

Chapter 17 Operations Scheduling

December 17, 2008

Case Study Keep Patient Waiting? Not in My Office!

- ▶ What features of the appointment scheduling system were crucial in capturing “many grateful patients”?
- ▶ What procedure were followed to keep the appointment system flexible enough to accommodate the emergency cases, and yet be able to keep up with the other patients’ appointments?
- ▶ How were the special cases such as latecomers and no-shows handled?

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Work Center

- ▶ A **work center** is an area in a business in which productive resources are organized and work is completed
- ▶ Can be a single machine, a group of machines, or an area where a particular type of work is done

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Capacity and Scheduling

- ▶ **Infinite loading**
 - ▶ Work is assigned simply based on what is needed over time
- ▶ **Finite loading**
 - ▶ Approach actually schedules in detail each resource using the setup and run time required for each order
- ▶ **Forward scheduling**
 - ▶ Schedule each operation that must be completed forward in time
- ▶ **Backward scheduling**
 - ▶ Starts from some date in the future (possibly a due date) and schedules the required operations in reverse sequence

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Types of Manufacturing Scheduling Processes and Scheduling Approaches

Type of Process	Typical Scheduling Approach
Continuous process	Finite forward of process, machine limited
High-volume manufacturing	Finite forward of line, machined limited
Med-volume manufacturing	Infinite forward of process, labor and machined limited
Low-volume manufacturing	Infinite forward of jobs, labor and some machine limited

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Typical Scheduling and Control Functions

- ▶ Allocating orders, equipment, and personnel
 - ▶ Short-run capacity planning
- ▶ Determining the sequence of order performance
 - ▶ Establishing job priorities
- ▶ Initiating performance of the scheduled work
 - ▶ Dispatching of orders
- ▶ Shop-floor control
 - ▶ Production activity control

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Work-Center Scheduling Objectives

- ▶ Meet due dates
- ▶ Minimize lead time
- ▶ Minimize setup time or cost
- ▶ Minimize work-in-process inventory
- ▶ Maximize machine utilization

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Scheduling n Jobs on One Machine: Priority Rules for Job Sequencing

1. First-come, first-served (FCFS)
2. Shortest operating time (SOT)
3. Earliest due date first (DDate)
4. Slack time remaining (STR) first
5. Slack time remaining per operation (STR/OP)

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Priority Rules for Job Sequencing (Continued)

6. Critical ratio (CR)

$$CR = \frac{\text{Due date} - \text{Current date}}{\text{Number of days remaining}}$$

7. Last come, first served (LCFS)

8. Random order or whim

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Example of Job Sequencing: First-Come First-Served

Suppose you have the four jobs to the right arrive for processing on one machine

Jobs (in order of arrival)	Processing Time (days)	Due Date (days hence)
A	4	5
B	7	10
C	3	6
D	1	4

What is the FCFS schedule?

Do all the jobs get done on time?

No, Jobs B, C, and D are going to be late

Jobs (in order of arrival)	Processing Time (days)	Due Date (days hence)	Flow Time (days)
A	4	5	4
B	7	10	11
C	3	6	14
D	1	4	15

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Example of Job Sequencing: Shortest Operating Time

Suppose you have the four jobs to the right arrive for processing on one machine

Jobs (in order of arrival)	Processing Time (days)	Due Date (days hence)
A	4	5
B	7	10
C	3	6
D	1	4

What is the SOT schedule?

Do all the jobs get done on time?

Jobs (in order of arrival)	Processing Time (days)	Due Date (days hence)	Flow Time (days)
D	1	4	1
C	3	6	4
A	4	5	8
B	7	10	15

No, Jobs A and B are going to be late

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Example of Job Sequencing: Earliest Due Date First

Suppose you have the four jobs to the right arrive for processing on one machine

Jobs (in order of arrival)	Processing Time (days)	Due Date (days hence)
A	4	5
B	7	10
C	3	6
D	1	4

What is the earliest due date first schedule?

Do all the jobs get done on time?

Jobs (in order of arrival)	Processing Time (days)	Due Date (days hence)	Flow Time (days)
D	1	4	1
A	4	5	5
C	3	6	8
B	7	10	15

No, Jobs C and B are going to be late

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Example of Job Sequencing: Critical Ratio Method

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Suppose you have the four jobs to the right arrive for processing on one machine

Jobs (in order of arrival)	Processing Time (days)	Due Date (days hence)
A	4	5
B	7	10
C	3	6
D	1	4

What is the CR schedule?

Do all the jobs get done on time?

In order to do this schedule the CR's have been calculated for each job. If we let today be Day 1 and allow a total of 15 days to do the work. The resulting CR's and order schedule are:

CR(A)=(5-4)/15=0.06 (Do this job last)

CR(B)=(10-7)/15=0.20 (Do this job first, tied with C and D)

CR(C)=(6-3)/15=0.20 (Do this job first, tied with B and D)

CR(D)=(4-1)/15=0.20 (Do this job first, tied with B and C)

No, but since there is a three-way tie, only the first job or two will be on time

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Example of Job Sequencing: Last-Come First-Served

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Suppose you have the four jobs to the right arrive for processing on one machine

Jobs (in order of arrival)	Processing Time (days)	Due Date (days hence)
A	4	5
B	7	10
C	3	6
D	1	4

What is the LCFS schedule?

Do all the jobs get done on time?

Jobs (in order of arrival)	Processing Time (days)	Due Date (days hence)	Flow Time (days)
D	1	4	1
C	3	6	4
B	7	10	11
A	4	5	15

No, Jobs B and A are going to be late

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Scheduling n Jobs on Two Machines Steps of Johnson's rule

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- List the operation time for each job on both machine
- Select the shortest operation time
- If the shortest time is for the first machine, do the job first;
 - If the shortest time is for the second machine, do the job last.
 - In the case of a tie, do the job on the first machine.
- Repeat Steps 2 and 3 for each remaining job until the schedule is complete.

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Example of Job Sequencing: Johnson's Rule (Part 1)

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Suppose you have the following five jobs with time requirements in two stages of production. What is the job sequence using Johnson's Rule?

Jobs	Time in Hours	
	Stage 1	Stage 2
A	1.50	1.25
B	2.00	3.00
C	2.50	2.00
D	1.00	2.00

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Example of Job Sequencing: Johnson's Rule (Part 2)

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First, select the job with the smallest time in either stage.

That is Job D with the **smallest** time in the first stage. Place that job as early as possible in the unfilled job sequence below.

Jobs	Time in Hours	
	Stage 1	Stage 2
A	1.50	1.25
B	2.00	3.00
C	2.50	2.00
D	1.00	2.00

Drop D out, select the **next smallest** time (Job A), and place it 4th in the job sequence.

Drop A out, select the **next smallest** time. There is a tie in two stages for two different jobs. In this case, place the job with the smallest time in the **first** stage as early as possible in the unfilled job sequence.

Then place the job with the smallest time in the **second** stage as **late** as possible in the unfilled sequence.

Job Sequence	1	2	3	4
Job Assigned	D	B	C	A

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Shop-Floor Control: Major Functions

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1. Assigning priority of each shop order
2. Maintaining work-in-process quantity information
3. Conveying shop-order status information to the office

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Shop-Floor Control: Major Functions (Continued)

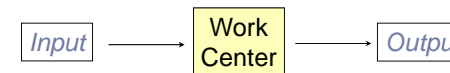
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4. Providing actual output data for capacity control purposes
5. Providing quantity by location by shop order for WIP inventory and accounting purposes
6. Providing measurement of efficiency, utilization, and productivity of manpower and machines

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Input/Output Control

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- ▶ *Planned input* should never exceed *planned output*
- ▶ Focuses attention on bottleneck work centers

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Principles of Work Center Scheduling

1. There is a direct equivalence between work flow and cash flow
2. The effectiveness of any job shop should be measured by speed of flow through the shop
3. Schedule jobs as a string, with process steps back-to-back
4. A job once started should not be interrupted
5. Speed of flow is most efficiently achieved by focusing on bottleneck work centers and jobs

Principles of Job Shop Scheduling (Continued)

6. Reschedule every day
7. Obtain feedback each day on jobs that are not completed at each work center
8. Match work center input information to what the worker can actually do
9. When seeking improvement in output, look for incompatibility between engineering design and process execution
10. Certainty of standards, routings, and so forth is not possible in a job shop, but always work towards achieving it

Personnel Scheduling in Services

- ▶ Scheduling consecutive days off
- ▶ Scheduling daily work times
- ▶ Scheduling hourly work times

Ref: Workload/scheduling at United Airlines: SSU9.avi

Question Bowl

A Work Center may be which of the following?

- a. **A single machine**
- b. **A group of machines**
- c. **An area where a particular type of work is performed**
- d. **All of the above**
- e. **None of the above**

Answer: d. All of the above

Question Bowl

When work is assigned to a work center simply based on what is needed over time, we would refer to this as which of the following scheduling systems?

- a. A finite loading of work
- b. An infinite loading of work
- c. Forward scheduling
- d. All of the above
- e. None of the above

Answer: b. An infinite loading of work

Question Bowl

Typical scheduling and controlling of operations include which of the following functions?

- a. Allocating orders at work centers
- b. Allocating equipment at work centers
- c. Allocating personnel at work centers
- d. All of the above
- e. None of the above

Answer: d. All of the above

Question Bowl

Typical scheduling and controlling of operations include which of the following functions?

- a. Determining the job sequences
- b. Dispatching
- c. Expediting late and critical orders
- d. All of the above
- e. None of the above

Answer: d. All of the above

Question Bowl

The major functions of a shop-floor control are which of the following?

- a. Conveying shop-order status
- b. Measuring efficiency
- c. Assigning priorities
- d. Maintaining WIP quantity information
- e. All of the above

Answer: e. All of the above (Correct answer can also include providing quantity by location and actual output data.)

Question Bowl

Which of the following is a Principle of Work-Center Scheduling?

- a. **There is a direct equivalence between work flow and cash flow**
- b. **Certainty of routings are very possible in a shop**
- c. **Reschedule only once a week**
- d. **All of the above**
- e. **None of the above**

Answer: a. There is a direct equivalence between work flow and cash flow (There are nine other principles.)
