KEDGE BUSINESS SCHOOL
ILS2016
Information Systems, Logistics and Supply Chain
6th International Conference
université de BORDEAUX

A Method for Work Teams Setup and Logistics

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Abstract. This paper presents a method for work teams setup and logistics. The proposed method solves a mathematical model in binary variables 0/1 based on the generalized assignment model in order to minimize the cost of transportation and set up working teams with a preset number of agents. The corresponding program was written in Microsoft-Excel-Solver and tested in a company providing outsourced services in more than 200 Brazilian cities.

Keywords: Work Teams, Provision of Services, Logistics, Optimization, Generalized Assignment Problem.

1 Introduction

An outsourced services company is responsible for providing cleaning crews, maintenance, support, concierge and surveillance for industries, banks, shopping centers, schools and hospitals. The company selects the agents, constitutes work teams and forwards them by public transportation to locations previously contracted. The company's objective is to minimize the transportation cost of agents to workplaces.
In this paper we propose a mathematical model in binary variables 0/1 based on the model of generalized assignment [1] to make the selection of agents and the formation of the teams. A review of models and solving methods proposed in the literature to the generalized assignment problem is available in Section 2. The methodology is presented in Section 3. Section 4 presents the mathematical model proposed to solve the problem. An illustrative example is provided in Section 5. The proposed method was tested in a company providing outsourced services in more than 200 Brazilian cities. A test carried out in the city of Belo Horizonte, Brazil, is presented in Section 6. In computational tests, we have used the Microsoft-Excel-Solver to solve the assignment problem, because Excel is a very popular software and is available in most computers. A discussion about the proposed method and the results obtained is presented in Section 7. The final conclusion is presented in Section 8.

2 Review

The generalized assignment problem is NP-complete [2]. Hence, there are many heuristics to solve it in the literature. A review of exact and heuristic methods to solve the problem with different objective-functions, transformations and limits is presented in [3]. The large number of methods developed based on branch-and-bound is shown in [4]. An extensive and detailed study to compare the performance of heuristics is proposed in [5]. A literature review of metaheuristics and heuristics is made in [6]. A comprehensive description of the state of the art is shown in [7]. Tabu search metaheuristic is used by [8] and [9]. Quick heuristic algorithms to solve the problem are described by [10], [11] and [12]. Lagrangian and dynamic programming are associated in the method proposed by [13]. Branch-and-bound combined with tabu search is proposed by [14].

3 Methodology

This study aims to select agents to perform tasks in workplaces previously hired by the company. Agents are selected based on the costs of transportation between their homes and workplaces. The company provided the addresses of agents and workplaces. The costs of the transportation between the addresses of

the agents and workplaces were obtained from Google Maps. The cost matrix c_{ij} between agents and workplaces has been inserted in an Excel spreadsheet. The assignment of agents to workplaces was obtained by solving the model proposed by Excel-Solver. Excel-Solver has been used for the following reasons: 1) the real problems to be solved have small or medium size and the limit on decision variables on Microsoft-Excel-Solver is 200 [15]; 2) Excel is available in most computers; 3) Excel is popular and good to train users.

4 Model

In the generalized assignment model proposed in this paper we have m agents to perform work in n places with m > n. The agents i may only be assigned to a single workplace j and each workplace requires a number of agents b_j. The cost of the assignment is given by the cost c_{ij} of shipping agents i to workplaces j. In the classical model of the generalized assignment [1], we have m < n and the execution of task j by agent i requires an amount a_{ij} of the resource b_i.

Let x_{ij} be a binary variable 0/1: $x_{ij} = \begin{cases} 1 \text{ if the agent i is assigned to the workplace j} \\ 0 \text{ otherwise} \end{cases}$

The classic model of the generalized assignment can then be rewritten as follows:

$$Min\ f = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij} \tag{1}$$

Subject to:

$$\sum_{i=1}^{m} x_{ij} \leq 1\ (j = 1,...,n) \tag{2}$$

$$\sum_{j=1}^{n} x_{ij} = b_j\ (i = 1,...,m) \tag{3}$$

$$x_{ij} = 0/1 \tag{4}$$

The objective function (1) minimizes the sum of the cost of transportation of the agents to workplaces. Constraint (2) determines that each agent is assigned to a single workplace, but that not all agents will be assigned to workplaces. Constraint (3) gives the number of agents in every workplace. Constraint (4) establishes the type of variables.

5 Example

To illustrate the proposed model, we have seven agents for assignment to three workplaces. The workplaces require 2, 1 and 2 respectively agents, ie, five agents in total. Transportation costs of the agents to workplaces are given in Table 1.

Table 1: Transportation costs.

	Workplace 1	Workplace 2	Workplace 3
Agent 1	5	4	5
Agent 2	4	5	5
Agent 3	5	5	5
Agent 4	6	6	5

Agent 5	5	4	5
Agent 6	6	8	5
Agent 7	4	3	4

The corresponding mathematical model is given by:

Minimize f = $5x_{11} + 4x_{12} + 5x13 + 4x_{21} + 5x_{22} + 5x_{23} + 5x_{31} + 5x_{32} + 5x_{33} + 6x_{41} + 6x_{42} + 5x_{43} + 5x_{51} + 4x_{52} + 5x_{53} + 6x_{61} + 8x_{62} + 5x_{63} + 4x_{71} + 3x_{72} + 4x_{73}$

Subject to

$$\begin{cases} x_{11} + x_{12} + x_{13} \leq 1 \\ x_{21} + x_{22} + x_{23} \leq 1 \\ x_{31} + x_{32} + x_{33} \leq 1 \\ x_{41} + x_{42} + x_{43} \leq 1 \\ x_{51} + x_{52} + x_{53} \leq 1 \\ x_{61} + x_{62} + x_{63} \leq 1 \\ x_{71} + x_{72} + x_{73} \leq 1 \\ x_{11} + x_{21} + x_{31} + x_{41} + x_{51} + x_{61} + x_{71} = 2 \\ x_{12} + x_{22} + x_{32} + x_{42} + x_{52} + x_{62} + x_{72} = 1 \\ x_{13} + x_{23} + x_{33} + x_{43} + x_{53} + x_{63} + x_{73} = 2 \\ x_{ij} = 0/1 \end{cases}$$

The result obtained by Solver-Excel is: $x_{12} = x_{21} = x_{31} = x_{43} = x_{73} = 1$ and all other variables are zero. Thus, agents 2 and 3 will be assigned to workplace 1, the agent 1 to workplace 2 and the agents 4 and 7 to workplace 3. Agents 5 and 6 will not be assigned to any workplace. The assignment cost is 4 + 4 + 5 + 5 + 4 = 22.

6 Results

Computational tests were performed for work teams setup in an outsourced services company that operates in more than 200 Brazilian cities, including four large cities: São Paulo (11.9 million inhabitants), Belo Horizonte (2.502 million inhabitants), Campinas (1,080 inhabitants) and Ribeirão Preto (666,000 inhabitants). In this paper we present the test carried out for the selection of agents related to a contract of provision of services in car dealerships in the city of Belo Horizonte, MG.
Table 2 provides the transportation fares between 26 agents (Agent 1, Agent 2… Agent 26) and 6 workplaces (Workplace 1, Workplace 2… Workplace 6) in Belo Horizonte, Brazil. These fares were provided using Google Maps.
The objective is to setup 6 teams with 3, 5, 2, 5, 7 and 4 agents respectively. In the test, all agents will be assigned to any workplace. The mathematical model to solve the problem has 26 x 6 = 156 binaries variables 0/1. The problem has been solved using Microsoft-Excel-Solver.
Figure 1 presents the Microsoft-Excel-Solver programming in order to solve the problem. Results are presented in Table 3. Table 4 provides the cost reduction between current and new solution. The global travel time reduction is available in the Table 5. The travel times to the workplaces were also provided by Google Maps.

Table 2: Transportation fares.

	Workplace 1	Workplace 2	Workplace 3	Workplace 4	Workplace 5	Workplace 6
Agent 1	3,4	5,85	6,8	3,4	5,85	5,85
Agent 2	5,85	5,85	9,25	7,65	5,85	5,85
Agent 3	6,8	3,4	6,8	6,8	5,85	3,4
Agent 4	3,4	2,2	3,4	1,8	1,8	1,8
Agent 5	3,4	3,1	3,4	3,4	3,4	3,4
Agent 6	6,8	6,2	9,25	8,6	8,7	6,8

Agent 7	5,85	5,3	5,85	4,25	4,25	4,25
Agent 8	5,85	5,3	9,25	3,4	6,8	5,8
Agent 9	5,85	7,65	6,8	3,4	4,25	3,4
Agent 10	6,8	7,65	3,4	4,25	1,8	3,4
Agent 11	6,2	3,4	6,8	3,4	3,4	3,4
Agent 12	3,1	7,65	3,4	4,25	4,25	3,4
Agent 13	6,2	3,4	6,8	5,85	3,4	3,4
Agent 14	3,1	3,4	6,8	3,4	1,8	1,8
Agent 15	5,3	5,85	9,25	5,85	4,25	5,85
Agent 16	6,2	3,1	4,9	1,8	1,8	3,4
Agent 17	4,15	3,4	6,8	2,45	3,4	3,4
Agent 18	3,4	3,4	5,85	2,45	0	2,45
Agent 19	5,85	5,85	5,85	4,25	4,25	4,25
Agent 20	5,85	5,85	3,4	3,4	4,25	3,4
Agent 21	3,4	3,4	3,4	3,4	3,4	3,4
Agent 22	3,4	3,4	6,8	3,4	5,85	5,85
Agent 23	6,8	6,8	3,4	3,4	3,4	3,4
Agent 24	6,8	6,8	6,8	3,4	3,4	5,85
Agent 25	6,8	6,8	6,8	3,4	3,4	3,4
Agent 26	5,85	5,58	9,25	3,4	5,85	5,85

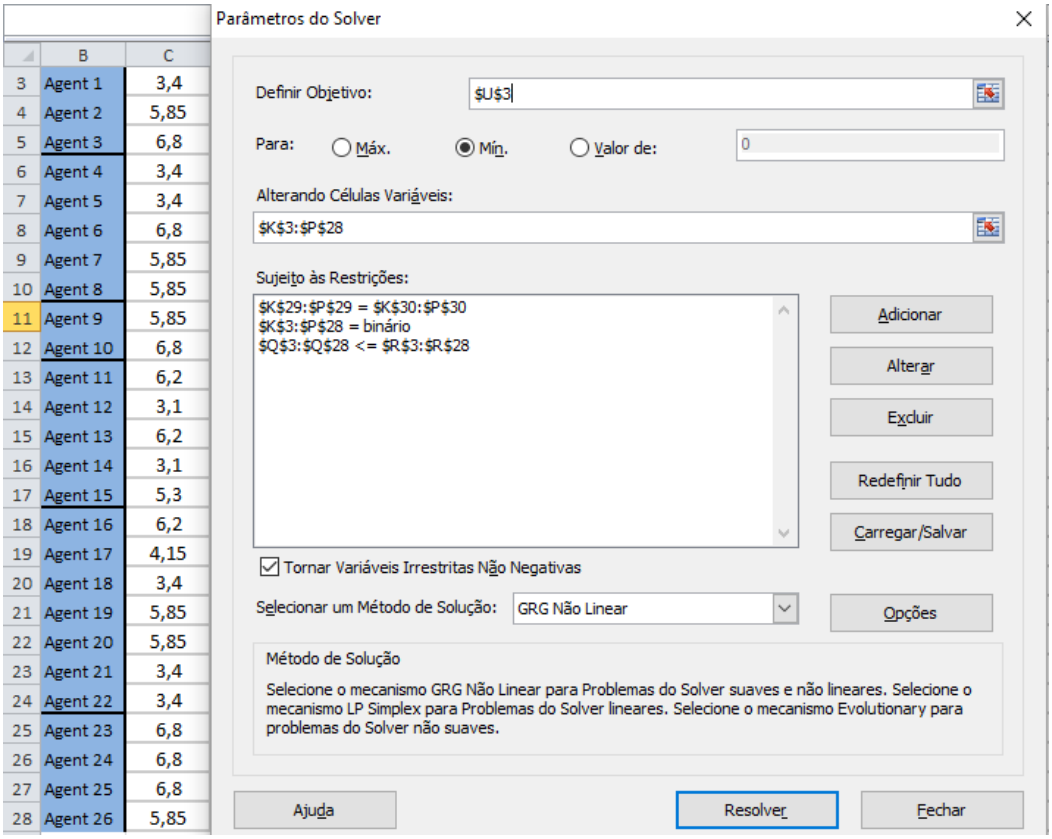

Figure 1: Microsoft-Excel-Solver programming.

Table 3: Results.

	Workplace 1	Workplace 2	Workplace 3	Workplace 4	Workplace 5	Workplace 6
Agent 1	1	0	0	0	0	0
Agent 2	0	1	0	0	0	0
Agent 3	0	1	0	0	0	0
Agent 4	0	0	0	0	0	1
Agent 5	0	1	0	0	0	0
Agent 6	0	1	0	0	0	0
Agent 7	0	0	0	0	0	1
Agent 8	0	0	0	1	0	0
Agent 9	0	0	0	1	0	0
Agent 10	0	0	0	0	1	0
Agent 11	0	1	0	0	0	0
Agent 12	1	0	0	0	0	0
Agent 13	0	0	0	0	1	0
Agent 14	0	0	0	0	1	0
Agent 15	0	0	0	0	1	0
Agent 16	0	0	0	0	1	0
Agent 17	0	0	0	1	0	0
Agent 18	0	0	0	0	1	0
Agent 19	0	0	0	1	0	0
Agent 20	0	0	1	0	0	0
Agent 21	0	0	1	0	0	0
Agent 22	1	0	0	0	0	0
Agent 23	0	0	0	0	0	1
Agent 24	0	0	0	0	1	0
Agent 25	0	0	0	0	0	1
Agent 26	0	0	0	1	0	0
Number of Agents	3	5	2	5	7	4

Table 4: Cost reduction.

Expenses	Solver	Current
One way	BRL 84,85	BRL 112,55
Day	BRL 169,70	BRL 225,10
Month	BRL 3.733,40	BRL 4.952,20
Saving	BRL 1.218,80	24,6%

Table 5: Time reduction (minutes).

Time	Solver	Current
One way	2109	2113
Day	4218	4226
Month	92796	92972
Saving	176	0,2%

7 Discussion

The proposed method allows finding the global optimal solution of the problem, for all agents and all workplaces. This solution, however, has no practical interest because it mixes agents working in different sectors such as car dealerships, supermarkets and hospitals. Agents have different abilities and cannot be exchanged for each other. So it is better solving the problem by economic sectors, specific contracts or geographical areas. The solution obtained by decomposition of the problem provides a more realistic and effective solution for system management. In addition, we can solve smaller problems using Microsoft's Solver.

8 Conclusion

In this paper a mathematical model in binary variables 0/1 is proposed for the work teams setup and logistics. The objective function minimizes the transportation cost. The first constraint ensures that each agent is assigned to a single workplace, but not all agents will be compulsorily assigned. The second constraint establishes the number of agents in every working team. The proposed formulation is based on the generalized assignment model [1].
The proposed model was tested on a real problem of work teams setup of a company providing outsourced cleaning services, maintenance, support, concierge and surveillance. The company provides work teams to perform services in industries, schools, hospitals, shopping centers and banks. The outsourcing company is present in over 200 Brazilian cities. In the test presented in the paper we performed the assignment of 26 agents to 6 workplaces. The result obtained reduced the transportation cost around 25%.
All tests carried out with company's data provide good results. The work will continue with the following tasks: a) proposition of a new mathematical model for the assignment problem taking into account the skills, expertise and expectations of each agent; b) implementation of the program in Microsoft-Excel-Open-Source for solving large-scale problems; c) development of a new solving method for the generalized assignment problem.

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