

**MARMARA UNIVERSITY**

**COMPUTER ENGINEERING DEPARTMENT**

**CSE 7004 - Combinatorial Optimization**

**Term Project**

Multi-Unit Non-discriminatory Combinatorial Auction Problem

**MUNCA**

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In this project, I modify Multi-Unit Non-discriminatory Combinatorial Auction Problem described in [1] such that each item has an associated cost if it is allocated. For this problem I solved given 48 test case with Gurobi and heuristic solution(PS2) which is updated version of PS from Özer [1].

I have one-hour time limit for Gurobi solver. I have used Python programming language for this project. I read given test case file and create structure to be able to solve with Gurobi and PS2. Here is my structure for given test cases:

* CAB:
* Item:
  + Number of units
  + Cost of item
* Bid:
  + Price of bid
  + Subbid:
    - Quantity
    - List of Item

# Gurobi Integer Linear Programming Solver:

In the modified version of original problem, only objective function is changed. New objective function is formulated as follows:

# Heuristic Solver with PS2 algorithm:

In the original PS algorithm, problem does not contain cost variable. I updated PS algorithm by considering cost of items. Additionally, I consider number of requested item for subbid since it makes subbid more flexible; subbid can be fulfilled with different types of item.

Feasibility checking is not trivial problem because of ORed items and I solve this problem by converting problem into feasible network flow problem [1].

I used minimum cost flow algorithm from Python NetworkX library to check bid set is feasible or not.

I have only updated ranking phase of PS algorithm, allocation phase is same with PS. I have written pseudocode of PS2 algorithm as follows:

|  |
| --- |
| **Algorithm PS2** |
| MUNCA problem instance |
|  |
| **/\* Ranking Phase \*/** |
|  |
|  |
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Figure 1:The pseudocode for the PS2 algorithm.

# Result of Test Cases:

I have sent detailed results in excel file for all cases. Excel file includes 3 sheet; first sheet is comparison of Gurobi vs PS2, second is results of Gurobi and third is results of PS2.

Here a sample result of objective value of Gurobi solver and maximum value of PS2 heuristic for number of bids are 500:

|  |  |  |  |
| --- | --- | --- | --- |
| CAB ID | Gurobi Objective Value | PS2 Heuristic Value | Gap |
| 0 | 587768 | 530278.055 | 0.097811292 |
| 4 | 2215271 | 1904780.952 | 0.140159111 |
| 8 | 4734896 | 4239554.186 | 0.104615101 |
| 12 | 146546 | 144036.622 | 0.017123477 |
| 16 | 687492 | 656090.434 | 0.0456758 |
| 20 | 1374044 | 1327024.258 | 0.034220207 |
| 24 | 133285 | 130517.575 | 0.020764625 |
| 28 | 759536 | 738474.984 | 0.027728916 |
| 32 | 1307618 | 1279278.614 | 0.021672604 |
| 36 | 85664 | 83785.308 | 0.021936032 |
| 40 | 456312 | 445526.567 | 0.023636284 |
| 44 | 939903 | 913786.023 | 0.027786449 |

Table 1: Gurobi vs PS2 for 500 bids test case

In Gurobi solver I have 6 cases which cannot find optimal value in given time (1hour) as seen in *Table 2* and all these 6 cases have 10000 bids. This result shows that problem become harder when number of bids increase.

|  |  |  |  |
| --- | --- | --- | --- |
| CAB ID | Objective  Value | Status | Run Time |
| 3 | 945953 | OPTIMAL | 237.12 |
| 7 | 3525622 | OPTIMAL | 3165.33 |
| 11 | 8709390 | OPTIMAL | 828.52 |
| 15 | 294863 | OPTIMAL | 1138.17 |
| 19 | 1342260 | OPTIMAL | 967.81 |
| 23 | 2752830 | TIME\_LIMIT | 3602.27 |
| 27 | 310759 | OPTIMAL | 3557.48 |
| 31 | 1590467 | TIME\_LIMIT | 3601.80 |
| 35 | 2869129 | TIME\_LIMIT | 3600.29 |
| 39 | 221475 | TIME\_LIMIT | 3628.75 |
| 43 | 1179799 | TIME\_LIMIT | 3600.55 |
| 47 | 2474269 | TIME\_LIMIT | 3603.53 |

Table 2:Objective value and optimality status for number of bids ae 10000

# Discussion

In this project, I have learnt using Gurobi Simplex and modelling given linear or integer linear programming problem in Python. I also observe that feasibility control is not a simple problem.

As seen in *Table 1* PS2 algorithm finds acceptable results in polynomial time complexity but Gurobi solver finds optimal solution for most of the cases and Gurobi solver results always better than PS2 algorithm even for “TIME\_LIMIT” cases.

I have tried PS2 heuristics with different parameters, for example when I delete cost factor for my PS2 heuristic I got better results for some cases. I observe that heuristic solutions are problem specific and we cannot measure performance of heuristic for small test case size.

# References

[1] Özer, Ali Haydar, and Can Özturan. "A model and heuristic algorithms for multi-unit nondiscriminatory combinatorial auction." Computers & Operations Research 36.1 (2009): 196-208.