Research Journal of Mathematical and Statistical Sciences _____ ISSN 2320-6047
Vol. **5(5),** 9-13, May **(2017)** *Res. J. Mathematical and Statistical Sci.*

Job sequencing problem using deviation technique

Anita B. Watekar
Department of Mathematics, Abasaheb Garware College, Pune-411004, MS, India
anita7783@gmail.com

Available online at: www.isca.in, www.isca.me
Received 8th March 2017, revised 28th April 2017, accepted 11th May 2017

Abstract

The job sequencing technique is used to find the sequence of jobs which minimizes total time required to process the jobs on various machines. In this paper we have proposed Deviation Technique to solve job sequencing problem. We have given examples to illustrate the use of method for sequencing of n jobs on two machines, sequencing of n jobs on three machines and sequencing of n jobs on m machines.

Keywords: Job sequencing problem, Processing time, Johnson's Algorithm, Deviation, Total elapsed time, idle time.

Introduction

Job sequencing problem has important applications in Computer Science and real world. In day to day life we come across the situation where one needs to save the time required for processing the products on different machines. Job sequencing plays an important role to find optimal job sequence to reduce the total time required when different products are processed on more than two machines. Job sequencing problem is to find the sequence of jobs which minimizes the time required for completing all the jobs. In general $(n!)^m$ different choices of job sequences[1] are possible when we want to process n jobs on m machines. Hence it need more time for calculations. In this case the sequencing technique becomes very effective as it reduces calculation work and time. There are many algorithms[2,4,5] proposed for job sequencing problem. Johnson's algorithm is most commonly used for job sequencing but it has restricted application for n jobs m machines problem.

Definitions

Definition 1: (Processing time) Processing time is the time required for a job to process on a particular machine.

Definition 2: (Total Elapsed time) Total elapsed time is the total time required to complete the jobs from start of first job to end of last job in a sequence.

Definition 3: (Idle time) Idle time is the time when there is no job to process on a machine. i.e. it is the time for which the machine remains free.

Assumptions of sequencing problem[6]

Times required to process jobs on each machine are previously known and they are independent on the order in which jobs are to be processed on the machines. The time required for a job to move from a particular machine to other machine is negligible. We can start new job on a machine only after finishing current job on that machine. At any time only one job can process on a machine. The order of completion of jobs is independent of the sequence of jobs.

No passing rule means passing is not allowed i.e. When the processing order of jobs is M1M2 then it must go on machine M1 first then on machine M2.

Deviation Technique to solve job sequencing problem:

We illustrate the method in three types.

Type I Sequencing n jobs on two machines:

Suppose we want to process n jobs on two machines M1 and M2 in order M1M2.

Step 1: Find row deviation for each row. Row deviation is the difference between times in corresponding cells to the minimum time in that row. Similarly find column deviation for each column. Column deviation is the difference between times in corresponding cells to the minimum time in that column.

Step 2: Consider cell for which both deviations are zero, corresponding job is 'k' say. Assign this job k as follows: i. If it is zero on machine M1 place it to the left side of our sequence after the previously assigned jobs. ii. If it is zero on machine M2 place it to the right side of our sequence before the previously assigned jobs. iii. If there is a tie for zero deviation on machine M1 then assign smallest subscript job first. If there is a tie for zero deviation on machine M2 then assign largest subscript job first.

If there is a tie for zero deviation on machine M1 and M2 then assign job on machine M1 on left side and job on machine M2 on right side.

Step 3: Delete the assigned job and repeat the procedure on remaining jobs until all jobs get placed.

Step 4: Calculate the total time require to process all the jobs in a sequence which is total elapsed time and the time for which machines remains free.

Example:

Jobs / Machines	1	2	3	4	5
M1	5	1	9	3	10
M2	2	6	7	8	4

First calculate deviation for each job.

Jobs / Machines	1	2	3	4	5
M1	5 (4, 3)	1 (0, 0)	9 (8, 2)	3 (2, 0)	10 (9, 6)
M2	2 (0, 0)	6 (4, 5)	7 (5, 0)	8 (6, 5)	4 (2, 0)

For job 1 both deviations are zero and it is on machine M2. We place job 1 to right side of our sequence. For job 2 both deviations are zero on Machine M1. We place job 2 to left side of our sequence as follows

2				1

Delete jobs 1 and 2 from our list. The reduced table for remaining jobs and its deviation is given as follows:

Jobs / Machines	3	4	5
M1	9 (6, 2)	3 (0, 0)	10 (7, 6)
M2	7 (3, 0)	8 (4, 5)	4 (0, 0)

For job 4 both deviations are zero and it is on machine M1. We place job 4 to left side of our sequence after job 2. For job 5 both deviations are zero on machine M2. We place job 5 to right side of our sequence before job 1 as follows:

2	4		5	1

Delete assigned jobs 4 and 5. Only one job remains we place it at remaining position in our sequence. The required job sequence is

2	4	3	5	1

Calculate the time required to process this sequence of jobs.

Machines	M1		M2	
Jobs	In time	Out time	In time	Out time
2	0	1	1	7
4	1	4	7	15
3	4	13	15	22
5	13	23	23	27
1	23	28	28	30

Total elapsed time = 30, For machine M1, idle time = 2, For machine M2, Idle time = 3

Type II: Sequencing n jobs on three machines:

Suppose we want to process n jobs on three machines M1, M2 and M3 in order M1M2M3.

Step 1: Find row deviation for each row. Row deviation is the difference between times in corresponding cells to the minimum time in that row. Similarly find column deviation for each column. Column deviation is the difference between times in corresponding cell to the minimum time in that column.

Step 2: Consider cell for which both deviations are zero, corresponding job is 'k' say. Assign this job k as follows: i. If it is zero on machine M1 place it to the left side of our sequence after previously assigned jobs. ii. If it is zero on machine M3 place it to the right side of our sequence before previously assigned jobs. iii. If it is zero on machine M2 then consider processing time on machine M1 and M3. If processing time on machine M1 is smaller than M3, place it to the left side of our sequence after previously assigned jobs otherwise place it to the right side of our sequence before previously assigned jobs. iv. If there is a tie for zero deviation on machine M1 then assign smallest subscript job first. If there is a tie for zero deviation on machine M3 then assign largest subscript job first. If there is a tie for zero deviation on machine M2 then consider job having smaller time and assign it first by using iii.

Step 3: Delete the assigned job and repeat the procedure on remaining jobs until all jobs get placed.

Step 4: Calculate the total time require to process all the jobs in a sequence which is total elapsed time and the time for which machines remains free i. e. idle time.

Example:

Jobs / Machines	1	2	3	4	5
M1	9	11	7	8	12
M2	6	7	3	4	5
M3	5	10	9	7	6

First calculate deviation for each job.

Jobs / Machines	1	2	3	4	5
Machine M1	9 (2, 4)	11 (4, 4)	7 (0, 4)	8 (1, 4)	12 (5, 7)
M2	6 (3, 1)	7 (4, 0)	3 (0, 0)	4 (0, 0)	5 (2, 0)
M3	5 (0, 0)	10 (5, 3)	9 (4, 6)	7 (2, 3)	6 (1, 1)

For job 1 both deviations are zero and it is on machine M3. We place job 1 to the right side of sequence. For jobs 3 and 4 both deviations are zero on machine M2. For job 3, time on machine M1 is smaller than M3, place job 3 to the left side of sequence. For job 4, time on machine M3 is smaller than machine M1, place job 4 to right side of sequence before job 1 as follows:

3			4	1

Delete jobs 1, 3 and 4 from the list. The reduced table for remaining jobs and its deviation is as follows:

Jobs / Machines	2	5
M1	11 (0, 4)	12 (1, 7)
M2	7 (2, 0)	5 (0, 0)
M3	10 (4, 3)	6 (0, 1)

For job 5 both deviations are zero on machine M2. Time on machine M3 is smaller than time on machine M1. Place job 5 to right side of sequence before job 4 as follows:

3		5	4	1

Delete job 5 from the list. Then place the remaining job 2 in the available position. The required job sequence is

3	2	5	4	1

Calculate the time required to process this sequence of jobs.

Machines	M1		M2		M3	
Jobs	In time	Out time	In time	Out time	In time	Out time
3	0	7	7	10	10	19
2	7	18	18	25	25	35
5	18	30	30	35	35	41
4	30	38	38	42	42	49
1	38	47	47	53	53	58

Total elapsed time = 58, For machine M1, idle time = 11, For machine M2, idle time = 33, For machine M3, idle time = 21

Type III Sequencing n jobs on m machines:
Suppose we want to process n jobs on m machines M1, M2 . . ., Mm in order M1M2…Mm.

Step 1: Find row deviation for each row. Row deviation is the difference between times in corresponding cells to the minimum time in that row. Similarly find column deviation for each column. Column deviation is the difference between times in corresponding cells to the minimum time in that column.

Step 2: Consider cell for which both deviations are zero, corresponding job is 'k' say. Assign this job k as follows:

i. If it is zero on machine M1 place it to the left side of our sequence after previously assigned jobs.

ii. If it is zero on machine Mm place it to the right side of our sequence before previously assigned jobs.

iii. If it is zero on machine Mi, $1 < i < m$ then consider sum of row deviations of cells above machine i and sum of row deviations of cells below machine i. If sum of above cell deviations is smaller than sum of below cell deviations place job i to the left side of our sequence after previously assigned jobs otherwise place it to the right side of our sequence before previously assigned jobs.

iv. If there is a tie for zero deviation on machine M1 then assign smallest subscript job first. If there is a tie for zero deviation on machine Mm then assign largest subscript job first.

Step 3: Delete the assigned job and repeat the procedure on remaining jobs until all jobs get placed.

Step 4: Calculate the total time require to process all the jobs in a sequence which is total elapsed time and the time for which machines remains free i. e. idle time.

Example:

Jobs / Machines	1	2	3	4
M1	6	5	4	7
M2	1	5	3	2
M3	4	3	4	2
M4	2	4	5	1
M5	8	9	7	5

First calculate deviation for each job.

Jobs / Machines	1	2	3	4
M1	6 (2, 5)	5 (1, 2)	4 (0, 1)	7 (3, 6)
M2	1 (0, 0)	5 (4, 2)	3 (2, 0)	2 (1, 1)
M3	4 (2, 3)	3 (1, 0)	4 (2, 1)	2 (0, 1)
M4	2 (1, 1)	4 (3, 1)	5 (4, 2)	1 (0, 0)
M5	8 (3, 7)	9 (4, 6)	7 (2, 4)	5 (0, 4)

For job 1 both deviations are zero and it is on machine M2. Sum of row deviations above machine M2 is 2 and below machine M2 is 6. We place job 1 to left side of sequence. For job 4 both deviations are zero and it is on machine M4. Sum of row deviations above machine M4 is 4 and below machine M4 is 0. We place job 4 to right side of sequence as follows.

1			4

Delete jobs 1 and 4 from the list. The reduced table for remaining jobs and its deviation is as follows:

Jobs / Machines	2	3
M1	5 (1, 2)	4 (0, 1)
M2	5 (2, 2)	3 (0, 0)
M3	3 (0, 0)	4 (1, 1)
M4	4 (0, 1)	5 (1, 2)
M5	9 (2, 6)	7 (0, 4)

For job 2 both deviations are zero and it is on machine M3. Sum of row deviations above machine M3 is 3 and below machine M3 is 2. We place job 1 to right side of sequence before job 4. Then place job 3 in remaining position. The required job sequence is

1	3	2	4

Calculate the time required to process this sequence of jobs.

Machines	M1		M2		M3		M4		M5	
Jobs	In time	Out time	In time	Out time	In time	Out time	In time	Out time	In time	Out time
1	0	6	6	7	7	11	11	13	13	21
3	6	10	10	13	13	17	17	22	22	29
2	10	15	15	20	20	23	23	27	29	38
4	15	22	22	24	24	26	27	28	38	43

Total elapsed time = 43, For machine M1, idle time = 21, For machine M2, idle time = 32, For machine M3, idle time = 30, For machine M4, idle time = 31, For machine M5, idle time = 14.

Conclusion

In this paper, we have given new method deviation technique to find job sequence. Also we have calculated total elapsed time and idle time for this sequence. It is easy to use. It is used for any n job 'm' machines problem as it do not require to convert the problem of m machines into two machines.

References

1. Laha Dipak and Chakraborty Uday Kumar (2009). An efficient hybrid heuristic for makespan minimization in permutation flow shop scheduling. *Int. J. Adv Manuf Technol*, 44(5-6), 559-569. DOI 10.1007/s00170-008-1845-2, Springer-Verlag London Limited 2008.

2. Kumar Sandeep and Jadon Pooja (2014). A Novel Hybrid Algorithm for Permutation Flow Shop Scheduling. *Int. J. of Comp. Sci. and Info. Tech.* (IJCSIT), 5(4), 5057-5061.

3. Singh Kumar Punit and Kumar R. (2012). Path Optimization Algorithm for Network Problems using Job Sequencing Technique. *Int. J. of Dist. and Para. Sys (IJDPS)*, 3(3), 301-309.

4. Gupta Srikant, Ali Irfan and Ahmed A. (2016). A New Algorithm for Solving Job Shop Sequencing Problem. *Int. J. of Comp. Sci. Engg.(IJCSE)*, 5(2), 93-100.

5. Iqbal Pervaiz, Sheik Dr. P.S. Uduman and Srinivasan Dr. S. (2013). Job Sequencing Problem Using Advanced Heuristics Techniques. Proceedings of Int. Conference on Applied Mathematics and Theoretical Computer Science-2013, ISBN 978-93-82338-35-2

6. Iyer P. Sankara (2008). Operations Research. Tata McGraw-Hill Publishing Company Limited, India, 194-201, ISBN (13): 978-0-07-066902-4, ISBN (10): 0-07-066902-3.