Scheduling

Notes 11

Cost Analysis in Flow Shop Scheduling Problems

- In its most general form, the costs can be listed as follows:

- -Operation cost
- -Job Waiting cost
- -Machine idle cost
- - Penalty cost

Operation Cost

- For any job i,

- α_i= Operation cost of job i
- P_{ik}=Processing time of job i that is independent of the sequence
- H_{ik}=Processing cost of the machine k the job i (speed)
- h_{ik}= Unit set-up cost of machine k
- S_{jik}= Job j comes before job i and set-up time of the machine k for the job i.

Operation Cost

- $\alpha_i = \sum_{k=1}^{m}(P_{ik}\ H_{ik} + h_{ik}s_{jik})$
- For a sequence of ‘‘S’’ that contains n jobs,
- $\propto_{(S)} = \sum_{i=1}^{n}\sum_{k=1}^{m} P_{ik}\ H_{ik} + \sum_{i=1}^{n}\sum_{k=1}^{m} h_{ik}\ S_{jik}$

- $\sum_{i=1}^{n}\sum_{k=1}^{m} P_{ik}\ H_{ik}$ is fixed and independent of the sequence.
- $\alpha(S) = \sum_{i=1}^{n}\sum_{k=1}^{m} h_{ik}\ S_{jik}$ is dependent on the sequence and can be written in the total cost function.

Job Waiting Cost

- This cost can be considered as the cost of work in process jobs.
- C_i= Raw material cost of the job i
- V_{ik}= Vik is the added value to the job i by the machine k
- The value of the job i on machine k is:
- $C'_{ik} = C_i + \sum_{L=1}^{k-1} V_{iL}$

Job Waiting

- r= Expected return for this invested capital.
- y_{ik}= the waiting time of job i in front of machine k

- Waiting cost of job i is:
- $\beta_i = \sum_{k=1}^{m} r(C_i + \sum_{L=1}^{k-1} V_L)y_{ik}$

- For a sequence of ‘’S’’ that contains n jobs,
- $\beta_{(S)} = \sum_{i=1}^{n} \sum_{k=1}^{m} r(C_i + \sum_{L=1}^{k-1} V_L)y_{ik}$

Job Waiting Cost

- $W_{ik} = r(C_i + \sum_{L=1}^{k-1} V_L)$
- $\beta_{(S)} = \sum_{i=1}^{n} \sum_{k=1}^{m} y_{ik} W_{ik}$

- yi1= 0

Machine Idle Cost

- X_{ik}= The idle time on machine k before job i starts processing
- r_k= Net loss of the rate of return machine k
- Machine idle cost for machine k is:
- $\gamma_k = \sum_{i=1}^{n} X_{ik} r_k$

- For a sequence of “S”,
- $\gamma(S) = \sum_{i=1}^{n} \sum_{k=1}^{k} X_{ik} r_k$

Penalty Cost

- This cost occurs when the previously agreed deadlines are not met.
- Apart from that, the loss of the image of the company or extra costs for express orders can be considered as penalty costs. But it is difficult to calculate these types of cost, so we take lateness of jobs as penalty cost.

- di= due date of the job i
- T_i = max{0,L_i}= Tardiness of job i.
- Penalty cost of job i:
- $\delta_i = p_i T_i$
- For a sequence of ‘’S’’
- $\delta(S) = \sum_{i=1}^{n} p_i T_i$

Total Cost

- TC(S)= α(s)+β(s)+γ(S)+δ(S)

$$=\sum_{i=1}^{n}[\sum_{k=1}^{m}\left(h_{ik}S_{jik}+y_{ik}W_{ik}+r_{k}X_{ik}\right)+p_{i}T_{i}]$$

Workforce Scheduling

- Workforce management deals in the process of balancing the allocated work by the available resources to complete the work. Generally, service organizations face varying demand, which is very difficult to manage with demand management strategies. In such cases workforce scheduling or rostering can be performed to allocate right size of resources against varying demand. Determining right size of resources are always a challenge because hiring or staffing too many people during low demand hours or days of a week may increase cost of operation, whereas hiring or staffing too low number of employees during high demand my impact the service quality or target service levels. Work shift scheduling helps in finding employee shift arrangements to match a time varying demand for a service.

Workforce Scheduling

- A service organization needs to schedule employees where organization works for seven days a week and provides each employee two consecutive days off. Services are available 24 hours of the day and 7 days of week round the year. The organization wants to minimize the total number of employees or to minimize the total slack capacity. At the same time based on the predicted demand each day requires minimum number of employees. As per rules, each employee wants two consecutive days off from work not necessarily weekend.

Workforce Scheduling

- Tibrewala, Philippe, and Brown developed a technique for scheduling a seven day operation giving each employee two consecutive days off.
- Step 1: Find out the minimum number of employees needed for each day of the week
- Step 2: Given the above requirements, calculate the number of employees needed for each pair of consecutive days
- Step 3: Find the pair of days with the lowest total needed

- Step 4: Update the number of employees you still need to schedule for each day
- Step 5: Using the updated staffing needs, repeat steps 2 through 4 until you have satisfied all needs

Example

- This example shows how a staff of six people can be scheduled.

(1) Day of the week	M	T	W	Th	F	Sa	Su
Number of staff needed	4	5	5	3	5	2	3

Solution

Given the above requirements, calculate the number of employees needed for each pair of consecutive days.

(1) Pair of Consecutive Days	Total of Staff needed
Monday & Tuesday	9 employees
Tuesday & Wednesday	10 employees
Wednesday & Thursday	8 employees
Thursday & Friday	8 employees
Friday & Saturday	7 employees
Saturday & Sunday	5 employees

- Find the pair of days with the lowest total needed.
- Assign the first employee to the lowest total needed consecutive days off.
- Update the number of employees you still need to schedule for each day.

(2) Day of the week	M	T	W	Th	F	Sa	Su
Number of staff needed	3	4	4	2	4	2	3

(2) Pair of Consecutive Days	Total of Staff needed
Monday & Tuesday	7 employees
Tuesday & Wednesday	8 employees
Wednesday & Thursday	6 employees
Thursday & Friday	6 employees
Friday & Saturday	6 employees
Saturday & Sunday	5 employees

(3) Day of the week	M	T	W	Th	F	Sa	Su
Number of staff needed	2	3	3	1	3	2	3

(3) Pair of Consecutive Days	Total of Staff needed
Monday & Tuesday	5 employees
Tuesday & Wednesday	6 employees
Wednesday & Thursday	4 employees
Thursday & Friday	4 employees
Friday & Saturday	5 employees
Saturday & Sunday	5 employees

(4) Day of the week	M	T	W	Th	F	Sa	Su
Number of staff needed	1	2	3	1	2	1	2

(4) Pair of Consecutive Days	Total of Staff needed
Monday & Tuesday	3 employees
Tuesday & Wednesday	5 employees
Wednesday & Thursday	4 employees
Thursday & Friday	3 employees
Friday & Saturday	3 employees
Saturday & Sunday	3 employees

(5) Day of the week	M	T	W	Th	F	Sa	Su
Number of staff needed	0	1	2	0	1	1	2

(5) Pair of Consecutive Days	Total of Staff needed
Monday & Tuesday	1 employees
Tuesday & Wednesday	3 employees
Wednesday & Thursday	2 employees
Thursday & Friday	1 employees
Friday & Saturday	2 employees
Saturday & Sunday	3 employees

(6) Day of the week	M	T	W	Th	F	Sa	Su
Number of staff needed	0	1	1	0	0	0	1

(6) Pair of Consecutive Days	Total of Staff needed
Monday & Tuesday	1 employees
Tuesday & Wednesday	2 employees
Wednesday & Thursday	1 employees
Thursday & Friday	0 employees
Friday & Saturday	0 employees
Saturday & Sunday	1 employees

(7) Day of the week	M	T	W	Th	F	Sa	Su
Number of staff needed	0	0	0	0	0	0	0

Employees	M	T	W	Th	F	Sa	Su
1	x	x	x	x	x	off	off
2	x	x	x	x	x	off	off
3	x	x	off	off	x	x	x
4	x	x	x	x	x	off	off
5	off	off	x	x	x	x	x
6	x	x	x	x	off	off	x

- This technique gives a work schedule for each employee to satisfy minimum daily staffing requirements.

Resources

- www.csus.edu/indiv/b/blakeh/mgmt/documents/opm101chapter15_000.ppt
- http://zoomin.idt.mdh.se/course/KPP227/Documents/LE9_Scheduling.pdf
- http://nptel.ac.in/courses/110106046/Module%208/Lecture%203.pdf
- http://www.math.harvard.edu/archive/20_spring_05/handouts/assignment_overheads.pdf
- Gupta, J.N.D., ECONOMIC ASPECTS OF PRODUCTION SCHEDULING SYSTEMS, J. Operations Research Soc. of Japal1 Vo!. 13, No. 4, March 1971.
- Sıralama ve Programlama, Hüseyin Başlıgil
- Çizelgeleme Ders Notları, Prof. Dr. Hüseyin Başlıgil