

LECTURE 41: SCHEDULING

Learning Objectives

After completing the introductory discussion on Scheduling, the students would be able to understand what scheduling is and how important it is to high volume and intermediate volume systems. It would also help them to learn how to address scheduling needs in Job shops. The students would also learn the use and interpretation of Gantt Charts . They would also use Assignment method for loading along with common Priority Rules. They would also learn the common and unique scheduling problems in Service Systems.

Scheduling

Scheduling: Scheduling is an important tool for manufacturing and service industries where it can have a major impact on the productivity of a process. In manufacturing, the purpose of scheduling is to minimize the production time and costs, by telling a production facility what to make, when, with which staff, and on which equipment. Similarly, scheduling in service industries, such as airlines and public transport, aim to maximize the efficiency of the operation and reduce costs.

Scheduling

Modern computerized scheduling tools greatly outperform older manual scheduling methods. This provides the production scheduler with powerful graphical interfaces which can be used to visually optimize real-time work loads in various stages of the production, and pattern recognition allows the software to automatically create scheduling opportunities which might not be apparent without this view into the data. For example, an airline might wish to minimize the number of airport gates required for its aircraft, in order to reduce costs, and scheduling software can allow the planners to see how this can be done, by analyzing time tables, aircraft usage, or the flow of passengers.

Scheduling

Companies use backward and forward scheduling to plan their human and material resources. Backward scheduling is planning the tasks from the due date to determine the start date and/or any changes in capacity required, whereas forward scheduling is planning the tasks from the start date to determine the shipping date or the due date.

Benefits of Scheduling

Scheduling: Establishing the timing of the use of equipment, facilities and human activities in an organization

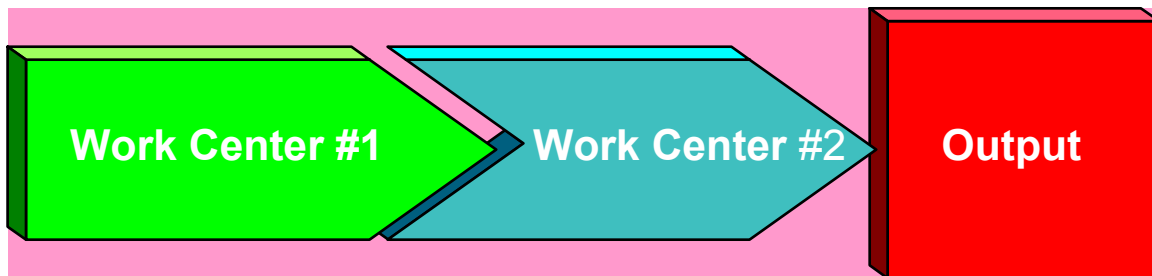
1. Effective scheduling can yield
2. Cost savings
3. Increases in productivity

The benefits of production scheduling include:

1. Process change-over reduction
2. Inventory reduction, leveling
3. Reduced scheduling effort
4. Increased production efficiency
5. Labor load leveling
6. Accurate delivery date quotes
7. Real time information

High-Volume Systems

1. Flow system: High-volume system with Standardized equipment and activities
2. Flow-shop scheduling: Scheduling for high-volume flow system



Scheduling Manufacturing Operations

High-volume
Intermediate-
volume
Low-volume
Service
operations

High-Volume Success Factors

Process and product design
Preventive maintenance
Rapid repair when breakdown occurs
Optimal product mixes
Minimization of quality problems
Reliability and timing of supplies
Intermediate-Volume Systems
Outputs are between standardized high-volume systems and made-to-order job shops
Run size, timing, and sequence of jobs

Economic run size:

$$Q_0 = \sqrt{\frac{2DS}{H}} \sqrt{\frac{p}{p-u}}$$

Scheduling Low-Volume Systems

Loading - assignment of jobs to process centers
Sequencing - determining the order in which jobs will be processed
Job-shop scheduling
Scheduling for low-volume
systems with many
variations
in requirements

Gantt Load Chart

Gantt chart - used as a visual aid for loading and scheduling

Load Chart

Load chart – A type of Gantt Chart that shows the loading and idle times for a group of machines or list of departments

Work Center	Mon.	Tues.	Wed.	Thurs.	Fri.
1	Job 3			Job 4	
2		Job 3	Job 7		
3	Job 1			Job 6	Job 7
4	Job 10				

Schedule chart – A type of Gantt Chart that shows the orders or jobs in progress and whether they are on schedule or not.

Input/Output Control Chart – A type of Control Chart that shows management of work flow and queues at the work centers

Loading Types

The common types of loading include the following

1. Infinite loading
2. Finite loading
3. Vertical loading
4. Horizontal loading
5. Forward scheduling
6. Backward scheduling
7. Schedule chart

We now briefly discuss these type of Loading

1. Infinite loading. Jobs are assigned to work centers without regard to the capacity of the work center.
2. Finite loading Jobs are assigned to work centers with regard to the capacity of the work center and job processing times.
3. Vertical loading: Loading jobs at a work center, job by job, usually according to some priority criterion, using infinite loading i.e. Jobs are assigned to work centers without regard to the capacity of the work center.
4. Horizontal loading: Loading each job on all work centers it will require, then the next job on all work centers, according to some priority, using finite loading i.e. Jobs are assigned to work centers with regard to the capacity of the work center and job processing times.
5. Forward scheduling: Scheduling ahead, from some point in time
6. Backward scheduling: Scheduling by working backwards from the due date

7. Schedule chart A Gantt chart that shows the orders or jobs in progress and whether they are on schedule or not.

Assignment Method of Linear Programming

Assignment Model is a type of linear programming model for optimal assignment of tasks and resources

Hungarian method is the method of assigning jobs by a one for one matching to identify the lowest cost solution

Lets take a step by step approach to understand and make use of Hungarian Method

Hungarian Method

- First of all, acquire the relevant cost information and arrange it in tabular form
- Second, obtain the Row Reduction, this is obtained by subtracting the smallest number in each row from every number in the row. Enter the results in a new table.
- Third, Obtain the Column Reduction by subtracting the smallest number in each column of the new table from every number in the column.
- Fourth, test whether an optimum assignment can be made. You do this by determining the minimum number of lines needed to cover (i.e.) cross out all zeros. If the number of lines equal the numbers of row, an optimum assignment is possible. IN that case move to final step.
- Fifth, if the numbers of lines is less than the number of rows, modify the table in the following manner
 - Subtract the smallest uncovered number from every uncovered number in the table.
 - Add the smallest uncovered number to the numbers at the intersections of covering lines
 - Numbers crossed out but not at intersections of cross out lines carry over unchanged to the next table.
- Sixth, Repeat steps fourth and fifth unless an Optimal table is obtained
- Seventh, make the assignments. Begin with rows or columns with only one zero. Match items that have zeros, using only one match for each row and each column. Cross out both the row and column for each row.

Hungarian Method Example

Please refer to the matrix which shows Jobs 1,2,3 and 4 with Machines A, B, C and D.

JOBS	A	B	C	D
1	8	6	2	4
2	6	7	11	10
3	3	5	7	6
4	5	10	12	9

Please apply the Hungarian Method to make appropriate assignments.

Select the Row Minimum

MACHINE					
JOBS	A	B	C	D	ROW MIN
1	8	6	2	4	2
2	6	7	11	10	6
3	3	5	7	6	3
4	5	10	12	9	5

Subtract the smallest number in each row

To form a new table and select column minimum

MACHINE				
JOBS	A	B	C	D
1	6	4	0	2
2	0	1	5	4
3	0	2	4	3
4	0	5	7	4
COL MIN	0	1	0	2

Subtract the smallest number in each column & Enter the results to form a new table

MACHINE				
JOBS	A	B	C	D
1	6	3	0	0
2	0	0	5	2
3	0	1	4	1
4	0	4	7	2

Determine the minimum number of lines needed to cross out all zeros. Here we have three lines only and rows are 4, so the solution is not optimal

MACHINE				
JOBS	A	B	C	D
1	6	3	0	0
2	0	0	5	2
3	0	1	4	1
4	0	4	7	2

Hungarian Method Example

Subtract the smallest value that has not been crossed out from every number that has not been crossed out (1 here) and add this to numbers that are at intersections of covering lines

MACHINE				
JOBS	A	B	C	D
1	6+1=7	3	0	0
2	0+1=1	0	5	2
3	0	0	3	0
4	0	3	6	1

Determine the minimum number of lines needed to cross Out all 0 (4), since this equals the number of rows , we obtain the optimum assignment.

MACHINE				
JOBS	A	B	C	D
1	7	3	0	0
2	1	0	5	2
3	0	0	3	0
4	0	3	6	1

Make the assignments, start with rows and columns with Only one 0. Match jobs with machines that have 0 costs.

MACHINE				
JOBS	A	B	C	D
1	7	3	0	0
2	1	0	5	2
3	0	0	3	0
4	0	3	6	1

The assignment according to Hungarian Method is therefore
A4, 2B,1C AND 3D

Sequencing

Sequencing: Determine the order in which jobs at a work center will be processed.

Workstation: An area where one person works, usually with special equipment, on a specialized job.

Summary

Scheduling is the timing and coordination of Operations. Scheduling problems differ in nature because of the system being designed for high volume, intermediate or low volume flow. In our next lecture we will discuss its complementary and supplementary concept of Sequencing.