Sequencing Models for n Jobs through 2 Machines

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Abstract— In this paper we studied sequencing models for n jobs through 2 machines. Each of n jobs must be start first on machine A and then on machine B. Running times for each job are given. Also specified are arbitrary time slack which order that a job may not be started on machine B until some what a certain time has elapsed since starting the job on machine A. A rule is given for processing the sequence in which jobs are to be run on machines using the same sequence for both machines in order to minimize the time between the start of production of the first job on machine A and the completion of production of the last job on machine B.
Key words: Sequencing Models, Algorithm, Operations Research

I. Definition

In sequencing problems, there are two or more jobs to be finished and one or more machines are available for this mission. We want to know when each job is to begin and what its due date is. We also want to know which services are required to do each job, in which order these services are required and how long each operations is to take.

Sequencing problems have been most commonly experienced in production store where different out comes are to be processed over several combinations of machines.

II. Introduction

Let there be n jobs to be performed one at a time on each of m machines. The order of the machine in which each jobs should be performed is given (for example, job 1 is performed on machines A,C,B, in this order). Also, the time required for preparing each job on each machine is given. The problem is to find out $(n\ !)^m$ possible sequences, that technologically feasible sequence for processing the jobs which gives minimum total elapsed time for all the jobs.
Let Aj=time required for job j on machine A.
B_j=time required for job j on machine B, and
T=total elapsed time for jobs (1, 2,…. n) i.e.., time from start of the first job to completion of the last job.

III. Assumptions in sequencing problems:

The following assumptions are usually made while dealing with sequencing problems:

- At a particular time, only one operation is carried through on a machine.
- once started an each operation must be completed.
- Before starting a succeeding operation, an operation must be completed.
- Each type only one machine is available.
- A job is performed under the order specified.
- Order of performing the operations are independent in processing times.
- The time required to transport jobs from one machine to another is negligible in the transportation time.
- When the period under consideration starts, jobs are completely known and are ready for processing.
- The cost of in-process inventory for each job is same and small.

IV. Algorithm

The best technique for determining an optimal sequence was introduced by Johnson & bellman which is discussed below.

1) Select the minimum processing time out of all the A_j' s and B_j's then do the s^{th} job in last.
2) If there is a lie in selecting minimum of all the processing times, then there are following ways to deal with such a situation:
- If the minimum of all the processing time is A_s, which is also equal to B_p that is $Min(A_j=B_j)= A_s =B_p$ then do the s^{th} job first and p^{th} job in last.
- If min (A_j, B_j)=A_s , but $A_s = A_k$, i.e., there is a tie for minimum among A_j's then select anyone.
- If $min(A_j=B_j)=B_p$ but $B_p=B_T$, i.e.. ,there is a tie for minimum among B_j's then select anyone.
- Now eliminate the job which has already been assigned from another consideration and repeat steps 1 and 2 until an optimal sequence is obtain.

V. Basic terms used in sequencing

1) Number of machines: It refer to the number of service facilities through which a job must pass before it is assumed to be completed.
2) Processing Order: In which given machines are required for completing the job in this sequence.
3) Processing Time: On each machine, it indicates the time required by a job.
4) Total Elapsed Time: It is the time interval between starting the first job and completing the last job including the idle time by the given set of machines.
5) Idle time on a machine: A machine does not have a job to process in the time, i.e. idle from the end of job (j-1) to the start of job j.
6) No passing rule: On given machines jobs are to be processed in maintaining the order.

VI. Problems on n jobs through two machines:

1) In a factory, there are six jobs to process, each of which should go to machines A and B in the order AB. The processing timings in minutes are given, determine the optimal sequencing and total elapsed time.

Jobs	1	2	3	4	5	6
Machine A	8	5	3	6	10	9
Machine B	4	9	7	7	5	2

A. Solution:

Step 1: the minimum of the times given in for job 6 in machine B. so perform job 6 in the end. It is last in the sequences. Now delete this job from the given data.

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Step2: In the remaining timings now the minimum is for job 3 on machine A. so do the job 3 first. Now delete this job 3 also.

3					6

Step3: Now the smallest time is 3 minutes for job first on machine B. thus perform job 1 at the second last before job 6.

3				1	6

The Total Elapsed Time T Is Obtained As Under:

Job sequence	Mac A	Mac B	Machine A		Machine B		Idle time for mac B
			In	out	In	out	
3	3	7	0	3	3	10	3
2	5	9	3	7	10	19	-
4	6	7	7	13	19	26	-
5	10	5	13	23	26	31	-
1	8	4	23	31	31	35	-
6	9	2	31	40	40	42	5

Step4: After assigning job 1, we observe that the smallest value of 4 minutes is shared by job 2 on machine A and job 5 on machine B. So perform job 2 first and job 5 in at the end i.e. job 2 after job 3 and job 5 before job 1.

3	2		5	1	6

Step5: Now the only job remaining is job 4 it shall be assigned the only space left in the sequence. Optimal resultant sequence of jobs is

3	2	4	5	1	6

2) A machine operator has to perform two operations printing and binding, on a number of different jobs. The time required to perform these operations (in minutes) for each job is known. Determine the order in which the jobs should be processed in order to minimise the total time required to turn out all the jobs.

Job	Time for printing(minutes)	Time for binding (minutes)
1	3	8
2	12	10
3	5	9
4	2	6
5	9	3
6	11	1

Also find the total processing time and idle times for printing and binding operations.

Solution:

The solution procedure is described below.

By questioning the columns, we find the smallest value. It is binding time of 1 minute for job 6 in second column thus we schedule job 6 last for printing (and thereafter for binding)as shown below:

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The reduced set of processing times becomes:

Job	Printing time (minutes)	Binding time (minutes)
1	3	8
2	12	10
3	5	9
4	2	6
5	9	3

The smallest value is printing time of 2 minutes for job 4 in first column. Thus we schedule job 4 first as shown below.

4					6

The reduced set of processing times becomes:

Job	Printing time(minutes)	binding time(minutes)
1	3	8
2	12	10
3	5	9
5	9	3

There are two equal minimal values: printing time of 3 minutes for job 1 in first column and binding time of 3 minutes for job 5 in second column. According to the rules, job 1 is scheduled next to job 4 and 5 next to job 6 as shown below:

4	1			5	6

The reduced set of processed times becomes

Job	Printing time(minutes)	binding time(minutes)
2	12	10
3	5	9

The smallest value is printing time of 5 minutes for job 3 in first column. Therefore, we schedule job 3, next to job 1 and we get the optimal sequence as

4	1	3	2	5	6

Now we can calculate the elapsed time. The details are shown in table:

Job	Printing operation		binding operation	
	time in	time out	time in	Time out
4	0	2	2	8
1	2	5	8	16
3	5	10	16	25
2	10	22	25	35
5	22	31	35	38
6	31	42	42	43

Thus the above table is minimum elapsed time is 43 minutes. Idle time for printing operation is 1 minute (from 42nd minute to 43rd minute) and for binding operation is 2+4=6 minutes (from 0-2 and 38-42 minutes).

We have 5 jobs, each of which must go through the two operation turning and threading. Processing times are given in the table below:

Processing time in hours.

Job	1	2	3	4	5
turning	5	1	9	3	10
threading	2	6	7	8	4

Determine a sequence for the 5 jobs that will minimise the elapsed time T.

Solution:

By the columns we find the smallest value 1 in job 2.

2				

The smallest value 2 in job 1.

2				1

The smallest value 3 in job 4.

2	4			1

The smallest value 4 in job 5.

2	4		5	1

The smallest value 7 in job 3.

2	4	3	5	1

job	Turning operation		Threading operation	
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

The sequence for the 5 jobs is given by 2-4-3-5-1.
The minimise elapsed time T_{min}=30 hours.

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