JMSCOWA 4 (1) (2023) Pages:. 29-34

Journal homepage: https://pcijournal.org/index.php/jmscowa

Journal of Mathematics and Scientific Computing with Applications

Published: Pena Cendekia Insani

OPTIMIZATION OF SHIFT SCHEDULING OF EMPLOYEES OF K3 MART INDEPENDENT FIELD BRANCH IN MEDAN USING INTEGER LINEAR PROGRAMMING

Widya Afriani[1]

[1]Department of Mathematics, Universitas Udayana, Bali, Indonesia

Article Info

Article history:

Received 08 20, 2022
Revised 09 30, 2022
Accepted 01 20, 2023

Keywords:

Integer Linear Programming; K3 Mart; Shift Scheduling; Work Efficiency

ABSTRACT

Effective shift scheduling is an important element in human resource management at K3 Mart, Lapangan Merdeka, Medan, which operates for 24 hours. Challenges such as uneven shift distribution, disproportionate work schedules, and errors due to manual scheduling can reduce productivity, increase employee fatigue, and trigger internal conflicts. This research aims to optimize shift scheduling using the Integer Linear Programming (ILP) method. Primary data from employee interviews is used to build a mathematical model. The model is designed to minimize the number of workers in one scheduling period, while still considering constraints such as minimum employee requirements per shift, fair shift rotation, and a balanced distribution of days off. Model processing is done using Dev-C++ software, resulting in an optimal schedule that can meet operational needs without causing conflicts or labor shortages. The results show that the ILP method is able to produce an efficient, fair, and productivity-enhancing schedule, while maintaining workload balance and employee health. In addition, this method is flexible to adjust to changing operational needs. Implementation of this method in the retail sector can improve operational efficiency and employee welfare, with regular evaluation and updates to ensure its sustainability.

Corresponding Author:

Widya Afriani,
Department Of Mathematic,
Universitas Udayana
Email: widyaafriani69@gmail.com

1. INTRODUCTION

K3 Mart is a modern store that has a lifestyle concept with a Korean touch. Here, we can find various Korean products such as snacks, drinks, and K-Pop merchandise. One of the main icons at K3 Mart is that you can make your own instant noodles. In Medan, K3 Mart already has many branches. One of them is located at Merdeka Square. Because it has many enthusiasts, K3 Mart always operates around the clock. This makes employees overwhelmed in serving customers. Therefore, good shift scheduling is needed to increase employee efficiency in serving customers who come.

Shift scheduling is very important to do, especially at K3 Mart, Lapangan Merdeka branch, Medan, which is continuously operating. This is done to maintain the quality of service to customers. Creating a shift schedule manually can be time-consuming and demands precision to ensure optimal results without errors. Scheduling errors can have a negative impact on employees, such as assigning two shifts consecutively, such as a night shift followed by a morning shift, which can result in fatigue due to lack of rest. This, in turn, reduces productivity and work performance. Another common issue is the uneven distribution of shifts. If an employee consistently only receives morning or night shifts, this can lead to dissatisfaction and internal conflict among staff due to unfairness in the scheduling process [1].

To overcome these problems, an effective solution is needed to minimize errors that may occur during the creation of employee shift schedules, especially those caused by human error. This system will also speed up the schedule creation process compared to the manual method. This scheduling system is designed based on certain rules to reduce the possibility of errors [1]. Decisions related to employee scheduling can be solved through a mathematical model approach, which is a special model designed to handle scheduling problems in various situations. This model consists of an objective function and a number of constraints, with an appropriate algorithm used to find the optimal solution. Employee scheduling is formulated as an integer linear programming model, which allows optimizing employee performance while reducing salary costs incurred by K3 Mart. This is achieved by minimizing the objective function, which is to minimize the total shifts scheduled during a certain period while still meeting the operational needs of each shift, while still considering the various constraints that exist [2].

2. RESEARCH METHODE

This research is quantitative research. The data used in this study is primary data by interviewing one of the K3 Mart employees [3]. Testing existing theories by examining the relationship between variables is called a quantitative method. Data consisting of numbers can be analyzed based on statistical procedures by measuring existing variables. Anyone involved in quantitative research also needs to have hypotheses to test the theory [4]. In this study, the integer linear programming method is used to solve K3 Mart employee shift scheduling.

2.1 Linear Programming

Linear programming is a way to solve problems with multiple constraint functions to achieve a specific goal, such as minimizing costs or profits. While programming means planning, the linear nature indicates that all mathematical functions in this model are linear functions. Therefore, linear programming is the act of planning to achieve the optimal result the best outcome from all available alternatives. The standard form of linear programming has the following characteristics:

1. All limiting functions have non-negative right-hand side values
2. All decision variables are not negative
3. The objective function can be either maximization or minimization

In general, linear modeling involves 3 important basic components namely: objective function, constraint function, and decision variables. General form of linear program model:

Objective Function:

$$Z = \sum_{j=1}^{n} c_j x_j = c_1 x_1 + c_2 x_2 + \cdots + c_n x_n \qquad (2.1)$$

Constraint Function:

$$\sum_{j=1}^{n} a_{ij} x_j \ (\leq, =, \geq) b_i$$
$$x_j \geq 0 \qquad (2.2)$$

For $i = 1,2, \dots, m$ and $j = 1,2, \dots, n$

By:

$Z =$ The objective function for which the optimal value is sought (maximum, minimum)

$C_j =$ The price coefficient of the decision variable in the objective function, or the parameter that is used as an optimization criterion

$X_j =$ Decision variables to be sought or activity variables (outputs)

$a_{ij} =$ Constant of the jth activity variable in the i-th constraint

$b_i =$ Resource capacity i (excess or limited) available to be allocated to each unit of activity [5].

2.2 Integer Linear Programming

Variables such as the number of cars or houses must be round values in some situations. Linear programming models cannot be used to solve such cases. Another type of linear programming (LP) is integer programming (IP), which assumes that divisibility is weakened or completely lost. Not all decision variables can be broken down by a small number, which is why it came into existence. For example, if the decision variable at hand is the number of products that should be produced to achieve maximum profit, then an answer of 10/3 is highly unlikely as we cannot produce half-and-half products. In this case, it is necessary to decide whether to use 3 or 4 products [6].

Linear integer programming is linear programming in which some or all of the variables are non-negative integers [5]. A linear program also requires that all its variables are integers. When decisions must be made in integer form, an integer program is required. This is in contrast to fractions which are often used in linear programs. In integer binary languages, a model is called pure (all) integer if it expects all base variables to have integer values, either positive integer or zero. If the model only expects certain variables to have integer values, it is called mixed integer. And if the model expects only zero or one values for its variables, it is called zero one integer programming. Actually, the integer programming model is the same as the linear programming model, but the variable constraints must be integers [6].
There are 3 kinds of problems in integer programming, namely:

1. Pure integer programming, which is the case where all decision variables must be integers
2. Mixed integer programming, which is the case where some, but not all, decision variables must be integers
3. Binary integer programming, a special problem case where all decision variables must have values 0 and 1.

The model of integer programming is as follows:

Maximize $\sum_{j=1}^{n} c_j x_j$ (2.3)

With constraints $\sum_{j=1}^{n} a_{ij} x_j = b_i, i = 1,2,3,\ldots,m$

$x_j \geq 0$ (2.4)

x_j integer, for some or for all $j = 1,2,3,\ldots,n$

There are 3 kinds of integer program solving methods:

1. Graphical Method: It is a method similar to the linear program solving method but with an additional barrier, i.e. the decision variables are partially or all integers.
2. Rounding Method: This method offers a conventional or old-fashioned approach to solving integer program problems by rounding, or rounding off, the most optimal solution if possible.
3. Branch-and-Bound Method: This method describes a problem as a tree, and then divides or branches it into smaller groups [6].

3. RESULT AND ANALYSIS

In this research, a scheduling model is formulated to determine how the part shift between employees, the number of employees required and employee days off. The scheduled employees are K3 Mart employees at one of the branches in Medan. Similar problems can be addressed with this model because of its generality. In this case, (i) is the number of employees, (j) is the number of shifts, and (d) is the number of days in a scheduling period. This scheduling will establish the following rules:

1. For each employee, the number of employees per shift must be met.
2. Each employee only works one shift per day.
3. In one day, there must be 4 employees on vacation
4. For every employee who works for four consecutive days, they get the next day off.

Based on the above rules, the employee scheduling model can be made as follows:

1. Decision Variable

$$X_{i,j,d} = \begin{cases} 1, & if\ employee\ i\ works\ on\ day\ d\ in\ shift\ j \\ 0, & if\ employee\ i\ does\ not\ work\ on\ day\ d\ in\ shift\ j \end{cases}$$

i : Employee = 1,2,3,....,25
j : Shift = 1,2,3,4
d : Day = 1,2,3,....,30

2. Objective Function

The objective function z of scheduling workers' working days is to minimize the number of workers who work in one scheduling period. The objective function of worker scheduling is as follows:

$$Min\ Z = \sum_{i=1}^{25} \sum_{j=1}^{4} \sum_{d=1}^{30} X(i,j,d)$$

3. Constraint

a. Required number of employees per shift

$$\sum_{i=1}^{25} X_{i,1,d} \geq 5, \qquad \forall d = 1,2,3,\ldots,30$$

$$\sum_{i=1}^{25} X_{i,2,d} \geq 7, \qquad \forall d = 1,2,3,\ldots,30$$

$$\sum_{i=1}^{25} X_{i,3,d} \geq 4, \qquad \forall d = 1,2,3,\dots,30$$

$$\sum_{i=1}^{25} X_{i,4,d} \geq 5, \qquad \forall d = 1,2,3,\dots,30$$

b. Each employee only works one shift per day.

$$\sum_{j=1}^{4} X_{i,j,d} = 1, \;\; \forall d = 1,2,3,\dots,30 \;\; \forall i = 1,2,\dots,25$$

c. In a day, there must be 4 employees off

$$\sum_{i=1}^{25}\sum_{j=1}^{4} X_{i,j,d} = 21, \;\; \forall d = 1,2,3,\dots,30$$

d. Maximum number of employee holidays

$$X_{1,j,d} = 0, \;\; \forall j = 1,2,3,4 \;\; \forall d = 6,7,13,14,20,21,27,28$$
$$X_{2,j,d} = 0, \;\; \forall j = 1,2,3,4 \;\; \forall d = 6,7,13,14,20,21,27,28$$

e. All decision variables are integer 0 or 1

$$\sum_{j=1}^{4}\sum_{d=1}^{30} (1 - X_{i,j,d}) \leq 8, \;\; \forall i = 1,2,3,\dots,25$$

f. All decision variables are integer 0 or 1

$$X_{i,j,d} \in (0,1), \forall i,j,d$$

The workday scheduling problem that has been modeled is then processed using Dev-C++ software. Based on the available input data, the optimum results obtained show a minimum number of workers of 25 people, which will be shown in Table 1.

Table 1. Optimal Schedule Scheme

Day	Workers																								
J	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	N	S	L	S	L	S	N	M	L	P	M	M	P	P	N	M	S	N	N	P	S	L	S	S	P
2	M	L	P	S	P	P	S	S	S	N	L	P	P	N	L	S	L	M	N	S	M	N	N	S	M
3	S	M	P	S	M	N	N	S	S	S	P	L	L	M	P	N	N	P	M	P	L	N	L	S	S
4	N	M	S	L	M	N	M	P	P	L	S	S	N	N	P	M	N	L	P	L	S	P	S	S	S
5	L	M	N	S	P	L	N	P	P	N	S	S	M	S	M	N	S	P	N	P	M	S	S	L	L
6	L	L	N	S	S	S	N	P	S	M	P	S	N	M	M	L	P	P	L	N	M	P	S	N	S
7	L	L	N	S	S	S	L	S	P	N	M	P	N	L	S	N	S	P	M	M	M	P	P	N	S
8	S	P	N	L	N	S	S	L	P	S	M	N	L	L	S	N	P	N	S	M	S	M	P	M	P
9	N	N	L	P	L	P	N	P	P	M	N	M	P	S	M	S	L	N	S	S	S	L	S	S	M
10	M	S	M	P	S	L	L	P	S	N	L	S	N	P	N	M	S	L	P	M	S	P	S	N	N
11	S	N	M	P	P	S	P	S	L	N	M	S	N	S	L	P	M	S	N	L	S	P	N	L	M
12	N	S	M	M	M	N	S	N	N	L	S	P	S	P	S	L	M	P	L	P	S	S	L	P	N
13	L	L	S	S	N	M	S	P	N	S	N	L	S	P	N	P	N	M	S	S	P	M	M	P	L
14	L	L	P	M	S	P	S	L	S	P	S	P	S	N	S	M	N	N	N	P	L	M	M	S	N
15	P	N	L	M	P	P	L	M	S	N	P	S	L	S	N	L	S	N	M	M	S	N	S	S	P
16	S	N	S	P	N	N	P	M	S	L	S	P	M	L	M	P	P	N	L	S	L	S	S	N	M
17	S	N	P	L	M	S	S	N	P	P	M	L	S	S	S	P	M	N	P	L	N	L	M	N	S
18	S	M	S	S	S	N	S	L	L	S	P	S	M	P	P	N	M	L	P	N	M	P	N	N	L
19	P	P	N	S	L	N	P	M	M	S	N	S	S	N	L	S	L	P	M	N	P	S	M	L	S
20	L	L	M	S	N	L	S	P	P	N	L	M	P	S	P	P	S	S	N	S	N	M	S	M	N
21	L	L	N	S	S	P	L	S	N	S	M	P	S	P	S	P	M	M	S	N	N	P	L	M	N
22	P	S	N	L	S	M	S	P	M	P	M	L	N	S	N	P	S	N	N	S	S	M	L	P	L
23	P	M	L	M	N	P	N	N	S	L	P	N	N	P	L	S	L	S	S	S	S	P	M	M	S
24	S	N	S	M	S	L	N	M	N	P	S	M	S	N	S	M	S	N	L	L	P	P	P	L	P
25	S	S	P	P	M	M	S	L	N	N	M	P	N	L	P	N	S	S	S	N	L	L	S	P	M
26	N	N	N	S	L	S	M	P	S	P	M	M	L	P	P	L	M	L	S	S	P	N	S	N	S
27	L	L	S	P	S	M	P	P	L	M	L	S	M	N	S	P	N	S	S	N	N	N	M	S	P
28	L	L	N	M	M	S	P	P	S	P	P	S	M	S	N	S	N	L	S	L	N	M	N	N	S

29	P	S	L	S	M	P	L	S	M	N	S	M	N	N	S	M	L	P	S	P	L	P	N	N	S
30	S	S	M	N	M	S	N	P	L	L	P	L	M	N	S	M	S	P	N	P	S	L	N	S	P

Description:

P : Morning Shift (08.00 - 16.00)
S : Day Shift (16.00 - 00.00)
M : Middle Shift (12:00 - 20:00)
N : Night Shift (23.00 - 07.00)
L : Holiday

K3 Mart Medan uses an optimization approach to create an effective and fair employee schedule. This schedule ensures that employees do not work more than their monthly schedule. Periodically, holidays are also taken to balance the workload and health of employees. To prevent employee fatigue, the shift rotation pattern prevents them from working too many shifts, especially night shifts.

This schedule was developed using an integer linear programming approach to ensure that each shift has enough employees to meet the needs of the store, without conflicts or shortages. As a result, this schedule can increase store productivity and reduce idle time. In addition, it is a fair work schedule that shows concern for employee health. Furthermore, it is expected to provide full coverage for each shift, so that store operations can run smoothly. Nonetheless, the schedule plan should be checked periodically to ensure that the store's operational needs and employee satisfaction remain in balance. Analysis of the needs of each shift based on the store's activity pattern can be the basis for increasing the number of workers for the next scheduling.

4. CONCLUSION

In this study, the integer linear programming (ILP) method is used to optimize employee shift scheduling at K3 Mart Medan. This model considers operational constraints such as the minimum number of employees per shift, shift rotation, and equal distribution of days off. The results show that the ILP method can produce an optimal, efficient, and fair schedule scheme so that each shift can be fulfilled without experiencing difficulties.

This method not only increases store productivity but also ensures that the workload and health of employees are balanced with planned shifts and sufficient rest time. This research shows that the ILP model can be used to solve complex scheduling problems by using Dev-C++ software to process the data. In the retail sector, especially in stores that operate around the clock, the implementation of this scheduling plan really helps human resource management. However, periodic evaluation is still required to adapt the schedule to changing operational needs and ensure long-term efficiency.

5. REFERENCES

[1] S. A. Darmawan, I. Cholissodin dan T. , “Optimasi Penjadwalan Mesin dan Shift Karyawan Menggunakan Algoritme Genetika (Studi Kasus Pada PT. Petro Jordan Abadi),” *Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer,* pp. 6793-6801, 2018.

[2] M. Widyaningsih, “Optimasi Penjadwalan Jumlah Perawat Dengan Menggunakan Linear Programming,” *Jurnal Bisnis & Manajemen,* pp. 39-56, 2018.

[3] M. Syafrudin, I. Djakaria, A. R. Nuha dan D. Wungguli, “Penjadwalan karyawan Qmart Super Store menggunakan metode Goal Programming secara Preemptive dan Nonpreemptive,” *AKSIOMA: Jurnal Matematika dan Pendidikan Matematika,* pp. 328-339, 2023.

[4] A. Kusumastuti, A. M. Khoiron dan T. A. Achmadi, Metode Penelitian Kuantitatif, Yogyakarta: Penerbit Deepublish, 2020.

[5] I. M. R. Katili dan N. Achmad, “Penerapan Metode Integer Linear Programming Pada Penjadwalan Karyawan,” *Jurnal Riset dan Aplikasi Matematika (JRAM),* pp. 63-73, 2020.

[6] A. Alfian, “Model Integer Programming Untuk Mengoptimalkan Perencanaan Produksi di UKM "X",” *Jurnal Ilmiah Teknik Industri,* pp. 99-107, 2019.