Employee Scheduling Problem

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***Abstract*—This paper introduces a multiobjective programming model for automating the generation of optimized monthly shift schedules in organizations with diverse operational needs. The proposed approach considers shift coverage requirements and seniority-based workload rules to address the complexities of employee scheduling. By formulating the problem using mathematical programming techniques, the model aims to balance conflicting constraints and optimize the allocation of qualified staff to shifts. The practical implications include increased operational efficiency, improved compliance with workplace regulations, and enhanced staff satisfaction. This methodology provides a valuable tool for organizations seeking to streamline scheduling processes and achieve a harmonious balance between operational requirements and employee well-being.**

I. Introduction

Efficient staff scheduling is a ubiquitous challenge across various service-oriented industries, encompassing healthcare, aviation, hospitality, and law enforcement domains. The scheduling of personnel is a dynamic task that requires a delicate balance between the needs of employees or customers and the operational tasks at hand. The temporal dimension of scheduling further adds complexity, with schedules ranging from daily to monthly durations.

This paper focuses on the implementation of a rotation schedule method, a flexible approach particularly well-suited for fields where the workload exhibits variability. While the fixed schedule method finds its utility in predictable work environments, the rotation schedule method is instrumental in distributing the workload equitably among employees over different shifts.

II. Problem Statement

Organizations face a formidable challenge in employee scheduling, where the aim is to optimize workforce utilization while adhering to both staff-specific constraints and overarching organizational objectives. The current reliance on manual scheduling through Excel sheets often results in schedules that inadvertently violate crucial constraints. Given these constraints, the challenge lies in developing an automated system capable of generating monthly schedules that meticulously adhere to these conditions. The system must intelligently allocate staff to shifts, ensuring comprehensive coverage, adherence to weekly hour averages, and compliance with shift rotation and overtime limitations. The overarching objective is to elevate the efficiency and accuracy of the scheduling process, fostering a harmonious equilibrium between staff constraints and organizational imperatives.

The problem involves 3 distinct shifts:
(I) Morning Shift (M): 06:00–14:00
(II) Evening Shift (E): 14:00–22:00
(III) Overtime Shift (O): 12:00-20:00
The rules for scheduling taken into account can be summarized as follows:
1) Working 7 days a week necessitates a consistent workforce. A day must include two operators and 4 supervisors.
2) Each employee is obligated to work an average of 40 hours per week.
3) A minimum number of employees need to be present in both morning and evening shifts.
4) Employees commit to a consistent shift (morning or evening) for an entire week.
5) An employee cannot work the morning shift the next day if he/she works the evening shift the previous day or vice versa. 6) Overtime shifts are capped at two per employee per week.
7) Every alternate week, a shift rotation occurs, i.e. if an employee works in the morning shift this week, he/she will be working in the evening shift the next week.

Our objective is to minimize the employment cost and overtime shifts required to be done by an employee.

III. Model Formulation

This optimization model aims to efficiently schedule employee shifts over a given planning horizon while considering shift requirements, maximum working days, shift continuity, rotation constraints, and overtime limitations. The model minimizes the total costs associated with regular shifts and overtime hours, achieving an optimal allocation of shifts among employees.

A. Notations

1) i: Variation in days. Ranges from 1 to n.
2) j: Employee. Ranges from 1 to N.
3) l: Level of employee. Level 1 implies supervisor and level 2 implies operator.

4) N(l): Number of employees required each day.
5) cost_regular(l): Cost of a particular employee to work in morning or evening shift.
6) cost_overtime(l): Cost of a particular employee to work in overtime shift.
7) beta1: weightage of the first objective i.e. minimize cost.
8) beta2: weightage of the second objective i.e. minimize overtime cost.

B. Decision Variables

The used decision variables can be described as follows:
var_M(i,j,l): Binary variable indicating whether an employee j of level l is assigned a morning shift on ith day.
var_E(i,j,l): Binary variable indicating whether an employee j of level l is assigned an evening shift on ith day.
var_O(i,j,l): Binary variable indicating whether an employee j of level l is assigned an overtime shift on ith day.

C. Model Constraints

The scheduling rules have been modeled into constraints and presented in this section.
1) Each employee should work only one shift per day:

$$var_M(i,j,l) + var_E(i,j,l) + var_O(i,j,l) \leq 1 \tag{1}$$

2)There should be a Minimum number of employees of each level must be present each day. For Level 1 employees

$$\sum_{j=1}^{P} var_M(i,j,l) + var_E(i,j,l) + var_O(i,j,l) \geq 2 \tag{2}$$

For level 2 employees

$$\sum_{j=1}^{P} var_M(i,j,l) + var_E(i,j,l) + var_O(i,j,l) \geq 4 \tag{3}$$

3) An employee must work for fixed 5 days a week in regular shifts:

$$\sum_{i \in S_w} var_M(i,j,l) + var_E(i,j,l) = 5 \tag{4}$$

4) The absolute difference in the number of employees for the morning and evening shifts should not exceed 1. This constraint is written to ensure that there is even no. of distribution of no of employees between morning and evening shifts.

$$\left| \sum_{j,l} var_M(i,j,l) - \sum_{j,l} var_E(i,j,l) \right| \leq 1 \tag{5}$$

5) An employee cannot work the evening shift the next day if he/she works the morning shift the previous day.

$$var_M(i,j,l) + var_E(i+1,j,l) \leq 1 \tag{6}$$

6) An employee cannot work the morning shift the next day if he/she works the evening shift the previous day.

$$var_M(i+1,j,l) + var_E(i,j,l) \leq 1 \tag{7}$$

7) In a week, working the overtime shift must be not more than twice a week for a particular employee of level l.

$$\sum_{i \in S_w} var_O(i,j,l) \leq 2 \tag{8}$$

8) Every alternate week, a shift rotation occurs, i.e. if an employee works in the morning shift this week, he/she will be working in the evening shift the next week.

$$var_M(i,j,l) + var_M(i+7,j,l) \leq 1 \tag{9}$$

$$var_E(i,j,l) + var_E(i+7,j,l) \leq 1 \tag{10}$$

D. Objective Function

The multiobjective model minimizes the total costs associated with regular shifts and overtime hours as well as overtime shifts of employees, achieving an optimal allocation of shifts among employees.

$$Z = \beta 1 * (\sum i,j,l(var_M(i,j,l) + var_E(i,j,l)) * cost(l) + var_O(i,j,l) * cost\_overtime(l))) + \beta 2 * (\sum i,j,l var_O(i,j,l)))$$

IV. Results

The optimization model developed for employee scheduling effectively balances various constraints while minimizing costs. The results offer valuable insights and solutions for creating feasible and cost-effective schedules, promoting workforce efficiency, and minimizing overtime expenses.
Code settings:
i no of days 1*7
j employee 1*4
l level 1, 2
cost _regular(l) 1 100, 2 50
cost_overtime(l) 1 120, 2 75

		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Supervisor	E1		E	E	E	E		E
	E2	M		E	E	E		E
	E3	E		M	M		E	E
	E4		M		M	M	M	M
	E5	M	M	M	M		E	
Operator		Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
	E1	E	E	E	E		M	
	E2	E			M	M	M	M
	E3	M	M	M		M	O	M
	E4	M	M	M	M	M	O	O
	E5		E	E	E	E		M

Total No. of Employees(M):
Case-1 M = 10
Objective function value Z = 22500.000000
Case-2 M = 5
Objective function value Z = 11931.000000
Case-3 M = 4
Objective function value Z = 10816.000000
Case-4 M = 3
Infeasible solution

V. CONCLUSIONS

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If we set no. of employees to 10, Z comes out to be 22500, If we reduce it to 5, the objective function value further reduces significantly to 11931, which is primarily caused by allocating more overtime shifts and reducing the cost of an employee, If we try to reduce it to 3, the solution becomes infeasible which means that there are not enough employees to meet the requirements of an organization.

Improved Shift Management: The model provides an efficient schedule allocation, ensuring all shift requirements are met while maximizing employee availability.

Cost Reduction: By employing the optimization model, significant reductions in overall costs associated with regular shifts, overtime hours, and penalty costs were observed.

Enhanced Workforce Efficiency: Optimal schedules contribute to a more streamlined and efficient workforce, meeting operational demands while minimizing unnecessary overtime.

VI. FUTURE WORK

Future Considerations:
Refinement of Cost Parameters: Fine-tuning the cost parameters could further optimize the cost-effectiveness of the schedules.
Real-Time Implementation: Considerations for implementing this model in a real-time scheduling system could enhance operational efficiency by continually adapting to changing workforce demands.
Additional Constraints: Incorporation of further constraints or preferences, such as employee preferences, skill sets, or specific shift rotations, could refine the model to better suit specific organizational requirements.

Overall, the optimization model developed for employee scheduling presents a powerful tool for enhancing operational efficiency, reducing costs, and ensuring an optimal allocation of workforce resources.

VII. REFERENCES

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