

IEOR 4405

Lecture 1 Introduction

Scheduling

- **Topics in this class**
 - Modeling and formulating scheduling problems
 - Algorithms for solving scheduling problems
 - Understanding “hard” vs. “easy” problems
- **Analysis Tools**
 - Algorithm design and analysis of running times
 - Solution quality
 - NP-completeness
 - Probability
 - Linear programming
 - Dynamic programming

Four Components of a Scheduling Problem

1. Processes/Tasks
2. Resources/Machines
3. Constraints
4. Objectives

Example: Project Scheduling – System Installation

- Development and installation of trading tools for the Frankfurt Stock Exchange by Deutsche Borse Group
 - *Tasks*: 300 software projects
 - *Resources*: 1500 employees divided into 200 types
 - *Constraints*: Projects may be interrelated by
 - Precedence constraints
 - Milestones
 - Joint use of resources
 - *Objective*: minimize makespan (schedule length)

Example: Hot Strip Mill Production Scheduling

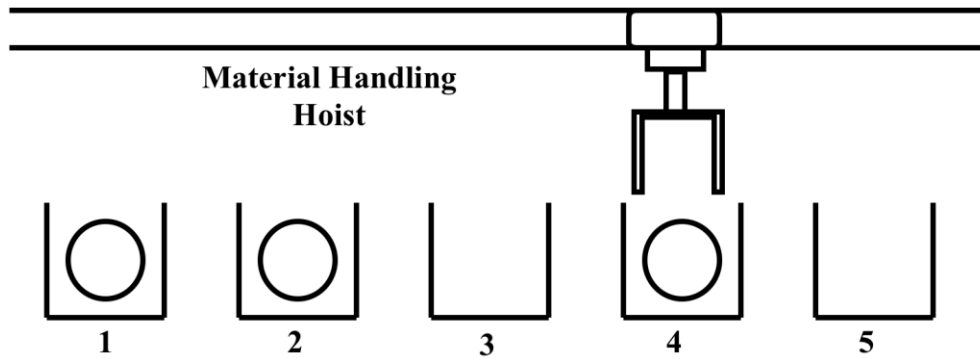
- Integrated Steel plant, Acme Steel, Chicago
- The mill transforms large bars of steel into coils of sheet
 - *Tasks:* Orders for some quantity and types of coils
 - *Resources:* Machines
 - *Constraints:*
 - Product quality restrictions
 - Process efficiency standards
 - *Objectives:*
 - Minimize set up times
 - Minimize energy usage
 - Minimize number of delays orders

Flight Crew Scheduling

- At American Airlines, crew costs are the 2nd highest component of direct operating cost
 - *Tasks: Flights*
 - *Resources: Crews*
 - *Constraints:*
 - Union work rules
 - Safety rules
 - Limits on flight time, connection time, maintainance time
 - *Objective:* Minimize the total cost (salary, hotel expense, etc.)

Example: Robot Scheduling in a Circuit Board Production Line

- Control of robots requires real-time scheduling
- A circuit board must be sequentially processed within a series of chemical tanks
- A board can stay in a tank for a fixed time, otherwise it becomes defective



**Material Handling
Hoist**

Chemical Tanks

Robot Control (cont)

- *Tasks:* Circuit Boards
- *Resources:* Chemical tanks
- *Constraints:*
 - Fixed sequence of jobs
 - Robot can move one job at a time from tank to tank
- *Objective:* maximize throughput (rate that jobs are finished)

Sequencing of Commercial Breaks by a TV Network

- Management of commercial airtime at Channel 4
- Scheduling 5 minute breaks across 6 regions
- *Tasks:* Commercials
- *Resources:* Time spots in regions
- *Constraints:*
 - *No overlaps or gaps*
 - Advertisers may express preferences for certain spots
- *Objective:*
 - Maximize profitability of commercials sold

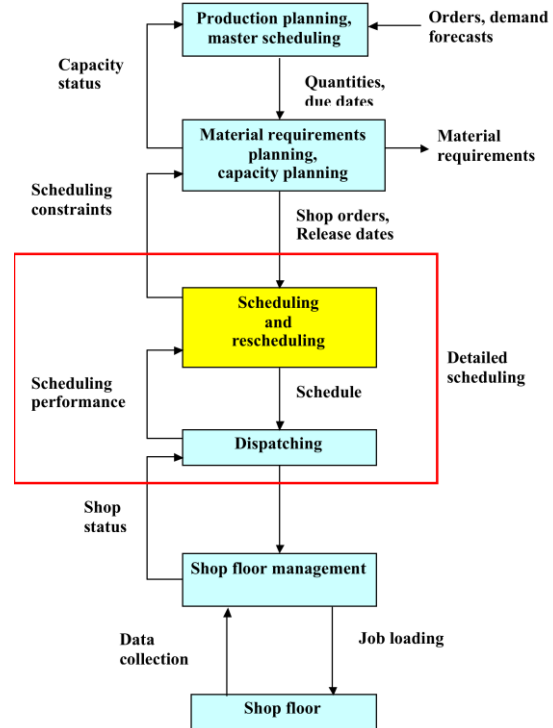
Assigning CPU time to Tasks in a Data Center

- Companies such as Amazon, Google, Facebook run large data centers and need to allocate time to processing tasks
 - *Tasks*: Computing jobs with processing times, priorities, arrival times, etc.
 - *Resources*: Computers (homogeneous or heterogeneous)
 - *Constraints*: Precedence constraints, use of memory or disk
 - *Objective*: Response time or fairness or energy usage or

Automobile Factory

- *Tasks: Car*
- *Resources: Machines and Labor*
- *Constraints:*
 - Precedence constraints on the various parts of the car, e.g. tires, axles, glass, body ..
 - Each machine can work on one car at a time
 - Each worker can work on one car at a time
- *Objective: Throughput*

Scheduling in Manufacturing



Scheduling in Services

