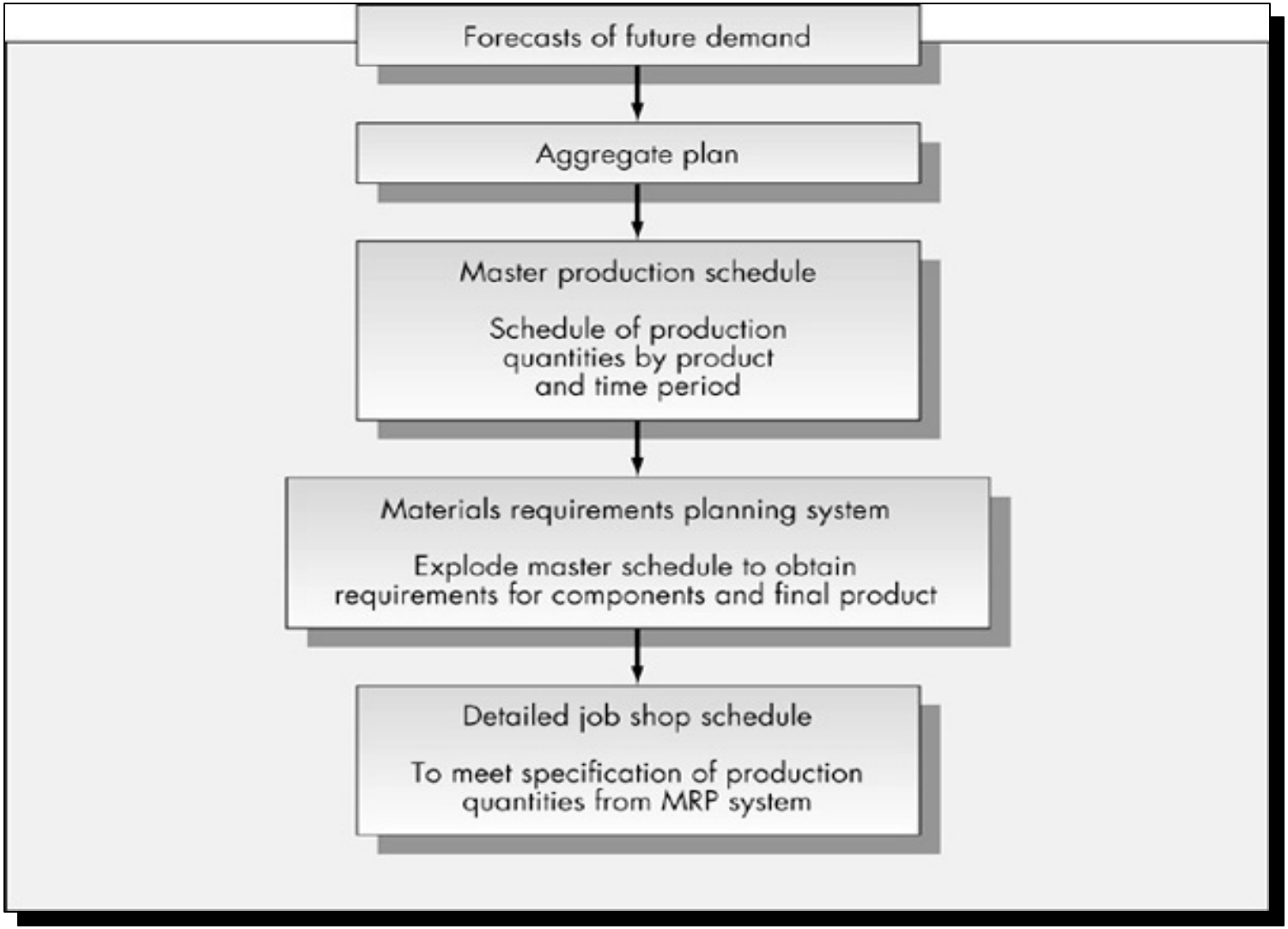
IE375 Spring 2024

Additional Notes
for Scheduling

Hierarchy of Production Decisions



Characteristics of the Job Shop Scheduling Problem

- Machine environment :
  - Number and Variety of Machines,
  - Flow Patterns
  - Processing Characteristics
- Sometimes decomposable
- Bottleneck machine
- Objective
- Complicated: Evaluation of Alternative Rules
  - Job Arrival Pattern
  - Number and skill level of workers

Objectives in Job Shop Scheduling

- Meet due dates
- Minimize work-in-process (WIP) inventory
- Minimize average flow time
- Maximize machine/worker utilization
- Reduce set-up times for changeovers
- Minimize direct production and labor costs

(note: that these objectives can be conflicting)

Terminology

- Flow shop: n jobs processed through m machines in the same sequence
- Job shop: the sequencing of jobs through machines may be different, and there may be multiple operations on some machines.
- Parallel machines : May be identical or not

- Flow time of job i: Time elapsed from initiation of first job until completion of job i.
- Makespan: Flow time of the job completed last.
- Tardiness: The positive difference between the completion time and the due date.
- Lateness: Difference between completion time and due date (may be negative).

Scheduling Problems in Operations

- Job Shop Scheduling
- Assembly Line Balancing
  - (6th Edition - 8.10 or 7th Edition –9.10)
- Project Scheduling
  - (6th Edition - Chapter 9 or 7th Edition – Chapter 10)
- Dynamic versus Static Scheduling
- Personnel Scheduling
- Vehicle Scheduling and Routing
- Scheduling Courses, Exams

Common Sequencing Rules

- FCFS - First Come First Served - Jobs processed in the order they come to the shop.
- SPT - Shortest Processing Time - Jobs with the shortest processing time are scheduled first.
- EDD - Earliest Due Date - Jobs are sequenced according to their due dates.
- CR- Critical Ratio. Compute the ratio of processing time of the job and remaining time until the due date. Schedule the job with the largest CR value next.
- Index Rules

Stochastic Scheduling: Static Case

- Single machine case. Suppose that processing times are random variables. If the objective is to minimize average expected weighted flow time, jobs are sequenced according to expected weighted SPT. That is, if job times are $t_1, t_2, \ldots,$ and the respective weights are $w_1, w_2, \ldots$ then job i precedes job $i+1$ if

$$E[t_i]/w_i < E[t_{i+1}]/w_{i+1}.$$

(Similar to WSPT rule with processing times replaced by their expected values)

Stochastic Scheduling: Static Case (continued)

- Johnsons algorithm for scheduling n jobs on two machines in the deterministic case has a natural extension to the stochastic case as long as the job times are exponentially distributed.

Stochastic Scheduling: Dynamic Analysis

- When jobs arrive to the shop dynamically over time, queueing theory provides a means of analyzing the results.
  - M/M/1, ..., G/GI/1 queues: random arrivals to a single machine with random processing times.
  - **Little's Law : $L=\lambda W$**
- If the selection discipline does not depend on the flow times, the mean flow times are the same, but the variance of the flow times will differ.
- If job times are realized when the job joins the queue rather than when the job enters service, SPT generally results in lowest expected flow time.

Use of simulation

- A reasonable way of evaluating a few policies
- A reasonable way of showing your policy versus current
- Not straightforward!
  - Detail level
  - Comparison metrics
  - You need to have an approach to simulate

How to approach a Real Machine Scheduling Problem?

- Analyze and deal only with the “significant” part
- Set measures that are important
- Check whether there is a reported “optimal” approach for any of the measures
- If none – heuristic – use of known results to come up with an intuitive approach (approaches)
  - Check special cases – should work
  - Approaches to improvement of the solution
  - Test your approach – artificial data – simulation - ...