Shift Scheduling Model Considering Workload for Housekeeping Department

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Abstract. Workforce scheduling is an important factor in operational planning for hotel industry, since it will give direct effect to service offered to customers and hotel's operational cost. This research is focus on shift scheduling for housekeeping department. The shift scheduling model has considered the physical workload in form of rating of perceived exertion (RPE) Borg's Scale, and psychosocial workload has been considered in form of worker's preference. The mathematical model for the shift scheduling has been built in goal programming model. Evaluation of the developed shift scheduling model shows that the resulting schedule balances the physical workload which also level shift allocation among workers, decrease violations of forward rotation shift allocation and consecutive night shift, also consider worker's preference. The model results global optimal solution for simple problem and feasible solution for complex problem with tight constraints. The model can be applied generally for housekeeping department as long as in the same applied management rules.

Keywords: workforce scheduling, workload, workers' preference, goal programming

1. INTRODUCTION

One of the factors that impose the hotel's quality is its rooms condition, since rooms are the main service offered by hotel industry. Hotel's rooms have to be always in a clean and tidy condition. And it highly depend on human resource that usually organized in housekeeping department. As in most departments in hotel industry, workforce requirement for housekeeping department depend on the occupancy rate, it could be vary in time. Since housekeeping department generally operates for more than 8 hours, it apply shift system to organize its workers. The shift scheduling become important part of operational planning for hotel industry because it has to manage the workers for satisfiying workers requirement and maintaining workers' performance in the same time. For the hotel management, the workers assignment in shift scheduling will give significant effect on operational cost (Ernst *et al.*, 2004; Li *et al.*, 2012), because it will impose to payroll. And for the workers itself, shift scheduling pattern will influence the workers' performance (Chiang *et al.*, 2010; Puttonen *et al*, 2010; Lee *et al.*, 2011). Because the shift allocation for workers will influnce the balance between working time and social time. So that, shift shceduling development have to consider paramaters that will give effect to worker's work-life balance, besides the management rules and policies.

The objective of this research is to develop workload-based shift scheduling model for housekeeping department. The considered workload in this research is physical workload and psychosocial workload. Physical workload represents physical job performed by housekeeping department workers, and psychosocial workload represents individual worker relation with their job and environment (Green & Taylor, 2008) for considering the work-life balance. Previous researches have been conducted by Purnama & Yuniartha (2014), Dewi *et al*. (2014), and Yuniartha *et al*. (2015) to identify the shift scheduling parameters, workload level, and its relation.

Purnama & Yuniartha (2014) have identified the shift scheduling parameters of hotels in Daerah Istimewa Yogyakarta Province for housekeeping department, Front Office Department, and Security Department. Daerah Istimewa Yogyakarta Province is one of famous tourism destination in Indonesia, so that tourism is one of mainstay industry. Annual publication of Welfare Indicators 2013 published by BPS-Statistics of Daerah Istimewa Yogyakarta Province has reported that trade, restaurant, and hotel sector is in the second rank of workforce absorption, after agriculture sector and followed by service sector. The statistical data has also reported significant increasing index of foreign tourist stayed in hotel compare to previous year (BPS-Statistics of Daerah Istimewa Yogyakarta Province, 2014). Purnama and Yuniartha (2014) have found weaknesses of applied shift scheduling by 20 observed hotels, i.e. long working hours, short hours in between-shift, and night shift in consecutive days. Many researches have found that weaknesses may give negative effect for workers' health, as reported in Antunes *et al*. (2010), Chen *et al*. (2010), Esquirol *et al*. (2011), Eldevik *et al*. (2013), Di Milia *et al*. (2013), Pimenta *et al*. (2013), Haus & Smolensky (2013).

For the same observed hotels, Dewi *et al*. (2014) have analysis workers' physical and psychosocial workload. Dewi *et al*. (2014) have found that physical and psychosocial workload in different shifts and hotels are not significant different in value. Furthermore, Yuniartha *et al*. (2015) have identified relation between measured workload, i.e. physical and psychosocial, in Dewi *et al*. (2014) and shift scheduling pattern in Purnama and Yuniartha (2014). Yuniartha *et al*. (2015) have shown that there is no direct influence of shift scheduling pattern to its physical and psychosocial workload. However, Dewi *et al*. (2014) have also shown that some of observed hotels are in moderate level of psychosocial workload, and it may indicate workers dissatisfaction. Lee *et al*. (2011) have found that workers satisfaction is influenced by their schedule flexibility to accommodate their individual and social requirement. So that the development of shift scheduling in this research will consider the parameters relate to workers' work-life balance and eliminates the weaknesses found in Purnama and Yuniartha (2014).

Shift scheduling researches considering parameters relate to workers' work-life balance have been conducted. Topaloglu & Selim (2010) and Eradipa *at al*. (2014) have considered work-stretch and off-day pattern parameter in their shift scheduling models. Work-stretch is consecutive work days before worker receive off-day and mostly determined as management rule to manage the workers requirement and workers' social life. Azaiez & Sharif (2005) and Eradipa *et al*. (2014) have developed shift scheduling considering worker references to accommodate schedule flexibility. Minimum consecutive night shift allocation as a constraint in shift scheduling model has been considered in Topaloglu & Selim (2010), to eliminate excess consecutive night shift. The effect of shift rotation direction to worker's psychological health and work-family conflict has been investigated by Amelsvoort *et al*. (2004). It has been found that forward shift rotation is preferable because give longer hours in between-shift. Workforce schedule under arrangement of shift allocation considering workload balance has been conducted by Dewi & Septiana (2015). In this workforce scheduling model, physical workload is used to determine maximum number of worker allocation and mental workload is balanced as a constraint to arrange the shift allocation for workers.

The shift scheduling model development in this research is based on shift scheduling parameters for housekeeping department in Purnama & Yuniartha (2014), to eliminate weaknesses of applied shift scheduling. The developed shift scheduling model will consider psychosocial workload in form of workers' preference to accommodate schedule flexibility satisfaction. The physical workload will be balanced as a constraint of the model in order to arrange shift allocation. The physical workload data used is data in Dewi *et al*. (2014) using rating of perceived exertion (RPE) Borg's Scale, i.e. conversion from measured workers' heart rate before and after perform a task.

2. SHFT SCHEDULING MODEL

The shift scheduling mathematic model has been developed for 3 shifts scenario using goal programming method. Goal programming method has 2 constraints, i.e. hard and soft constraint. The hard constraints have to be satisfied and the soft constraints may be violated (Azaiez & Sharif, 2005). The hard constrains relate to management rules for satisfying the worker requirement, shift allocation, off-day allocation, and distinctive shift for supervisor or female worker. Shift scheduling parameters in Purnama & Yuniartha (2014) have shown that there is distinctive policy for supervisor or female worker, i.e. they are could not be assigned in night shift. The soft constraints relate to minimize backward rotation of shift allocation and consecutive night shift. Worker could request for day-off or shift allocation on certain day, and it could be considered as hard constraint or soft constraint according to worker's preference. The objective function of the shift scheduling model is to minimize deviation of soft constraint. The mathematic model development has referred to Azaiez & Sharif (2005), Topaloglu & Selim (2010), Eradipa *at al*. (2014), and Dewi & Septiana (2015).

Notations, parameters, and variables:

i : index for worker, $i = 1, 2, \ldots, I$
j : index for day, $j = 1, 2, \ldots, m$
k : index for shift, $k = 1, 2, \ldots, s$
N : number of available workers
m : number of days to be scheduled
s : number of shifts in one day
w : total off-day during m days
R_{jk} : minimum number of workers on day j shift k
r : minimum consecutive working days before off-day, $r = 4, 5$, or 6
q : maximum consecutive night shift, $q = 2$ or 3

t : distinctive shift for supervisor or female worker

Z_k : RPE scale in shift k

$d1_{ij}$: deviation of first soft constraint; 1 if worker i assigned in shift 2 day j and shift 1 day j+1, 0 otherwise

$d2_{ij}$: deviation of second soft constraint; 1 if worker i assigned in shift 3 day j and shift 2 day j+1, 0 otherwise

$d3_{ij}$: deviation of third soft constraint; 1 if worker i assigned in shift s for 3 consecutive days, 0 otherwise

$d4_{ij}$: deviation of day-off preference; 0 if worker i has day-off on day j as his/her preference, 1 otherwise

$d5_{ij}$: deviation of shift preference; 0 if worker i assigned in shift k day j as his/her preference, 1 otherwise

ni, pi : deviation of RPE scale of worker i (E_i) to average RPE of all workers ($\bar{E}$)

Objective function

$$Min \sum_{i=1}^{n}\sum_{j=1}^{m} d1_{ij} + d2_{ij} + d3_{ij} + d4_{ij} + d5_{ij} + n_i + p_i \quad (1)$$

Hard constraint

Minimum worker on day j shift k

$$\sum_{i=1}^{n} X_{ijk} \geq R_{jk} \quad \text{for } \forall\text{jk} \quad (2)$$

Worker i will be assigned for only one shift or get off-day on day j

$$\sum_{k=1}^{s} X_{ijk} \leq 1 \quad \text{for } \forall\text{ij} \quad (3)$$

Worker who is assigned in night shift (k = 3) on day j could not be assigned in morning shift (k = 1) on day j+1

$$X_{ij3} + X_{i(j+1)1} \leq 1 \quad \text{for } \forall\text{ij} \quad (4)$$

Worker will have (m-w) working days

$$\sum_{j=1}^{m}\sum_{k=1}^{s} X_{ijk} = m - w \quad \text{for } \forall\text{i} \quad (5)$$

Worker will have r consecutive working days before get off-day

$$\sum_{k=1}^{s}\left(X_{ijk} + X_{i(j+1)k} + \cdots + X_{i(j+r)k}\right) \geq r \quad \text{for } \forall\text{ij} \quad (6)$$

Distinctive policy for supervisor or female worker

$$\sum_{j=1}^{m}\sum_{k=1}^{t} X_{ijk} = m - w \quad \text{for } \exists\text{i} \quad (7)$$

Soft constraints

Minimizing worker who is assigned in shift 2 on day j will be assigned in shift 1 on day j+1

$$X_{ij2} + X_{i(j+1)1} - d1_{ij} \leq 1 \quad \text{for } \forall\text{ij} \quad (8)$$

Minimizing worker who is assigned in shift 3 on day j will be assigned in shift 2 on day j+1

$$X_{ij3} + X_{i(j+1)2} - d2_{ij} \leq 1 \quad \text{for } \forall\text{ij} \quad (9)$$

Minimizing worker who is assigned in q consecutive night shift

$$X_{ij3} + X_{i(j+1)3} + \cdots + X_{i(j+q-1)3} - d2_{ij} \leq (q-1) \text{for } \forall\text{ij} \quad (10)$$

Physical workload balancing

Total physical workload of worker during m days

$$\sum_{j=1}^{m}\sum_{k=1}^{s} X_{ijk} \cdot Z_k = E_i \quad \text{for } \forall\text{i} \quad (11)$$

Average physical workload of all workers

$$\frac{\sum E_i}{N} = \bar{X} \quad (12)$$

Balancing of physical workload among workers

$$E_i - \bar{X} + n_i - p_i = 0 \quad \text{for } \forall\text{i} \quad (13)$$

$$n_i, p_i \leq 1 \quad \text{for } \forall\text{i} \quad (14)$$

Workers' preferences for proposing off-day on certain day

Hard constraint

$$\sum_{k=1}^{s} X_{ijk} = 0 \quad \text{for } \exists\text{ij} \quad (15)$$

Soft constraint

$$\sum_{k=1}^{s} X_{ijk} - d4_{ij} = 1 \quad \text{for } \exists\text{ij} \quad (16)$$

Worker's preferences for proposing shift assignment on certain day

Hard constraint

$$X_{ijk} = 1 \quad \text{for } \exists\text{ijk} \quad (17)$$

Soft constraint

$$X_{ijk} + d5_{ij} = 1 \quad \text{for } \exists\text{ijk} \quad (18)$$

3. MODEL EVALUATION AND DISCUSSION

Evaluation of the developed shift scheduling model has been conducted using shift scheduling parameter data in Purnama & Yuniartha (2014) to test the solution. The developed model results better schedule compare to actual applied schedule. The resulting schedule could reduce violations of forward rotation shift allocation and maximum consecutive night shift. The resulting schedule also could consider worker's preference, i.e. request for day-off or shift allocation on certain day. Solution of the developed model has been also tested using data in Eradipa *et al*. (2014). The developed model results better solution compare to solution in Eradipa *et al*. (2014). There are 2 violations in Eradipa *et al*. (2014) that can be eliminated. The developed model could result global optimal solution for simple problem but problem with more tight constraint needs more computation time and results feasible solution.

The evaluation of developed model is also performed to identify model behavior by modifying some parameters, i.e. maximum consecutive night shift, minimum consecutive working day before off-day, physical workload (RPE scale value), and number of available workers. Value of maximum consecutive night shift parameter could vary from 1 to 3. Problem with maximum consecutive night shift equal to 3 results better objective function, tend to 0. For problem with limited number of available workers, less than 6, the objective function will not equal to zero, means that there are violations for maximum consecutive night shift parameter. This violation is to satisfy minimum number of workers in night shift. It indicates that minimizing the worker assigned in consecutive night shift is restricted by number of available workers and minimum number of workers in night shift.

For satisfying the physical workload balancing constraint, the model will level shift allocation among workers. The total number of shift allocation for each worker will be equally. When the physical workload of each shift is equal to 0 or equal among shifts, the model results unequally shift allocation among shift. It is because the model will give more priority to satisfy forward rotation shift allocation. By balancing the physical workload, the model could give equally shift allocation among workers. It will avoid jealously between workers and could increase worker satisfaction to their schedule.

Value of minimum consecutive working days before off-day parameter could vary from 4 to 6, with scheduling period vary from one week (7 days) to one month (28 or 31 days). For minimum consecutive working days before off-day parameter is less than 6, the resulting schedule may give some workers with consecutive working days before off-day greater than the setting parameter. The model will balance the physical workload by leveling shift allocation among workers so that off-day arrangement is restricted by minimum number of required workers in certain shift, and result some workers with longer consecutive working days.

As already known, increasing number of available workers will increase number of parameter and variables so that increasing computational time to search the solution. Increasing number of available workers could not be guarantee will result better solution. Increasing number available workers certainly will results better objective function because the soft constraint of forward rotation shift allocation and maximum consecutive night shift could be more satisfied as shown in Table 1. However, there is no significant different in shift allocation as shown in Table 2. Table 2 shows increasing number of workers will decrease shift 1 allocation but increase shift 2 and 3 allocation to minimize backward rotation shift allocation. But when number of worker continues to increase, there is increasing of shift 1 allocation as well as shift 2 and 3 allocation. It means that workers requirement in each shift is already satisfied by recently number of available workers so that increasing number of workers will result excess workers assigned in certain shift.

Table 1: Effect of Increasing Workers to Objective Function

Hotel	Number of Workers	Objective Function
B	6	14
	7	9
	8	5

Table 2: Effect of Increasing Workers to Shift Allocation

Hotel	Number of Workers	Shift Allocation for Each Worker	
		Shift 1	Shift 2&3
A	5	11	12
	6	10	13
	7	10	13
B	6	9	15
	7	8	16
	8	10	14

4. CONCLUSION AND FUTURE RESEARCH

Evaluation of the developed shift scheduling model shows that the model results better schedule compare to actual applied schedule in Purnama & Yuniartha (2014) and schedule resulted in Eradipa *et al*. (2014). The resulted schedule can decrease violations of forward rotation shift allocation and consecutive night shift, also consider workers' preference in requesting day-off and shift allocation in certain day. Physical workload balancing constraint in the developed model can give equally shift allocation among workers which can increase worker satisfaction to their schedule. The developed model can result global optimal solution for simple problem and feasible solution for problem with more tight constraint.

Increasing number of available workers will decrease violations of forward rotation shift allocation, but also can conduce excess workers assigned in certain shift. And it will affect to operational cost for payroll. So that considering number of workers as decision variables is future research is suggested. Shift scheduling for other department in hotel industry is under consideration.

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