# TRƯỜNG ĐẠI HỌC CÔNG NGHỆ THÔNG TIN

# KHOA KHOA HỌC MÁY TÍNH



**UIT**

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**Assignment 2**

**Solving Knapsack Problems Using Google OR Tools**

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Môn:                           Trí tuệ nhân tạo

Lớp:                           CS106.N21.KHCL

Giảng viên hướng dẫn:          Lương Ngọc Hoàng

Sinh viên:                     Bùi Mạnh Hùng - 21522110

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Mục lục

# 1 Đặc trưng bài toán Snapsack

- Hàm mục tiêu: Max tổng giá trị các đồ vật của túi
- Tổng các đồ vật trong túi phụ thuộc vào 2 yếu tố
  - Tổng khối lượng các đồ vật có trong túi
  - Tổng giá trị các đồ vật trong túi

# 2 Thiết lập thực nghiệm

- Knapsack test instances: https://github.com/likr/kplib
  - Chọn dữ liệu trên các nhóm (0->12), mỗi nhóm chọn 8 test cases (bao gồm: 50 ,100,200,500,1000,2000,5000 items) chọn file dữ liệu đầu tiên 's00'
- Time limit: 3 phút

# 3 Kết quả thực nghiệm

**Kết quả chạy thực nghiệm được lưu ở folder:** *../assets/Result/*

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|---|---|---|---|---|---|
| 00Uncorrelated | n00050_R01000_s000 | 41990 | 14721 | 0.0 | True |
| 00Uncorrelated | n00100_R01000_s000 | 93074 | 22519 | 0.0 | True |
| 00Uncorrelated | n00200_R01000_s000 | 168634 | 50302 | 0.0 | True |
| 00Uncorrelated | n00500_R01000_s000 | 415984 | 118693 | 0.0 | True |
| 00Uncorrelated | n01000_R01000_s000 | 801622 | 252480 | 0.0 | True |
| 00Uncorrelated | n02000_R01000_s000 | 1617804 | 502731 | 0.0 | True |
| 00Uncorrelated | n05000_R01000_s000 | 4082004 | 1231707 | 0.006978 | True |
| 00Uncorrelated | n10000_R01000_s000 | 8104734 | 2478760 | 0.003997 | True |

Bảng 1: Kết quả thực nghiệm trên group test: 00Uncorrelated

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|---|---|---|---|---|---|
| 01WeaklyCorrelated | n00050_R01000_s000 | 31536 | 14232 | 0.0 | True |
| 01WeaklyCorrelated | n00100_R01000_s000 | 62128 | 29013 | 0.0 | True |
| 01WeaklyCorrelated | n00200_R01000_s000 | 113952 | 51563 | 0.0 | True |
| 01WeaklyCorrelated | n00500_R01000_s000 | 278516 | 127276 | 0.001026 | True |
| 01WeaklyCorrelated | n01000_R01000_s000 | 546104 | 245972 | 0.003999 | True |
| 01WeaklyCorrelated | n02000_R01000_s000 | 1105012 | 498452 | 0.002003 | True |
| 01WeaklyCorrelated | n05000_R01000_s000 | 2756450 | 1249257 | 0.002999 | True |
| 01WeaklyCorrelated | n10000_R01000_s000 | 5486334 | 2480964 | 0.370089 | True |

Bảng 2: Kết quả thực nghiệm trên group test: 01WeaklyCorrelated

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|---|---|---|---|---|---|
| 02StronglyCorrelated | n00050_R01000_s000 | 35078 | 14239 | 0.016999 | True |
| 02StronglyCorrelated | n00100_R01000_s000 | 71234 | 29017 | 0.097888 | True |
| 02StronglyCorrelated | n00200_R01000_s000 | 130726 | 51563 | 180.021158 | False |
| 02StronglyCorrelated | n00500_R01000_s000 | 324356 | 127278 | 180.032004 | False |
| 02StronglyCorrelated | n01000_R01000_s000 | 632744 | 245972 | 181.979087 | False |
| 02StronglyCorrelated | n02000_R01000_s000 | 1277090 | 498045 | 180.031568 | False |
| 02StronglyCorrelated | n05000_R01000_s000 | 3198668 | 1248734 | 180.006460 | False |
| 02StronglyCorrelated | n10000_R01000_s000 | 6365538 | 2480569 | 180.007750 | False |

Bảng 3: Kết quả thực nghiệm trên group test: 02StronglyCorrelated

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|---|---|---|---|---|---|
| 03InverseStronglyCorrelated | n00050_R01000_s000 | 29828 | 16714 | 1.365774 | True |
| 03InverseStronglyCorrelated | n00100_R01000_s000 | 60936 | 33968 | 0.0 | True |
| 03InverseStronglyCorrelated | n00200_R01000_s000 | 109928 | 61464 | 0.0 | True |
| 03InverseStronglyCorrelated | n00500_R01000_s000 | 272062 | 152031 | 180.093533 | False |
| 03InverseStronglyCorrelated | n01000_R01000_s000 | 527954 | 295477 | 180.052633 | False |
| 03InverseStronglyCorrelated | n02000_R01000_s000 | 1068028 | 597114 | 180.029904 | False |
| 03InverseStronglyCorrelated | n05000_R01000_s000 | 2676182 | 1496591 | 180.008852 | False |
| 03InverseStronglyCorrelated | n10000_R01000_s000 | 5318516 | 2975558 | 179.993665 | True |

Bảng 4: Kết quả thực nghiệm trên group test: 03InverseStronglyCorrelated

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|---|---|---|---|---|---|
| 04AlmostStronglyCorrelated | n00050_R01000_s000 | 35112 | 14238 | 0.016640 | True |
| 04AlmostStronglyCorrelated | n00100_R01000_s000 | 71222 | 29016 | 0.033714 | True |
| 04AlmostStronglyCorrelated | n00200_R01000_s000 | 130770 | 51563 | 180.006372 | False |
| 04AlmostStronglyCorrelated | n00500_R01000_s000 | 324308 | 127278 | 180.036311 | False |
| 04AlmostStronglyCorrelated | n01000_R01000_s000 | 632830 | 245972 | 0.201036 | True |
| 04AlmostStronglyCorrelated | n02000_R01000_s000 | 1277542 | 498200 | 180.039208 | False |
| 04AlmostStronglyCorrelated | n05000_R01000_s000 | 3199570 | 1249065 | 180.020682 | False |
| 04AlmostStronglyCorrelated | n10000_R01000_s000 | 6366528 | 2480964 | 180.001252 | False |

Bảng 5: Kết quả thực nghiệm trên group test: 04AlmostStronglyCorrelated

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|------------|------|-------------|--------------|---------|---------|
| 05SubsetSum | n00050_R01000_s000 | 28478 | 14239 | 0.0 | True |
| 05SubsetSum | n00100_R01000_s000 | 58034 | 29017 | 0.0 | True |
| 05SubsetSum | n00200_R01000_s000 | 103126 | 51563 | 0.0 | True |
| 05SubsetSum | n00500_R01000_s000 | 254556 | 127278 | 0.0 | True |
| 05SubsetSum | n01000_R01000_s000 | 491944 | 245972 | 0.000954 | True |
| 05SubsetSum | n02000_R01000_s000 | 996904 | 498452 | 0.001000 | True |
| 05SubsetSum | n05000_R01000_s000 | 2498514 | 1249257 | 0.001981 | True |
| 05SubsetSum | n10000_R01000_s000 | 4961928 | 2480964 | 0.002011 | True |

Bảng 6: Kết quả thực nghiệm trên group test: 05SubsetSum

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|------------|------|-------------|--------------|---------|---------|
| 06UncorrelatedWithSimilarWeights | n00050_R01000_s000 | 39352 | 2401482 | 0.028542 | True |
| 06UncorrelatedWithSimilarWeights | n00100_R01000_s000 | 79582 | 4902253 | 5.724008 | True |
| 06UncorrelatedWithSimilarWeights | n00200_R01000_s000 | 151356 | 9904900 | 0.0 | True |
| 06UncorrelatedWithSimilarWeights | n00500_R01000_s000 | 379538 | 24712055 | 180.047185 | False |
| 06UncorrelatedWithSimilarWeights | n01000_R01000_s000 | 742492 | 49525319 | 0.038749 | True |
| 06UncorrelatedWithSimilarWeights | n02000_R01000_s000 | 1496914 | 99050305 | 180.041867 | False |
| 06UncorrelatedWithSimilarWeights | n05000_R01000_s000 | 3744112 | 247621933 | 180.061833 | False |
| 06UncorrelatedWithSimilarWeights | n10000_R01000_s000 | 7449682 | 495247236 | 180.008307 | False |

Bảng 7: Kết quả thực nghiệm trên group test: 06UncorrelatedWithSimilarWeights

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|------------|------|-------------|--------------|---------|---------|
| 07SpannerUncorrelated | n00050_R01000_s000 | 26944 | 4569 | 0.004583 | True |
| 07SpannerUncorrelated | n00100_R01000_s000 | 48456 | 8748 | 184.616372 | False |
| 07SpannerUncorrelated | n00200_R01000_s000 | 95672 | 17274 | 180.014747 | False |
| 07SpannerUncorrelated | n00500_R01000_s000 | 229232 | 42898 | 180.494596 | False |
| 07SpannerUncorrelated | n01000_R01000_s000 | 457248 | 84656 | 180.012683 | False |
| 07SpannerUncorrelated | n02000_R01000_s000 | 919120 | 168004 | 180.013015 | False |
| 07SpannerUncorrelated | n05000_R01000_s000 | 2263368 | 413019 | 180.007814 | False |
| 07SpannerUncorrelated | n10000_R01000_s000 | 4566200 | 834925 | 180.001187 | False |

Bảng 8: Kết quả thực nghiệm trên group test: 07SpannerUncorrelated

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|---|---|---|---|---|---|
| 08SpannerWeaklyCorrelated | n00050_R01000_s000 | 20708 | 11452 | 1.435745 | True |
| 08SpannerWeaklyCorrelated | n00100_R01000_s000 | 41100 | 20824 | 0.001735 | True |
| 08SpannerWeaklyCorrelated | n00200_R01000_s000 | 81150 | 41116 | 16.501646 | True |
| 08SpannerWeaklyCorrelated | n00500_R01000_s000 | 197426 | 100076 | 181.059925 | False |
| 08SpannerWeaklyCorrelated | n01000_R01000_s000 | 392100 | 198664 | 180.031444 | False |
| 08SpannerWeaklyCorrelated | n02000_R01000_s000 | 783900 | 397176 | 180.027418 | False |
| 08SpannerWeaklyCorrelated | n05000_R01000_s000 | 1929000 | 977360 | 180.021426 | False |
| 08SpannerWeaklyCorrelated | n10000_R01000_s000 | 3894900 | 1973416 | 180.007283 | False |

Bảng 9: Kết quả thực nghiệm trên group test: 08SpannerWeaklyCorrelated

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|---|---|---|---|---|---|
| 09SpannerStronglyCorrelated | n00050_R01000_s000 | 56880 | 11540 | 180.036601 | False |
| 09SpannerStronglyCorrelated | n00100_R01000_s000 | 103312 | 20956 | 10.822692 | True |
| 09SpannerStronglyCorrelated | n00200_R01000_s000 | 203776 | 41288 | 180.037771 | False |
| 09SpannerStronglyCorrelated | n00500_R01000_s000 | 490256 | 99928 | 180.043452 | False |
| 09SpannerStronglyCorrelated | n01000_R01000_s000 | 977344 | 198772 | 180.048218 | False |
| 09SpannerStronglyCorrelated | n02000_R01000_s000 | 1958128 | 397264 | 180.039840 | False |
| 09SpannerStronglyCorrelated | n05000_R01000_s000 | 4818704 | 977252 | 180.015265 | False |
| 09SpannerStronglyCorrelated | n10000_R01000_s000 | 9726496 | 1973348 | 180.003395 | False |

Bảng 10: Kết quả thực nghiệm trên group test: 09SpannerStronglyCorrelated

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|---|---|---|---|---|---|
| 10MultipleStronglyCorrelated | n00050_R01000_s000 | 42676 | 14238 | 0.0 | True |
| 10MultipleStronglyCorrelated | n00100_R01000_s000 | 86632 | 29016 | 1.330307 | True |
| 10MultipleStronglyCorrelated | n00200_R01000_s000 | 163316 | 51558 | 22.912868 | True |
| 10MultipleStronglyCorrelated | n00500_R01000_s000 | 407556 | 127278 | 180.048263 | False |
| 10MultipleStronglyCorrelated | n01000_R01000_s000 | 798340 | 245970 | 180.020049 | False |
| 10MultipleStronglyCorrelated | n02000_R01000_s000 | 1612300 | 498450 | 180.044476 | False |
| 10MultipleStronglyCorrelated | n05000_R01000_s000 | 4039264 | 1249132 | 180.016926 | False |
| 10MultipleStronglyCorrelated | n10000_R01000_s000 | 8038728 | 2480964 | 180.056985 | False |

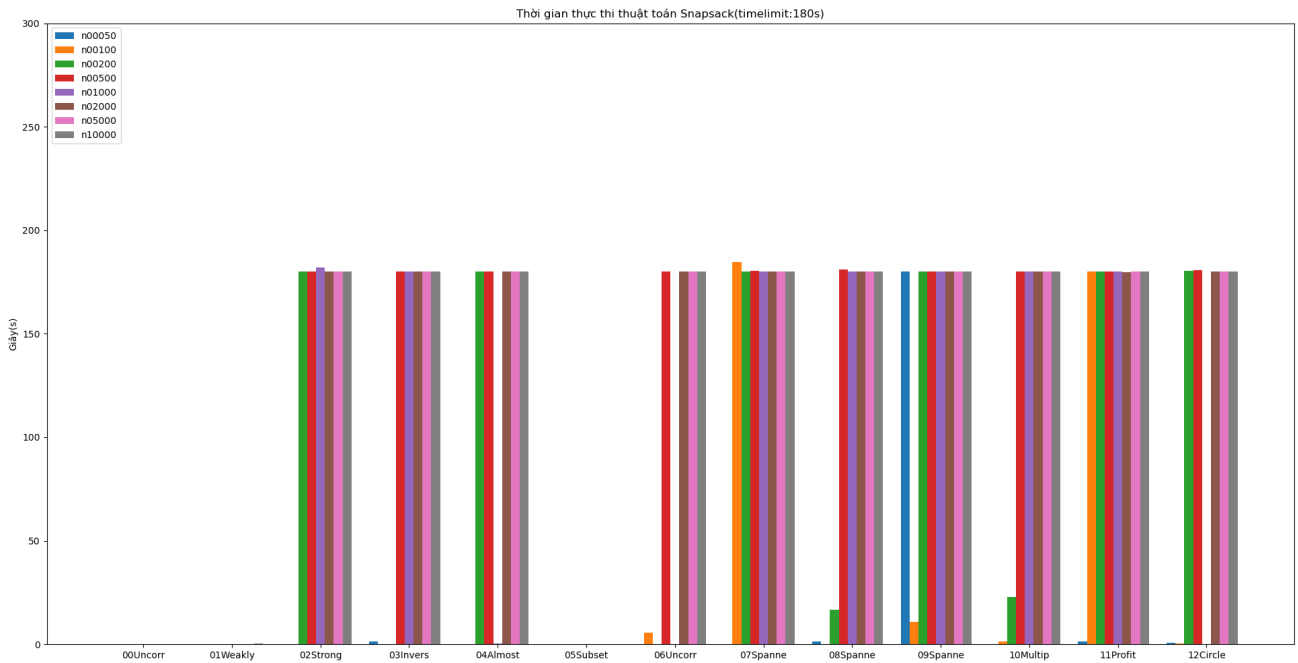Bảng 11: Kết quả thực nghiệm trên group test: 10MultipleStronglyCorrelated

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|---|---|---|---|---|---|
| 11ProfitCeiling | n00050_R01000_s000 | 28458 | 14238 | 1.252952 | True |
| 11ProfitCeiling | n00100_R01000_s000 | 58002 | 29015 | 180.039184 | False |
| 11ProfitCeiling | n00200_R01000_s000 | 103080 | 51562 | 180.036518 | False |
| 11ProfitCeiling | n00500_R01000_s000 | 254478 | 127277 | 180.041326 | False |
| 11ProfitCeiling | n01000_R01000_s000 | 491754 | 245972 | 180.009236 | False |
| 11ProfitCeiling | n02000_R01000_s000 | 996510 | 498450 | 179.872642 | True |
| 11ProfitCeiling | n05000_R01000_s000 | 2497596 | 2497596 | 180.034506 | False |
| 11ProfitCeiling | n10000_R01000_s000 | 4959912 | 2480964 | 180.003028 | False |

Bảng 12: Kết quả thực nghiệm trên group test: 11ProfitCeiling

| Group test | Case | Total value | Total weight | Runtime | Optimal |
|---|---|---|---|---|---|
| 12Circle | n00050_R01000_s000 | 600062 | 14239 | 0.709216 | True |
| 12Circle | n00100_R01000_s000 | 1222836 | 29017 | 0.210818 | True |
| 12Circle | n00200_R01000_s000 | 2172966 | 51563 | 180.225390 | False |
| 12Circle | n00500_R01000_s000 | 5363736 | 127278 | 180.567765 | False |
| 12Circle | n01000_R01000_s000 | 10365712 | 245972 | 0.016196 | True |
| 12Circle | n02000_R01000_s000 | 21005684 | 498452 | 180.042960 | False |
| 12Circle | n05000_R01000_s000 | 52646014 | 1249257 | 179.991590 | True |
| 12Circle | n10000_R01000_s000 | 104552450 | 2480964 | 179.995906 | True |

Bảng 13: Kết quả thực nghiệm trên group test: 12Circle

# 4 Đánh giá và kết luận



Hình 1: Thống kê thời gian thực thi

**Qua biểu đồ trên ta thấy:**

- Group test 0 , 1 , 5 dễ giải nhất (8/8 test case đều Optimal)

- Group test 12 khá dễ (5/8 test case Optimal mặc dù runtime $\approx$ timelimit ở một vài test case)

- Group test 3 , 6 khá khó giải (4/8 test case Optimal)

- Group test 4 , 8 , 10 khá khó giải (3/8 test case Optimal)

- Group test 2 , 11 khó giải (2/8 test case Optimal)

- Group test 7 , 9 khó giải nhất (1/8 test case Optimal)