E-ISSN: 2717-2937 | P-ISSN: 2783-1337

International Journal of Research in Industrial Engineering

IJRIE

www.riejournal.com

Int. J. Res. Ind. Eng. Vol. 10, No. 2 (2021) 155–164.

Paper Type: Original Article

Greedy Algorithm for Solving Student Allocation Problem in Internship Program: A Case Study

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Citation:

Ali, A.Y. (2021). Greedy algorithm for solving student allocation problem in internship program: a case study. *International journal of research in industrial engineering, 10*(2), 155-164.

Received: 16/01/2021 Reviewed: 29/02/2021 Revised: 17/03/2021 Accept: 03/05/2021

Abstract

This paper presented greedy algorithm for solving student allocation problem that has arisen in internship program. In internship program, engineering students stay one semester in industries which are located across the country and teachers visit students once/twice for supervision during the program. As the industries scatter across the country, teachers spend long time on travel. And this results in wastage of teachers working time and money spent for transport. Therefore, allocating students to universities near the internship location extensively reduces the transport time and money spent for transport. For the current study, we consider 4th mechanical engineering students who are currently working in the industry. The proposed approach extensively decrease the distance traveled from 23,210 km to 2,488.8 km and the time spent on the road from 397 hrs. 40 min to 51 hrs. 30 min. and finally, the results obtained from the greedy algorithm is compared with other heuristics (i.e., Genetic algorithm and Particle swarm optimization) and the greedy algorithm outperforms the other methods.

Keywords: Internship program, Students, allocation, Greedy algorithm.

1 | Introduction

Internship is program one full semester course where students spend the whole semester working in the industry. This provides the students the opportunity to link the concepts learned in classroom with the industrial practice. In this program, the students search for industries where they are going stayed for the semester based on their preference and mostly students prefer to be near to their family and the students who are unable to get acceptance from industries due to the limited capacity of the industries will be assigned by the industry linkage of the university. And, teacher visit the students once/twice in the semester for supervision in their hosting company. However, as the students scatter to different places across the country, the teachers spent a lot of time in transport. In addition to cost and time, the teaching and learning program of the university will be affected as many teachers will go for supervision. This paper investigates the benefits gained by reallocating the students to different public governmental universities which are located in near the student's internship location.

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10.22105/RIEJ.2021.266125.1179

The rest of the paper is organized as follows. The related works on assignment problem and greedy algorithm described in Section 2. The problem formulation and the proposed solution for solving the current problem are provided in Section 3. The results presents in Section 4. Finally, section 5 concludes the paper.

2 | Literature Review

2.1 | Assignment Problem

Problems related to assignment arise in a range of fields, for example, healthcare, transportation, education, and sports. In fact, this is a well-studied topic in combinatorial optimization problems under optimization or operations research branches. Besides, problem regarding assignment is an important subject that has been employed to solve many problems worldwide [1]. Within the education domain the assignment problem can be classified into two groups, time tabling [2] and allocating problem. The problem presented in this paper is allocation problem. The approaches for solving allocation problem are divided as exact method, heuristic, metaheuristic, and hybrid techniques. According to [3], exact methods assure to provide optimal solution, while heuristic methods simply try to produce a good but not certainly optimal solution. Mostly heuristic and metaheuristic are used when the problems are too large for exact methods.

Both methods are discussed in the literature. Anwar and Bahaj [4], used integer programming model for solving student project assignment problem. Pan et al. [5] used goal programming model to maximize the number of assigned projects. The student's preference was successfully increased by giving higher weightage to the higher preference. Further, Calvo-Serrano et al. [6] proposed mix-integerprogramming model by incorporating ranking of lecturers and research areas in the allocation process. This results in increased student satisfaction and decreased computation time for a large dataset.

On the other hand, Harper et al. developed population-based metaheuristic approach by applying GA and compared it with an optimal integer programming approach [7]. Ramli and Bakar [8] discussed how 0-1 IP model Analytical hierarchy process can be used to assign projects to students. The model dismissed student's preference for team members and as a result, the total constraints and variables increased significantly. Zukhri and Omar [9] explored new student's allocation problem by using genetic algorithm to allocate new students to classes to satisfy both students and room's requirements. Furthermore, Kenekayoro et al. [10] uses population-based techniques such as gravitational search algorithm, genetic algorithm, and ant colony optimization to solve student project allocation problem and concludes that the ant colony optimization algorithm outperformed the genetic and gravitational search algorithm for finding optimal solution to student project allocation problem. Manlove et al. [11] presented algorithmic and experimental results for finding maximum size stable matchings in instances of student project allocation problem. From algorithmic perspective, they proved that MAX-SPA-P becomes polynomial-time solvable if there is only one lecturer, whilst the problem remains NP-hard to approximate even if there are two lecturers involved. They also proved that it is NP-hard to find a maximum size stable matching if each preference list is of length at most 3.

2.2 | Greedy Algorithm

Greedy algorithm is an algorithmic paradigm that follows the problem solving approach of making the locally optimal choice at each stage with the hope of finding the global optimum. In many problems, a greedy strategy does not in general produce an optimal solution, but nonetheless a greedy heuristic may yield locally optimal solutions that approximate a global optimal solution in a reasonable time. Greedy algorithm is often used to solve the problems of some decisions, such as change money problem (when a shop clerk wants to change money for customers, he always tends to pay the largest domination coins firstly), knapsack problem (put several items with different weights and values into a knapsack whose loading capacity is limited, and maximize the total value of those items put into the knapsack [12].

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Extensive research has been discovered in the literature on greedy algorithm. Haket et al. [13] developed four variations of construction algorithms such as the sequential, the random, the saving regret, and the randomized adaptive greedy adding algorithm for efficiently allocating customers to different facilities near customer's location in Van Dorps service providing industry in the Netherland. They also develop three version of improvement heuristic such as the "first" improvement, the random "best" improvement, and the random "one-opt" local search algorithm and compared the results with CPLEX solution. And report the random greedy adding heuristic outperform other versions of construction algorithms for most of the reasonable capacity relaxation levels and recommend for problems with Van Dorp's characteristic. Qu et al. [14] propose distributed greedy algorithm for solving multi agent task assignment problem where each agent selects a task from its admissible task set. The objective of the study is to find an assignment profile that maximizes the global utility. In the proposed algorithm, when the communication links between agents are consistent with the admissible task sets, each agent can make its own decision in a distributed and asynchronous fashion. And the efficiency ratio of the algorithm is lower bounded by $1/(1+k)$, where $k\in[0,1]$ is a problem dependent curvature parameter. Ribas et al. [15] proposed an Iterated Greedy Algorithm (IGA) for solving both parallel blocking flow shop problem and distributed blocking flow shop problem by minimizing the total tiredness of jobs. Ying et al. [16] developed Iterated Reference Greedy (IRG) algorithm for solving Distributed no-Idle Permutation Flowshop Scheduling Problem (DNIPFSP). The aim of their study was to simultaneously assign jobs to various factories and to determine their production sequence in each factory to minimize the makespan. The performance of the proposed IRG algorithm is compared with a state-of-the-art Iterated Greedy (IG) algorithm, as well as the Mixed Integer Linear Programming (MILP) and the result show that the proposed IRG outperforms the IG algorithm. A new hybrid Deferential Evolution and Greedy Algorithm (DEGA) has been proposed and applied for solving multi-skill resource-constrained project scheduling problem [17]. In their study design of experiments method has been used to adjust parameters for investigated method to reduce the procedure of experiments. Various initializations, clone elimination, mutation and crossover operators have been applied. And finally, the result of the proposed algorithm has been compared with the result of other reference methods (HantCO, GRASP and multiStart Greedy) using the benchmark iMOPSE dataset.

2.3 | Motivation

Generally, service providers who must visit their customer are increasingly interested in reducing their employees' time and distance spent on the road [18]. In Ethiopian Universities, mostly engineering students has internship program which is one semester course where students spend the whole semester in the industry. And teachers visit the students once/twice in the semester for supervision. However, as students' scatter across the country the teachers who has to supervise students spend a long time on travel. Therefore, Ethiopian Universities can save their employees working time and the distance traveled by simply allocating students to other universities near the students' internship location for supervision. Customer allocation problem has received a plenty of attention in the field of facility location research [19], [20] and [21]. The general class of facility location problems concerns the location of facilities and the allocation of customers to those facilities, and if the facilities locations are fixed, it becomes an assignment problem. Thus, rather than focusing on where to locate facilities, we focus on which customer should be assigned to which facility [13].

The contribution of this paper is threefold. (1) to investigate the gains (i.e, time, cost, distance) achieved by allocating students in internship program into universities near student's location. (2) to develop a greedy algorithm for solving the current problem and compare the results with other heuristic methods.

2.4 | Merits and Limitations of the Paper

The main purpose of this research is to allocate university students who are doing their internship program in different industries across the country into the nearest public university for supervision. And this reduces the teachers valuable working time and distance spent on the road. However, the applicability of this research is depending on the willingness of the public universities to collaborate in the proposed solution and the similarity of the courses offered by the universities.

3 | Methodology

3.1 | Problem Formulation

The case study is conducted in Woldia University, Mechanical Engineering Department. One hundred twenty seven 4th year mechanical engineering department students are working in industries located in 23 different towns across the country. And, 18 teachers are assigned by the department to go to the industries where the students are located for supervision. And 13 public governmental universities with similar program are considered in this study, so that the students from these universities can be supervised by other university teachers nears the student's location. Therefore, only for Woldia University Mechanical Engineering Department we have 13x127 matrixes. The distance matrix of the current problem is shown in *Table 1*.

Table 1. Distance matrix.

Universities / Internship Location (no of students)	Shashemene (1)	Addis Abeba (19)	Deredawa (1)	Kombolcha (11)	Dilla (1)
Addis Abeba University	258.5		559.4	379.6	362.6
AASTU	236.7		559.4	384.1	345.1
ASTU	201.3	93.9	366.9	457.5	308.2
Dilla University	108.8	362.6	242.2	910.3	
Bahirdar University	741.4	492.5	938.7	498.2	847.2
Gonder University	907.6	658.8	1105.9	538.5	1014.2
Debretabor University	842.8	594	956.7	389.4	951.2
Debrebirhan University	369.5	130.4	566.9	247.5	477.9
Debremarkos University	554.2	305.4	751.6	483.6	662.6
Wollo University	616.7	398.2	676.2		937
Mizan Tepi University	539.7	568.4	1009.1	966.4	577.5
Woldia University	808.8	705.3	705.6	140	962.6
Hawasa University	24.7	279	584.1	641.1	85.2
Deredawa University	559.4	452.4		655.6	241.6
Arbaminch University	252.4	434.3	811.5	816.7	284.1

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Table 1. (Continued).

Bishoftu (6)	Arbaminch (1)	Hawasa (3)	Woldia (1)	Mizan (1)	Dessie (2)	Debremarkos (14)	Debrebirhan (3)	Debretabor (2)	Gonder (8)	Bahirdar (43)
66.2	434.3	279	705.3		398.2	305.4	130.4	594	658.8	492.5
44.4	488.9	260.4	668.5		404.7	321.2	137.1	608.8	673.6	507.5
47.1	453.5	224.9	616.3		476.7	395.2	209.1	681.3	747.6	581.5
314.8	284.1	85.2	960.3		937	662.6	478.2	951.2	1014.2	849.1
546.6	910.3	764.2	359.9		468.2	254	516.3	108.6	171.6	
713.5	1076.4	930.4	400.2		521.1	424.4	681.4	147.5		171.6
654.1	1011.6	865.5	251.1		420	359.5	616.6		153	108.6
175.2	563.7	393.3	386.8		274.5	331.5		616.6	681.4	516.3
363.6	724	578	609.9		475.1		331.5	359.5	424.4	254
451.5	831.3	660.9	119.5			475.1	274.5	420	521.1	468.2
635.1	534.4	539.3	1258.6		987	748.1	719.4	893.7	958.5	788.7
656.4	1054.8	523.7			119.5	609.9	386.8	251.1	398.3	357.6
229.9	245.8		523.7	521.6	660.9	578	393.3	865.5	930.4	764.2
404	811.5	584.1	705.6	1007.1	676.2	751.6	566.9	956.7	1105.5	938.7
451.3		245.8	1054.8	511.5	831.3	724	563.7	1011.6	1076.4	910.3

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Table 1. (Continued).

Gaint (1)	Dangla (1)	Burie (1)	Welega (1)	Sekota (1)	Debre Elias (3)	Dejen (2)
643.8	485	411.6	315.2	873.7	346.6	240.7
658.9	500.1	426.8	329.8	851.9	361.7	255.9
732.9	572.6	500.7	401.7	777.1	434.2	329.8
1000.6	841.7	768.4	669.4	1086	703.3	597.5
155.1	80.1	152.2	407.5	434.7	249.7	258.7
197.6	244.9	317	572.2	477.3	414.4	425.6
47.5	185.6	257.7	512.9	327.1	355.1	366.2
616.4	507.8	434.5	436.3	582.9	369.4	263.6
409.6	180.4	107.1	364	689.3	42	75.7
348.6	553.6	580.6	712.6	315.1	515.5	425.4
943.8	714.6	642.9	395.1	1223.4	740.3	821.4
225.9	430.8	503	758.2	195.9	600.4	611.5
915.6	756.8	683.5	584.4	1001.1	618.4	512.6
933	930.9	857.6	758.8	873.7	792.5	686.6
1061.7	902.9	829.5	637.2	1223.2	764.5	658.6

Assumptions.

The following assumptions are made in formulating the problem.

- *The students who are working in industry can be supervised by other university teachers near their work location.*
- *The capacity of the universities to supervised students are known.*
- *The total number of students to be supervised are less than or equal to the university's capacity.*
- *One teacher can supervise a maximum of 7 students.*

Indices.

I: set of students in industries, $i \in I$.

J: set of facilities (universities), $j \in J$.

Decision Variables.

X_{ij}: the number of students i assigned to university j.

C_{ij}: the associated unit cost of assigning student I to university j.

di: capacity of university *j*.

Mathematical Model.

$$\text{Min} \sum_{i\in I} \sum_{j\in J} \frac{1}{7} c_{ij} X_{ij}. \quad (1)$$

Subjected to:

$$\sum_{j\in J} X_{ij} = 1, \qquad \forall i\in I, \quad (2)$$

$$X_{ij} \in \{0,1\}, \qquad \forall i\in I, \forall j\in j, \quad (3)$$

$$\sum_{i\in I} X_{ij} \leq d_j, \qquad \forall j\in J. \quad (4)$$

Where let *I* be the students in different industries $I=\{1\ldots,i\ldots,\ldots,121\}$, *J* the universities in different location that can supervise the students with capacity d_j, $\frac{C_{ij}}{7}$ represent cost or distance between the location of the industry that host the students and the university supervised students (the constant 1/7 is included in cost coefficient to consider the fact that 1 teacher could supervise a maximum of 7 students).

Constraints.

Eq. (1) as an objective function aims to minimize the travel distance of teachers from universities to industries where students are located.

Eq. (2) ensures that each student is assigned to exactly one university.

Eq. (3) simply ensures the integrity of the solution on the decision variables.

Eq. (4) maintains the number of students in industry assigned to the university for supervision are must be less than or equals to the capacity of the university.

3.2 | Proposed Solution

The present work proposed greedy algorithm for solving student assignment problem in internship program. For the current problem we will propose random greedy adding heuristic as it matches with the Van Dorp's case [13], except that in our case reallocation cost is not considered as the facilities or universities serve different students each year. The main steps of the proposed algorithm are described as follow.

Input. The distance matrix (the distance between the student's location and the university) and the capacity of the universities d_j is given.

Step 0. Initialize universities, capacity, cost, and seed.

Step 1. Calculate weighted cost.

Step 2. Generate quasi random distribution of student's *c*.

Step 3. Allocate student c to university *j* from lowest to highest cost of allocation until its full capacity.

Step 4. Update solution and its associated cost.

Step 5. Move to next university.

Output. Assigned students to specific universities and the cost of the assignment.

Table 1. Random greedy algorithm.

1. $S \leftarrow \emptyset$;
2. $f(S) \leftarrow 0$;
3. $F \leftarrow \{i \in E : S \cup \{i\}$ is not infeasible$\}$
4. generate quasi random distribution of students c
5. for c=1 to i do
6. find students with value c
7. for j=1 to k
8. $i^* \leftarrow \text{argmin}\{c_i : i \in F\}$
9. if $i \leq d_j$ then
10. allocate student c to university j
11. else $j \leftarrow j+1$ //next university
12. $S \leftarrow S \cup \{i^*\}$;
13. $f(S) \leftarrow f(S) + c_{i^*}$;
14. $F \leftarrow \{i \in F \backslash \{i^*\} : S \cup \{i\}$ is not infeasible$\}$;
13. next c
14. Return S, f(S)

End.

4 | Results

The optimal solution for greedy algorithm is obtained by using matlab programming. The optimal assignment of students to universities is shown in *Table 1*. The comparison of the cost of the greedy algorithm with the optimal solution is presented in *Table 2*.

Table 2. Optimal assignment.

No	Universities	Students Assigned (internship location)
1	Addis Abeba University	10 (Addis Abeba),
2	AASTU	9 (Addis Abeba)
3	ASTU	6 (Bishoftu)
4	Dilla University	1 (Dilla)
5	Bahirdar University	15 (Bahirdar)
6	Gonder University	7 (Bahirdar), (8 Gonder)
7	Debretabor University	8 (Bahirdar), (2 Debretabor), 1 (Dangla), 1 (Gaint), 3 (Debreelias), 1 (Burie), 2 (Dejen)
8	Debrebirhan University	3 (Debrebirhan), 4 (Debremarkos)
9	Debremarkos University	10 (Debremarkos),
10	Wollo University	11 (Kombolcha), 2 (Dessie)
11	Mizan Tepi University	2 (Mizan)
12	Woldia University	1 (Woldia), 13 (Bahirdar), 1 (Sekota)
13	Hawasa University	3 (Hawasa), 1 (Shashemene)
14	Deredawa University	1 (Deredawa)
15	Arbaminch University	1 (Arbaminch)

Table 3. Total cost of the assignment.

Greedy Algorithm	Particle Swarm Optimization	Genetic Algorithm	Deviation From The Optimal
2,488.8	3111.2	3235.6	373

5 | Conclusion

In this paper, we have presented greedy algorithm for solving student allocation problem that has arisen in internship program. In internship program, students stay one semester in industries across the country and teachers visit students once/twice for supervision during the program. As industries scatter across the country, teachers spend long time on travel. Therefore, allocating students to universities near the internship location extensively reduces the transport time and money spent for transport. For the current study, we consider 4th mechanical engineering students who are currently working in the industry. The proposed approach extensively decreases the distance traveled from 23,210 km to 2,488.8 km and the time spent on the road from 397 hrs. 40 min to 51 hrs. 30 min. and finally, the results obtained from the greedy algorithm is compared with other evolutionary algorithms (i.e., Genetic algorithm and Particle swarm optimization) and the greedy algorithm outperforms the other methods.

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