

Heuristic Approach for Balancing Shift Schedules

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1. Introduction

In this paper, a heuristic approach for balancing shift schedules is proposed. For the shift schedules, various constraints which have usually been considered in real-world industry are used, and the objective is to minimize the differences of the workloads in each workgroup. The constraints and objective function are implemented in the proposed heuristic approach. Using a simple instance, the efficiency of the proposed heuristic approach is proved.

2. Heuristic Approach for Balancing Shift Schedules

In general, the design of shift schedule is to effectively assign each shift to a pre-defined period. Several works [1-6] on the optimal assignment of shift schedules have been performed. However, most of the works not considered the realistic constraints such as work and break times per week, a rule of shift change etc.

In this paper, therefore, we propose a heuristic approach considering several realistic constraints. First some assumptions for our heuristic approach are considered. Secondly, an objective function for considering the realistic constraints is set. Finally, a heuristic approach for effectively solving the model with the objective function and realistic constraints is proposed.

2.1 Design of Shift Schedules

Some assumptions for our heuristic approach are as follows:

- 1) Six workgroups and three shifts are considered.
- 2) Each shift is consist of M(Morning work), A(Afternoon work), N(Night work), S(Supporting work), T(Training work), and B(Break time).
- 3) Continuous works of three days for M, A, and N should be performed in each workgroup.
- 4) Continuous works of three weeks for T should be performed in each workgroup.
- 5) Shift design is scheduled during 180 days (=6 months * 30 days).

Using these assumptions, we set several constraints considered in real-world industry. The constraints are as follows:

- 1) The work times (including M, A, N, S, and T) of five days and the break times of two days should be assigned in each week.
- 2) The break times of two days should be assigned after each N shift.
- 3) The break time of a day should be assigned when the shifts (M → A and A → N) is changed.
- 4) The shift S should be assigned one time after the night work of continuous two days, that is, NN.
- 5) The breaks of continuous four days should not be appeared, that is, the NNNN does not be considered.
- 6) The back shifts such as A → M and N → A do not be considered.
- 7) Among each workgroup, a duplicated work or break should not be appeared.

The objective is to consider two factors: i) the difference of the sum of the work times (including M, A, N, S, and T) and ii) that of the break times (B) among each workgroup. The two factors should be minimized to balance the workloads in each workgroup. Therefore, they can be represented as follows:

$$\text{minimize } z = d_1 + d_2 \quad (1)$$

where d_1 : the difference of the sum of the work times in each workgroup.

d_2 : the difference of the sum of the break times in each workgroup.

In real-world industry, most of operation managers who deal with shift schedules usually regulate and control the schedules at hand, which may causes the unbalanced problem in the workloads of each workgroup. This means that the differences among the workloads of each workgroup within a pre-defined period highly depend on what character among M, A, N, S, T, and B will be assigned in the initial stage of scheduling each workgroup. For example, if for workgroup 1 the character assigned in initial stage is M, the following schedule is feasible.

$$\text{Workgroup 1: MMMBBAAABNNNBBS} \quad (2)$$

The expression (2) was designed under considering the assumptions and satisfying the constraints mentioned above.

On the other hand, if for workgroup 2 the assigned character is B, the following schedule is feasible.

$$\text{Workgroup 2: BBAAABNNNBBSMMM} \quad (3)$$

The above two feasible schedules for the workgroups 1 and 2 are assigned repeatedly during a pre-defined period. If we assume that the pre-defined period is 20 days, then the above expressions (2) and (3) can be represented to the following feasible schedules.

$$\text{Workgroup1: MMMBBAAABNNNBBSMMMMBB} \quad (4)$$

$$\text{Workgroup2: BBAAABNNNBBSMMMMBBAAA} \quad (5)$$

For the above two extended schedules, the numbers of generating M and A in expression (4) are 6 and 3, respectively, but those in expression (5) are 3 and 6, respectively. Therefore, the differences of the workload in the M and A of the expressions (4) and (5) are respectively 50%.

2.2 Proposed Heuristic Approach

To solve the unbalanced problem that can be generated in each workgroup, we propose a new heuristic approach, and its implementing procedure is as follows:

- Step 1:** Randomly generate a character among M, A, N, S, T, and B for each workgroup.
- Step 2:** As shown in expressions (4) and (5), sequentially generate the feasible schedules using the character generated in Step 1 for each workgroup.
- Step 3:** Calculate the values of the d_1 and d_2 in each workgroup, and then store the value of the Z shown in expression (1).
- Step 4:** If the current Z value obtained in Step 3 is better than the previous Z value stored, then the former replaces the latter as current value.
- Step 5:** Stop condition.
If no improvement of Z during continuous 10 iterations is done or a pre-defined iteration number is satisfied, then stop; otherwise go to Step 1.

3. Numerical Example

In numerical example, a simple instance is presented and tested to prove the efficiency of the proposed heuristic approach.

For the simple instance, we use the assumptions, constraints and objective function suggested in Section 2.1. The proposed heuristic approach is realized using Visual Basic Ver. 6.0 under IBM-PC Pentium-3 600MHz with 512Mbyte RAM.

Figure 1 partially shows the best schedules for each workgroup after the pre-defined stop condition (in our case, 100 iterations). In Figure 1, the sum of the

workloads (including M, A, N, S, and T) in the workgroups 1 and 6 is 13. That of the workloads in workgroups 2, 3, 4, and 5 is 14. This means that the workloads in each workgroup are almost same, which also implies that the sum of the breaks in each workgroup is almost same.

	Days																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	B	A	A	A	B	N	N	N	B	B	S	M	M	M	B	B	A	A	A	B
2	B	S	M	M	M	B	B	A	A	A	B	N	N	N	B	B	S	M	M	M
3	A	B	N	N	N	B	B	S	M	M	M	B	B	A	A	A	B	N	N	N
4	T	T	T	T	T	B	B	T	T	T	T	B	B	M	M	M	B	B	A	
5	M	M	B	B	A	A	A	B	N	N	N	B	B	S	T	T	T	T	B	
6	N	N	B	B	S	M	M	M	B	B	A	A	A	B	N	N	N	B	B	S

Figure 1. Best schedules for each workgroup

4. Conclusions

In this paper, we have proposed a heuristic approach for effectively balancing shift schedules. For the shift schedules, some assumptions and constraints have been considered. The objective is to minimize the differences of the workloads in each workgroup. Considering the assumptions, constraints and objective, we have proposed a heuristic approach. A simple instance has been presented to prove the efficiency of the proposed heuristic approach.

For our future study, we have a plan to consider the workload balancing problem among the workers of each workgroup and to design the balancing problem of the workers with over times in each workgroup.

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