ISSN: 2278 – 1323
International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)
Volume 1, Issue 7, September 2012

Branch and Bound Technique To Two Stage Flow Shop Scheduling Problem In Which Setup Time is Separated From Processing Time And Both Are Associated With Probabilities

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Abstract—: **This paper presents an algorithm with the help of branch and bound approach for a flow shop scheduling problems consisting of n jobs to be processed on 2 machines in which setup time is separated from processing time and both are associated with probabilities.**

Index Terms—. **Processing time ,Elapsed time, Branch and Bound ,Setup time**

I. Introduction

: Scheduling problems are common occurrence in our daily life e.g. ordering of jobs for processing in a manufacturing plant, programs to be run in a sequence at a computer center etc. Such problems exist whenever there is an alternative choice in which a number of jobs can be done. Now-a-days, the decision makers for the manufacturing plant have interest to find a way to successfully manage resources in order to produce products in the most efficient way. They need to design a production schedule to minimize the flow time of a product. The optimal solution for the problem is to find the optimal or near optimal sequence of jobs on each machine in order to minimize the total elapsed time.Johnson (1954) first of all gave a method to minimise the makespan for n-job, two-machine scheduling problems. The scheduling problem practically depends upon the important factors namely, Transportation time, break down effect, Relative importance of a job over another job etc. These concepts were separately studied by Ignall and Scharge (1965),Maggu and Dass (1981), Temiz and Erol(2004),Yoshida and Hitomi (1979), Lomnicki (1965), Palmer (1965) , Bestwick and Hastings (1976), Nawaz et al. (1983) , Sarin and Lefoka (1993) , Koulamas (1998) , Dannenbring (1977) , etc.Further we are using branch and bound technique to minimize the total elapsed time in which setup time is separated from processing time.

Manuscript received June, 2012.

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II. Practical Situation

Many applied and experimental situations exist in our day-to-day working in factories and industrial production concerns etc. In many manufacturing companies different jobs are processed on various machines. These jobs are required to process in a machine shop A, B, C, ---- in a specified order. When the machines on which jobs are to be processed are planted at different places, the transportation time (which includes loading time, moving time and unloading time etc.) has a significant role in production concern. The break down of the machines (due to delay in material,changes in release and tails date, tool unavailability, failure of electric current, the shift pattern of the facility, fluctuation in processing times, some technical interruption etc.) have significant role in the production concern

III. Notations

S : Sequence of jobs 1, 2, 3,….,n
S_k :Sequence obtained by applying Johnson's procedure, k = 1, 2, 3, ------ r.
M_j : Machine j= 1,2,
a_{ij} : Processing time of i^{th} job on machine M_j
p_{ij} : Probability associated to the Processing time a_{ij}
A_{ij}: Expected processing time.
S_{ij} : Set up time of ^{ith} job on machine M_j.
q_{ij} : Probability associated to the set up time a_{ij}
S_{ij} : Expected set up time of i^{th} job on machine M_j
$t_{ij}(S_k)$: Completion time of i^{th} job of sequence S_k on machine M_j

IV. PROBLEM FORMULATION

Let n jobs 1,2,……..,n be processed on three machines M_1, M_2 and M_3 in a way such that no passing is allowed. Let a_{ij} be the processing time of i^{th} job o n j^{th} machine with probabilities p_{ij} and s_{ij} be the set up time of i^{th} job on j^{th} machine with probabilities q_{ij}. Let A_{ij} be the expected processing time and S_{ij} be the expected set up time of i^{th} job on j^{th} machine.
Also consider the following structural relation.
either Min $(A_{i1} – S_{i2}) \geq$ max $(A_{i2} – S_{i1})$
or Max $(A_{i3} – S_{i2}) \geq$ max $(A_{i2} – S_{i3})$ or both.

THE MATHEMATICAL MODEL OF THE PROBLEM IN MATRIX FORM CAN BE STATED AS:

Jobs	Machine M_1				Machine M_2				Machine M_3			
I	a_{i1}	p_{i1}	s_{i1}	q_{i1}	a_{i2}	p_{i2}	s_{i2}	q_{i2}	a_{i3}	p_{i3}	s_{i3}	q_{i3}
1	A_{11}	p_{11}	s_{11}	q_{11}	a_{21}	p_{21}	s_{21}	q_{21}	a_{31}	p_{31}	s_{31}	q_{31}
2	A_{12}	p_{12}	s_{12}	q_{12}	a_{22}	p_{22}	s_{22}	q_{22}	a_{32}	p_{32}	s_{32}	q_{32}
3	A_{13}	p_{13}	s_{13}	q_{13}	a_{23}	p_{23}	s_{23}	q_{23}	a_{33}	p_{33}	s_{33}	q_{33}
-	-	-	-	-	-	-	-	-	-	-	-	-
n	A_{1n}	p_{1n}	s_{1n}	q_{1n}	a_{n2}	p_{n2}	s_{n2}	q_{n2}	a_{n3}	p_{n3}	s_{n3}	q_{n3}

Step 2:
Calculate the lower bounds using the following formula

(i) $l_1 = t(j_r,1) + \sum_{i \in j_r^i} G_i + \min_{i \in j_r^i}(H_i)$

(ii) $l_2 = t(j_r,2) + \sum_{i \in j_r^i} H_i$

Step 3:
Calculate $l = \max(l_1, l_2)$

Step 4:
We evaluate l first for the n classes of permutations, i.e. for these starting with 1, 2, 3………n respectively, having labelled the appropriate vertices of the scheduling tree by these values.

Step 5:
Now explore the vertex with lowest label. Evaluate l for the (n-1) subclasses starting with this vertex and again concentrate on the lowest label vertex. Continuing this way, until we reach at the end of the tree represented by two single permutations, for which we evaluate the total work duration. Thus we get the optimal schedule of the jobs.

Step 6: Prepare in-out table for the optimal sequence obtained in step 3 and get the minimum total elapsed time.

V. NUMERICAL ILLUSTRATION :

let 4 jobs are to be processed on two machines in which processing time and setting times are given with their respectative probabilities

Jobs	Machine M_1				Machine M_2			
i	A_i	p_i	s_i^a	r_i	B_I	Q_i	S_i^b	s_i
1	4	.2	2	.2	6	.1	3	.2
2	6	.5	3	.3	4	.2	2	.2
3	5	.1	1	.3	3	.3	3	.2
4	3	.2	2	.2	5	.4	2	.4

Our objective the total elapsed time.

Solution:

Step1.define expected time

JOBS	MACHINE A	MACHINE B
	A_i	B_i
1	.5	.2
2	1.4	-.1
3	-.1	.8
4	-.2	.6

Step2: $l_1 = t(j_r,1) + \sum_{i \in j_r^i} G_i + \min_{i \in j_r^i}(H_i)$

$l_2 = t(j_r,2) + \sum_{i \in j_r^i} H_i$

Step 3 and **Step 4**:
We have LB(1) = 2,LB(2)= 2.9, LB(3) = 1.4, LB(4) = 1.5
step 5:LB(3,1) = 1.5 , LB(3,2) = 2, LB(3,3) = 1.5 , LB(321)= 3.2 , LB(324) = 2.4
therefore, sequence is S :(3,2,4,1)

Step 6:

JOBS	MACHINE A	MACHINE B
	IN -OUT	IN -OUT
3	0-0.5	0.5-1.1
2	0.9-1.8	1.8-2.6
4	2.7-3.3	3.3-4.3
1	3.7-7.7	7.7-8.3

So .total elapsed time is 8.3

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ISSN: 2278 – 1323
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Volume 1, Issue 7, September 2012

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