Scheduling

Notes 9

‘’N’’ Job ‘’M’’ Machine Heuristics
NEH Algorithm for Minimizing Makespan in Flow Shop Problems

- The basic idea of this algorithm is to compare a job’s situation with other jobs.
- The algorithm is based on giving the priority to the job that has a maximum processing time total on all the machines.

- The steps of the algorithm can be summarized as follows:
- Step 1: Find the total processing time of every job ‘’i’’ on the machines.
- TPi=$\sum_{j=1}^{m} P_{ij}$ i=1,2,……,n j=1,2,……,m
- Step 2: Order the TPi values from large to the small.
- Step 3: Choose the first and second jobs on this order and make alternative sequences. Find the best sequence between these two jobs. Don’t change this sequence in the next steps of the algorithm and take i=3.

- Step 4: Choose the ith job from the list in the Step 2 and place this job on the possible ith order. Find the best intermediary sequence.
- Step 5: Stop if n=i , otherwise i=i+1 and go to the Step 4.

Example
4x3 situation

Machine / Job	1	2	3
1	14	22	11
2	26	32	14
3	18	11	13
4	16	24	37

Solution

- First of all, we find the total processing time of each job.
- TP1 = 14+22+11 = 47
- TP2= 26+32+14= 72
- TP3= 18+11+13= 42
- TP4= 16+24+37= 77

- Job 4 and Job 2 have maximum total processing times.

- We compare the completion times of these two jobs,
- If Job 4 is processed before Job 2
- If Job 2 is processed before Job 4

Job 4 is processed before Job 2

	1	2	3
4	16/16	24/40	37/77
2	26/42	32/74	14/91

Job 2 is processed before Job 4

	1	2	3
2	26/26	32/58	14/72
4	16/42	24/82	37/119

The best completion time belongs to (4,2) order and it is 91.
These two jobs should be always in this order.
Now, i=3 and we take Job 1 as next job, because job 1 has the third maximum completion time. We try (4,2,1), (4,1,2) and (1,4,2).

(4,2,1)

	1	2	3
4	16/16	24/40	37/77
2	26/42	32/74	14/91
1	14/56	22/96	11/107

(4,1,2)

	1	2	3
4	16/16	24/40	37/77
1	14/30	22/62	11/88
2	26/56	32/94	14/108

(1,4,2)

	1	2	3
1	14/14	22/36	11/47
4	16/30	24/60	37/97
2	26/56	32/92	14/111

When 3 possible sequence is analyzed, it is seen that (4,2,1) gives the best completion time with the value of 107.

Now i=4 and we take Job 1. There are 4 alternative sequences.

(4,2,1,3), (4,2,3,1), (4,3,2,1) and (3,4,2,1)

(4,2,1,3)

	1	2	3
4	16/16	24/40	37/77
2	26/42	32/74	14/91
1	14/56	22/96	11/107
3	18/74	11/107	13/120

(4,2,3,1)

	1	2	3
4	16/16	24/40	37/77
2	26/42	32/74	14/91
3	18/60	11/85	13/104
1	14/74	22/107	11/118

(4,3,2,1)

	1	2	3
4	16/16	24/40	37/77
3	18/34	11/51	13/90
2	26/60	32/92	14/106
1	14/74	22/114	11/125

(3,4,2,1)

	1	2	3
3	18/18	11/29	13/42
4	16/34	24/58	37/95
2	26/60	32/92	14/109
1	14/74	22/114	11/125

The optimal sequence is (4,2,3,1) with the max. completion time of 118.

CDS (Campbell Dudek and Smith) Heuristics for Minimizing Makespan in Flow Shop Problems

- It was developed in 1970. This algorithm is a very popular algorithm for using to find out the make span for a general m machines n jobs flow shop sequencing problem.
- For a general m machine problem you generalize it to find m-1 sequences. For example if you have 10 machines problem, you will evaluate 9 sequences.

Steps of the CDS Heuristic algorithm

- Convert a m-machine problem into a two machine problem.
- if we have m machines, we call them M1, M2, Mm, let us call sequence S1 as M1 and M m take the first machine and take the last machine, apply Johnson algorithm out of that, then, the second S2 will be M1+M2 and

  M m-1 plus M m.
- The third sequence will be M1+M2 +M3 and Mm-2 + Mm-1 +Mm take the first 3 and add then take the last 3 and add and do Johnson algorithm.
- The last sequence is Sm-1 and this sequence will be

  M1+M2+…..+Mm-1,and M2 +M3 +Mm. So, take the first m-1, take the last m-1 starting from 2.

Use the best of these m-1 schedules

Example
Use CDS to solve the problem

Machine / Job	1	2	3	4
1	1	13	6	2
2	10	12	18	18
3	17	9	13	4
4	12	17	2	6
5	11	3	5	16

Solution

- There are 4 machines , so we need 4-1=3 sequences to compare.
- First, we take machine 1 and machine 4 and apply Johnson's algorithm.

	M1	M4
J1	1	2
J2	10	18
J3	17	4
J4	12	6
J5	11	16

- Sequence 1-2-5-4-3

Finding Cmax for the 1-2-5-4-3 Sequence

Machine / Job	1	2	3	4
1	1/1	13/14	6/20	2/22
2	10/11	12/26	18/44	18/62
5	11/22	3/29	5/49	16/78
4	12/34	17/51	2/53	6/84
3	17/51	9/60	13/73	4/88

Cmax= 88

- Secondly, we sum the processing times of M1 and M2 for the first imaginary machine (M1+M2) and we sum the processing times of M3 and M4 for the second imaginary machine (M3+M4). Then we apply Johnson's algorithm.

	M1+M2	M3+M4
J1	14	8
J2	22	36
J3	26	17
J4	29	8
J5	14	21

- Sequences: 5-2-3-4-1 or 5-2-3-1-4

Finding Cmax for the 5-2-3-4-1 Sequence

Machine / Job	1	2	3	4
5	11/11	3/14	5/19	16/35
2	10/21	12/33	18/51	18/69
3	17/38	9/47	13/64	4/73
4	12/50	17/67	2/69	6/79
1	1/51	13/80	6/86	2/88

Cmax= 88

Finding Cmax for the 5-2-3-1-4 Sequence

Machine / Job	1	2	3	4
5	11/11	3/14	5/19	16/35
2	10/21	12/33	18/51	18/69
3	17/38	9/47	13/64	4/73
1	1/39	13/60	6/70	2/75
4	12/51	17/77	2/79	6/85

Cmax= 85

- Finally, we sum the processing times of M1,M2 and M3 for the first imaginary machine (M1+M2+M3) and we sum the processing times of M2, M3 and M4 for the second imaginary machine (M2+M3+M4). Then we apply Johnson's algorithm.

	M1+M2+M3	M2+M3+M4
J1	20	21
J2	40	48
J3	39	26
J4	31	25
J5	19	24

- Sequence: 5-1-2-3-4

Finding Cmax for the 5-1-2-3-4 Sequence

Machine / Job	1	2	3	4
5	11/11	3/14	5/19	16/35
1	1/12	13/27	6/33	2/37
2	10/22	12/39	18/57	18/75
3	17/39	9/48	13/70	4/79
4	12/51	17/68	2/72	6/85

Cmax= 85

According to CDS Heuristic 5-2-3-1-4 and 5-1-2-3-4 are best sequences

Resources

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