 | 302535 | 190007 | 180 | False |
| /08SpannerWeaklyCorrelated/n00050/R10000/s053.kp | 50 | 137709 | 86563 | 0 | True |
| /08SpannerWeaklyCorrelated/n00050/R01000/s053.kp | 50 | 13746 | 8642 | 0 | True |
| /09SpannerStronglyCorrelated/n00200/R10000/s039.kp | 200 | 755330 | 136330 | 184 | False |
| /09SpannerStronglyCorrelated/n00200/R01000/s039.kp | 200 | 75533 | 13633 | 180 | False |
| /09SpannerStronglyCorrelated/n00050/R10000/s039.kp | 50 | 179590 | 34590 | 3 | True |
| /09SpannerStronglyCorrelated/n00050/R01000/s039.kp | 50 | 17959 | 3459 | 3 | True |
| /09SpannerStronglyCorrelated/n10000/R10000/s039.kp | 10000 | 41214640 | 7382640 | 180 | False |
| /09SpannerStronglyCorrelated/n10000/R01000/s039.kp | 10000 | 4121464 | 738264 | 180 | False |
| /09SpannerStronglyCorrelated/n05000/R10000/s039.kp | 5000 | 20345300 | 3659300 | 180 | False |
| /09SpannerStronglyCorrelated/n05000/R01000/s039.kp | 5000 | 2034530 | 365930 | 180 | False |
| /09SpannerStronglyCorrelated/n01000/R10000/s039.kp | 1000 | 3994880 | 698880 | 180 | False |
| /09SpannerStronglyCorrelated/n01000/R01000/s039.kp | 1000 | 399488 | 69888 | 180 | False |

Continued on next page

| test case | Nitems | value | weight | time | optimal |
|---|--------|------------|----------|------|---------|
| /09SpannerStronglyCorrelated/n00500/R10000/s039.kp | 500 | 2016720 | 360720 | 180 | False |
| /09SpannerStronglyCorrelated/n00500/R01000/s039.kp | 500 | 201672 | 36072 | 180 | False |
| /09SpannerStronglyCorrelated/n00100/R10000/s039.kp | 100 | 372530 | 65530 | 180 | False |
| /09SpannerStronglyCorrelated/n00100/R01000/s039.kp | 100 | 37253 | 6553 | 180 | False |
| /09SpannerStronglyCorrelated/n02000/R10000/s039.kp | 2000 | 8102480 | 1454480 | 180 | False |
| /09SpannerStronglyCorrelated/n02000/R01000/s039.kp | 2000 | 810248 | 145448 | 180 | False |
| /10MultipleStronglyCorrelated/n10000/R01000/s095.kp | 10000 | 4032348 | 2483748 | 180 | False |
| /10MultipleStronglyCorrelated/n10000/R10000/s095.kp | 10000 | 40288426 | 24814426 | 180 | False |
| /10MultipleStronglyCorrelated/n00500/R01000/s095.kp | 500 | 202090 | 123090 | 180 | False |
| /10MultipleStronglyCorrelated/n00500/R10000/s095.kp | 500 | 2000825 | 1229825 | 0 | True |
| /10MultipleStronglyCorrelated/n05000/R01000/s095.kp | 5000 | 2005003 | 1231503 | 180 | False |
| /10MultipleStronglyCorrelated/n05000/R10000/s095.kp | 5000 | 20066897 | 12303897 | 180 | False |
| /10MultipleStronglyCorrelated/n00100/R01000/s095.kp | 100 | 40138 | 25038 | 0 | True |
| /10MultipleStronglyCorrelated/n00100/R10000/s095.kp | 100 | 402182 | 250182 | 2 | True |
| /10MultipleStronglyCorrelated/n02000/R01000/s095.kp | 2000 | 804622 | 495822 | 180 | False |
| /10MultipleStronglyCorrelated/n02000/R10000/s095.kp | 2000 | 8043326 | 4953326 | 180 | False |
| /10MultipleStronglyCorrelated/n00200/R01000/s095.kp | 200 | 79502 | 47802 | 0 | True |
| /10MultipleStronglyCorrelated/n00200/R10000/s095.kp | 200 | 784648 | 477648 | 180 | False |
| /10MultipleStronglyCorrelated/n00050/R01000/s095.kp | 50 | 19242 | 11442 | 0 | True |
| /10MultipleStronglyCorrelated/n00050/R10000/s095.kp | 50 | 194328 | 114328 | 0 | True |
| /10MultipleStronglyCorrelated/n01000/R01000/s095.kp | 1000 | 400426 | 244026 | 180 | False |
| /10MultipleStronglyCorrelated/n01000/R10000/s095.kp | 1000 | 3988028 | 2438028 | 180 | False |
| /11ProfitCeiling/n10000/R01000/s095.kp | 10000 | 2482824 | 2483750 | 180 | False |
| /11ProfitCeiling/n10000/R10000/s095.kp | 10000 | 24814254 | 24815167 | 180 | False |
| /11ProfitCeiling/n00500/R01000/s095.kp | 500 | 123063 | 123094 | 180 | False |
| /11ProfitCeiling/n00500/R10000/s095.kp | 500 | 1229793 | 1229831 | 180 | False |
| /11ProfitCeiling/n05000/R01000/s095.kp | 5000 | 1231149 | 1231624 | 180 | False |
| /11ProfitCeiling/n05000/R10000/s095.kp | 5000 | 12304590 | 12305048 | 180 | False |
| /11ProfitCeiling/n00100/R01000/s095.kp | 100 | 25029 | 25040 | 0 | True |
| /11ProfitCeiling/n00100/R10000/s095.kp | 100 | 250182 | 250187 | 0 | True |
| /11ProfitCeiling/n02000/R01000/s095.kp | 2000 | 495624 | 495824 | 180 | False |
| /11ProfitCeiling/n02000/R10000/s095.kp | 2000 | 4953603 | 4953787 | 180 | False |
| /11ProfitCeiling/n00200/R01000/s095.kp | 200 | 47793 | 47807 | 0 | True |
| /11ProfitCeiling/n00200/R10000/s095.kp | 200 | 477633 | 477649 | 122 | True |
| /11ProfitCeiling/n00050/R01000/s095.kp | 50 | 11439 | 11444 | 0 | True |
| /11ProfitCeiling/n00050/R10000/s095.kp | 50 | 114336 | 114336 | 11 | True |
| /11ProfitCeiling/n01000/R01000/s095.kp | 1000 | 243945 | 244026 | 180 | False |
| /11ProfitCeiling/n01000/R10000/s095.kp | 1000 | 2437947 | 2438032 | 180 | False |
| /12Circle/n10000/R01000/s095.kp | 10000 | 52334995 | 2483752 | 180 | False |
| /12Circle/n10000/R10000/s095.kp | 10000 | 1654260902 | 24815168 | 180 | False |
| /12Circle/n00500/R01000/s095.kp | 500 | 2593724 | 123095 | 180 | False |
| /12Circle/n00500/R10000/s095.kp | 500 | 81984649 | 1229832 | 180 | False |
| /12Circle/n05000/R01000/s095.kp | 5000 | 25951469 | 1231624 | 180 | False |
| /12Circle/n05000/R10000/s095.kp | 5000 | 820295200 | 12305050 | 180 | False |
| /12Circle/n00100/R01000/s095.kp | 100 | 527616 | 25040 | 0 | True |
| /12Circle/n00100/R10000/s095.kp | 100 | 16678289 | 250187 | 0 | True |
| /12Circle/n02000/R01000/s095.kp | 2000 | 10447467 | 495824 | 180 | False |
| /12Circle/n02000/R10000/s095.kp | 2000 | 330235769 | 4953787 | 180 | False |
| /12Circle/n00200/R01000/s095.kp | 200 | 1007338 | 47807 | 180 | False |
| /12Circle/n00200/R10000/s095.kp | 200 | 31841721 | 477650 | 180 | False |
| /12Circle/n00050/R01000/s095.kp | 50 | 241156 | 11445 | 1 | True |
| /12Circle/n00050/R10000/s095.kp | 50 | 7622148 | 114338 | 0 | True |

Continued on next page

| test case | Nitems | value | weight | time | optimal |
|---------------------------------|--------|-----------|---------|------|---------|
| /12Circle/n01000/R01000/s095.kp | 1000 | 5141874 | 244027 | 180 | False |
| /12Circle/n01000/R10000/s095.kp | 1000 | 162527317 | 2438033 | 179 | True |

2.1 Evaluate Test Group Difficulty

Table 2: Evaluate Test Group Difficulty

| test group | total time | rate optimal |
|------------|------------|--------------|
| 00 | 0 | 1.000000 |
| 01 | 0 | 1.000000 |
| 02 | 1849 | 0.375000 |
| 03 | 1800 | 0.375000 |
| 04 | 1451 | 0.500000 |
| 05 | 0 | 1.000000 |
| 06 | 1440 | 0.500000 |
| 07 | 2701 | 0.062500 |
| 08 | 2520 | 0.125000 |
| 09 | 2530 | 0.125000 |
| 10 | 1802 | 0.375000 |
| 11 | 1933 | 0.375000 |
| 12 | 2160 | 0.312500 |

To evaluate the difficulty of test group, there are many different way, but in this context we assume a test group is ease if the solver can easily find an optimal solution in half of test cases in that group.

Thus, **group 00, 01 04, 05, and 06 are easy and the rest is difficult**. Special, group 07, 08, and 09 are very difficult.

3 Conclusion

In practical terms, we should use solver tools to solve optimization problems.

In general, using multiple computers is an effective way to operate experiments, and using programming language to automatically generate reports is more smart!

4 References

- All about source code, experiment process documentation, and YouTube demo (if there) in this GitHub link: [github](#) to visit our website.
 - [youtube](#) to visit the demo video.
 - homepage to visit the home page' s guidelines.
 - repository to visit the repository of the test case set.
- Author: Quan Hoang Ngoc. Thank you for your reading.