Scheduling

Lecture-5

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Books Reference

- 1. Analysis of Manufacturing Systems

by J. E. Rooda and J. Vervoort

- 2. Production/ Operations Management
  by William J. Stevenson, IRWIN publisher,
  ISBN 0-256-13900-8

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Scheduling Manufacturing Operations

- Scheduling tasks are largely a function of the volume of system output.
- High-volume systems require approaches substantially different from those required by job shops and project scheduling requires still different approaches.
- We will consider scheduling for high-volume systems, inter mediate-volume systems, and low-volume (Job shop) scheduling.

Scheduling in High-Volume Systems

- Scheduling includes allocating workloads to specific work centers and determining the sequence in which operations are to be performed.
- High-volume systems are characterized by standardized equipment and activities that provide identical or highly similar operations on customers or products as they pass through the system.
- The goal is to obtain a smooth rate of flow of goods or customers through the system in order to get a high utilization of labor and equipment. High-volume systems are often referred to as flow systems; scheduling in these systems is referred to as flow-shop scheduling.
- Examples of high-volume products include autos, personal computers, radios and televisions, stereo equipment, toys, and appliances. In process industries, examples include petroleum refining, sugar refining, mining, waste treatment, and the manufacturing of fertilizers.

Scheduling in High-Volume Systems

- Examples of services include cafeteria lines, news broadcasts, and mass inoculations. Because of the highly repetitive nature of these systems, many of the loading and sequence decisions are determined during the design of the system.
- The use of highly specialized tools and equipment, the arrangement of equipment, the use of specialized material-handling equipment, and the division of labor are all designed to enhance the flow of work through the system, since all items follow virtually the same sequence of operations.
- A major aspect in the design of flow systems is *line balancing*, which concern allocating the required tasks to workstations so that they satisfy technical (sequencing) constraints and are balanced with respect to equal work times among stations.

Scheduling in High-Volume Systems

- *Process and product design* Here, cost and manufacturability are important, as is achieving a smooth flow through the system.
- *Preventive maintenance* Keeping equipment in good operating order can minimize breakdowns that would disrupt the flow of work.
- *Rapid repair when breakdowns occur* This can require specialists as well as stocks of critical spare parts.
- *Optimal product mixes* Techniques such as linear programming can be used to determine optimal blends of inputs to achieve desired outputs at minimal costs. This is particularly true in the manufacture of fertilizers, animal feeds, and diet foods.
- *Minimization of quality problems* Quality problems can be extremely disruptive, requiring shutdowns while problems are resolved.

Scheduling in Intermediate-Volume

- Intermediate-volume system outputs fall between the standardized type of output of the high-volume systems and made-to-order output of job shops.
- Like the high-volume, intermediate-volume systems typically produce standard outputs. If manufacturing is involved, the products may be made for stock rather than for special order. However, the volume of output in such cases is not large enough to satisfy continuous production.
- Thus, intermediate-volume work centers periodically shift from one job to another. In contrast to a job shop, the run sizes are relatively large. Examples of products made in these systems include canned food, baked goods, paint, and cosmetics. The three basic issues in these systems are the *run size* of jobs, the *timing* of jobs, and the *sequence* in which jobs should be processed.

Scheduling in Low-Volume Systems

- The features of low-volume systems (job shops) are much different from those of high and intermediate-volume systems.

- Products are made to order, and orders usually differ considerably in terms of processing requirements, materials needed, processing time, and processing sequence and setups.

- Because of these circumstances, job-shop scheduling is usually fairly complex. This is compounded by the impossibility of establishing firm schedules prior to receiving the actual job orders.

- Job-shop processing gives rise to two basic issues for schedulers: how to distribute the workload among work centers and what job processing sequence to use.

Loading

- Loading refers to the assignment of jobs to processing (work) centers. Loading decisions involve assigning specific jobs to work centers and to various machines in the work centers.

- Where a job can be processed only by a specific center, loading presents little difficulty. However, problems arise when two or more jobs are to be processed and there are a number of work centers capable of performing the required work. In such cases, the operations manager needs some way of assigning jobs to the centers.

- When making assignments, managers often seek an arrangement that will minimize processing and setup costs, minimize idle time among work centers, or minimize job completion time, depending on the situation.

Hungarian method

- Hungarian method is one-for-one matching. Each job must be assigned to only one machine.
- It is also assumed that every machine is capable of handling every job, and that the costs or values associated with each alignment combination are known and fixed.
- Once the relevant cost information has been acquired and arranged in tabular form.

Hungarian method

1. Subtract the smallest number in each row from every number in the row. Enter the results in a new table.
2. Subtract the smallest number in each column of the new table from every number in the column. Enter the results in another table.
3. Test whether an optimum assignment can be made. This is accomplished by deter mining the *minimum* number of lines needed to cover all zeros. If the number of lines equals the number of rows, an optimum assignment is possible. In that case, go to step 6. Otherwise go on to step 4. Note that "cover" means "cross out."
4. If the number of lines is less than the number of rows, modify table in this way:
   a) subtract the smallest uncovered number from every uncovered number in the table.
   b) add the smallest uncovered number to the numbers at *intersections* of covering lines.
5. Repeat steps 3 and 4 until an optimal table is obtained.
6. 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 the column after the match.

Example 1 Determine the optimum assignment of jobs to machines for the following data below

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

Example 2

- Three sales managers would like to sell their toys. The buyers are in three different position as A, B, and C and sales manager are at the positions D, E, and F. Find the shortest route covering all positions by using the following table. The table indicates the shortest path between two places.

	A	B	C
D	250	400	350
E	400	600	350
F	200	400	250

Example 3 Determine the optimum assignment of jobs to machines for the following data below

Jobs/ Machines	A	B	C	D
1	90	75	75	80
2	35	85	55	65
3	125	95	90	105
4	45	110	95	115

Sequence Rules

- FCFS
- SPT
- DD
- CR
- S/O
- Rush

Sequence Rules

- **Job Lateness:** This is the length offtime the job completion date is expected to exceed the date the job was due or promised to the customer. It is the difference between the actual completion time and t he due date.
- **Makespan:** This is the total time needed to complete a *group* of jobs. It is the length of time between the start of the first job in the group and the completion of the last job in the group.
- **Average Number of Jobs:** Jobs that are in a shop are considered to b e work-in-process inventory. The average work in process for a group of jobs can be computed using the following formula

Average number = Total flow time /Makespan of jobs

If the jobs represent equal amounts of inventory, the average number of jobs will also reflect the average work-in-process inventory. Of these rules, rush scheduling is quite simple and needs no explanation.

Example 1

- Processing times (including setup times) and due dates for six jobs waiting to be processed at a work center are given in the following table. **Determine the sequence of jobs, the average flow time, average job lateness, and average number of jobs at the work center, for each of these rules FCFS, SPT, DD.**

Job	Processing time	Due date
A	2	7
B	8	16
C	4	4
D	10	17
E	5	15
F	12	18

Solution

Job	Processing time (1)	Flow time (2)	Due date (3)	Days late (2-3) (0 if negative)
A	2	2	7	0
B	8	10	16	0
C	4	14	4	10
D	10	24	17	7
E	5	29	15	14
F	12	41	18	23
	41	120		54

Solution

- *The system follows FCFS system, then*

- *Average flow time:* 120/6 = 20 days

- *Average job lateness:* 54/6 = 9 days

- The *makespan* is 41 days. *Average number of jobs at the work center:* 120/41 = 2.93

Solution

- SPT (A-C-E-B-D-F)
- *Average flow time*= 108/6 = 18 days
- *Average job lateness*= 40/6 = 6.67 days
- *Average number of jobs at the work center*= 108/41 = 2.63

Solution

- DD (C-A-E-B-D-F)
- *Average flow time*= 110/6 = 18.33 days
- *Average job lateness*= 38/6 = 6.33 days
- *Average number of jobs at the work center*= 110/41 =2.68

Scheduling *Service* Operations

- Scheduling service systems presents certain problems not generally encountered in manufacturing systems. This is due to the failure to store or inventory services and the random nature of customer requests for service.
- In some situations, the second difficulty can be moderated by using selection or reservation systems, but the inability to store services in most cases is a fact of life that managers must contend with.
- An important aim in service systems is to match the flow of customers and service capabilities.
- An ideal situation is one that has a smooth flow of customers through the system. This would occur if each new customer arrives at the precise instant that the preceding customer's service is completed, as in a physician's office, or in air travel where the demand just equals the number of available seats.

Scheduling *Service* Operations

In each of these situations, customer waiting time is minimized, and the *service* system staff and equipment would be fully utilized.

Unfortunately, the random nature of customer requests for service that generally prevails in service systems makes it nearly impossible to provide service capability that matches demand.

If service times are subject to variability, because of differing processing requirements the inefficiency of the system is compounded. The inefficiencies can be reduced if arrivals can be scheduled (e.g., appointm ents), as in the case of doctors. However, in many circumstances appointments are not possible (super-markets, gas stations, theaters, hos pital emergency rooms, repair of equipment breakdowns). The emphasis is on intermediate-term decisions related to service capacity. Now, we will concern ourselves with short-term *scheduling*, in which much of the capacity of a system is essentially fixed, and the goal is to achieve a certain degree of customer service by efficient utilization of that capacity

Appointment Systems

- Appointment systems are intended to control the timing of customer arrivals in order to minimize customer waiting while achieving a high degree of capacity utilization.
- A doctor can use an appointment system to schedule office patients during the afternoon, leaving the mornings free for hospital duties. Even with appointments, problems can still arise due to lack of punctuality on the part of patients, no-shows, and the inability to completely control the length of contact time (e.g., a dentist might run into complications in filling a tooth and have to spend additional time with a patient, thus backing up later appointments).
- Some of this can be avoided by trying to match the time reserved for a patient with the specific needs of that case rather than setting appointments at regular intervals. Even with the problems of late arrivals and no-shows, the appointment system is a tremendous improvement over random arrivals.

Reservation Systems

- Reservation systems are designed to enable service systems to formulate a fairly accurate estimate of the demand on the system for a given time period and to minimize customer disappointment generated by excessive waiting or inability to obtain service.
- Reservation systems are widely used by resorts, hotels and motels, restaurants, and some modes of transportation (e.g., airlines, car rentals). In the case of restaurants, reservations enable management to spread out or group custom so that demand matches service capabilities. Late arrivals and no-shows can disrupt the system.

Operations Strategy

- Scheduling can either help or hinder operations strategy. If scheduling is done well, products and services can be made or delivered in a timely manner. Resources can be used to best advantage and customers will be satisfied.
- Scheduling not performed well will result in inefficient use of resources and possibly dissatisfied customers.
- The implication is clear: Management should not overlook the important role that scheduling plays in the success of an organization, giving a reasonable advantage if handled well or disadvantage if done poorly. Time-based competition depends on good scheduling.

Q & A

Thanks For Your Kind Attention