IO543: Scheduling

Lecture 1

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Today:

- Course summary and expectations
- Introduction to scheduling

My Background

- IBM (2001-2005)
- Mayo Clinic (2005-2007)
- Department of Industrial & Systems Engineering, NC State University (2007-2012)
- Research interests: optimization under uncertainty, applications in healthcare delivery and medicine

Course Contact Information

Instructor: Brian Denton
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Email: btdenton@umich.edu
Office Hours: Tues 1-2, Thurs 3-4, and by appt.

Go to CTools for: syllabus, calendar, lectures, assignments

Note: Syllabus and course calendar are subject to change. Please check the web site regularly.

Course Goal and Prerequisites

The goal of this course is for you to develop an understanding of the theory, methods, and applications of scheduling

This course assumes knowledge of:

- Undergraduate linear algebra, calculus, probability theory, and linear programming

We will also use Dynamic and Integer Programming in this class.

Course Summary

Meet twice per week (T/TH 10:30am – 12:00pm)

Course grading:

- Assignments approximately every 10 days: 15% of final grade (due at start of class, 20% deducted per day late)
- Midterm Exam: 30% of final grade (take home)
- Final exam: 40% of final grade
- In-Class assignments and participation: 15%

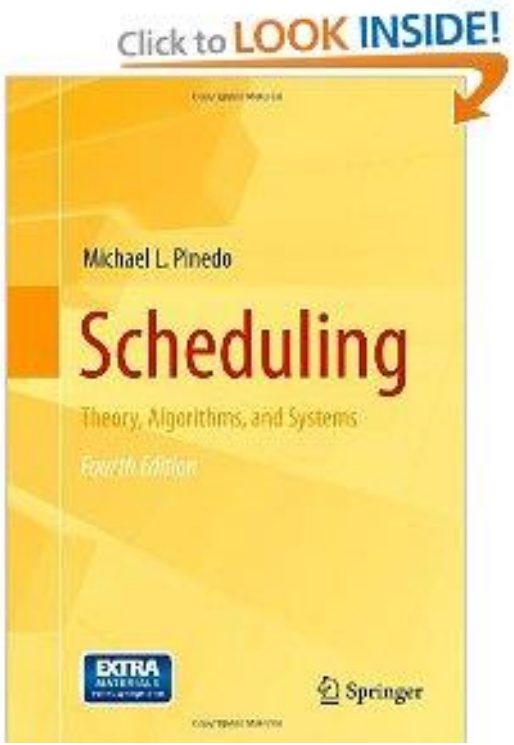
Grading

The final grade will be determined as follows:

- $97 \leq A+ \leq 100$
- $93 \leq A < 97$
- $90 \leq A- < 93$
- $87 \leq B+ < 90$
- $83 \leq B < 87$
- $80 \leq B- < 83$
- $77 \leq C+ < 80$
- $73 \leq C < 77$
- $70 \leq C- < 73$
- $67 \leq D+ < 70$
- $63 \leq D < 67$
- $60 \leq D- < 63$
- $F < 60$

I reserve the right to make “epsilon” changes based on effort and participation in class

Textbook



Following are also good supplementary references:

- "Integer Programming", L.A. Wolsey, 1998, John Wiley and Sons
- The Art and Theory of Dynamic Programming, Stuart Dreyfus and Averill Law, 1977

Full text available online through UM Library subscription
http://mirlyn.lib.umich.edu/Record/011493451

Expectations

MICHIGAN ENGINEERING
UNIVERSITY of MICHIGAN ■ COLLEGE of ENGINEERING

You:

Be on-time and participate in class

Turn off your phones, tablets, computers…

The work you hand in will be your own (assignments, tests, and exams are not collaborative)

Me:

Teach

Give you timely feedback

Be available during posted office hours

In-Class Work

We will engage in ***active learning*** in this class.

You will work in groups of 2-3 on a problem that uses the skills that you acquire. It is important to stay on top of the reading.

Some problems will be “in-class assignments”.

Rules for in-class assignments:

1) Hand in one solution to the problem will all names
2) Graded out of 3 points
3) You can ask me for help, but not the answer
4) Stop working when the assignment is done

Approximate Schedule

Week 1: Introduction to Scheduling

Weeks 2-3: Complexity Theory, Single Machine Models

Weeks 4-5: Parallel Machine Models, Project Scheduling

Weeks 6-7: Complex Scheduling Systems

Weeks 8-10: Stochastic Scheduling Models

Week 11: Online Scheduling

Week 12-14: Applications: Manufacturing, Services, and others

First Class Survey

Introduction to Scheduling

Definition (Oxford Dictionary):

Noun

A plan for carrying out a process or procedure, giving lists of intended events and times.

Verb

Arrange or plan (an event) to take place at a particular time.

Applications

- Nanomanufacturing
- Flight scheduling
- Elections
- Commercials
- Sports
- Computing
- Astronomy
- Medicine
- Military Operations
- Construction
- Finance
- Zombies

Sports Applications

Harvard Sports Analysis built a computer program to design a schedule to visit all 30 baseball stadiums in the shortest time.

Questions:

What criteria define a “good schedule?

What data is required to solve this problem?

Read more at:

http://online.wsj.com/article/SB10001424052702303657404576357560436672964.html

Gene Sequencing

Shotgun sequencing is a process in which biological samples pass through consecutive steps of processing.

Each sample has a certain processing priority, arrival date, and due date for completion.

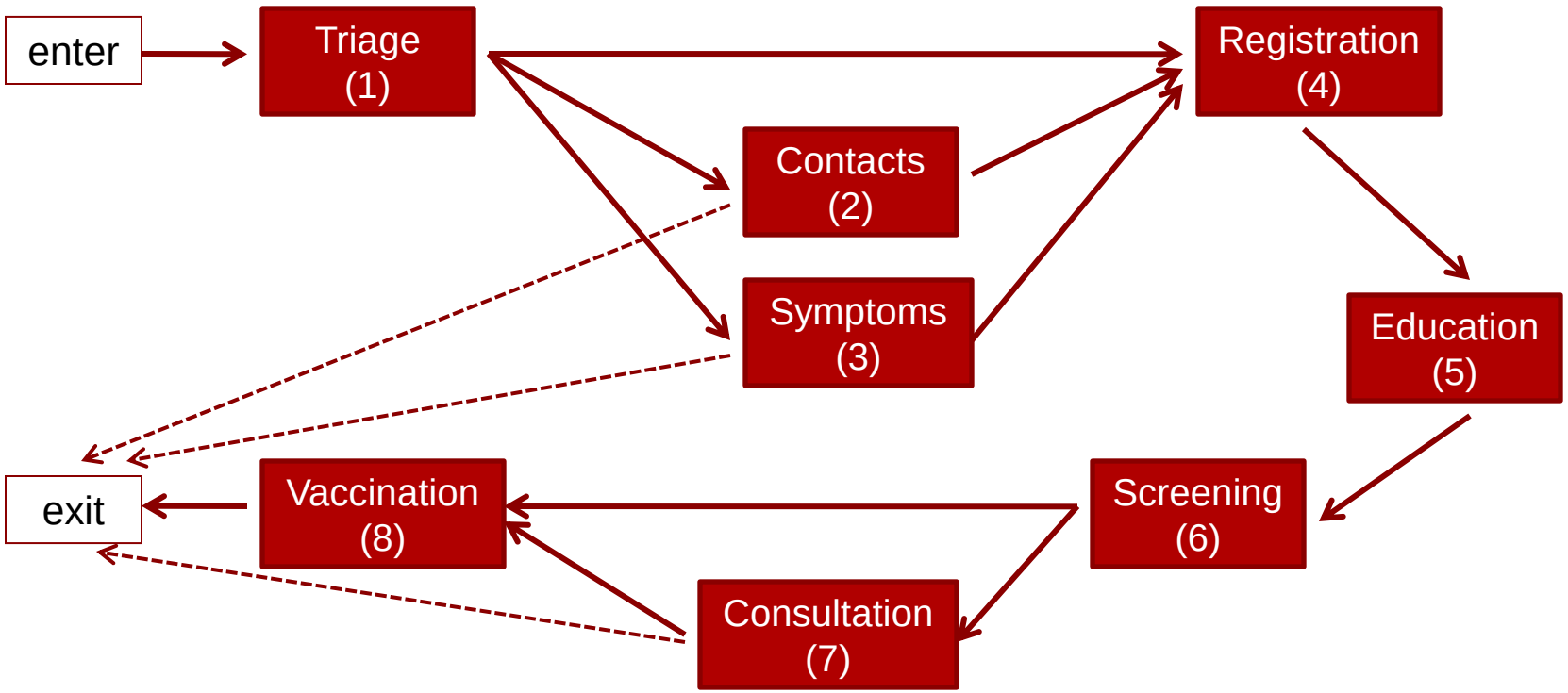
Strand	Sequence
Original	AGCATGCTGCAGTCATGCTTAGGCTA
First shotgun sequence	AGCATGCTGCAGTCATGCT------- ----------TAGGCTA
Second shotgun sequence	AGCATG---------- ------CTGCAGTCATGCTTAGGCTA
Reconstruction	AGCATGCTGCAGTCATGCTTAGGCTA

Read more at:

http://dspace.mit.edu/handle/1721.1/54214

POD Scheduling

Points of Dispensing (PODs) are used for mass dispensing of vaccines during emergencies:



Read more at: Aaby, et al. Montgomery County's Public Health Service Uses Operations Research to Plan Emergency Mass Dispensing and Vaccination Clinics. *Interfaces*, 36(6), pp. 569–579, 2006.

Central Questions

Important questions that the field of scheduling seeks to answer:

- How can the vast range of scheduling problems be classified?
- Which problems are easy and which are hard?
- How can scheduling problems be solved?

Parts of a Scheduling Problem

Scheduling problems involve:

- One or more resources called ***machines***
- One or more activities called ***jobs***
- Criteria for evaluating schedules (e.g. completion time, makespan, tardiness,…)
- Characteristics of jobs (e.g. processing times, due dates, weights,..)

Data

Data for scheduling problems includes:

- **Jobs:**
  - Processing time
  - Release dates
  - Due dates
  - Importance measure
  - Precedence Constraints
  - Routing
- **Scheduling Environment**
  - Number of machines
  - Machine speeds
  - Setup times
  - Batch sizes
  - Availability
  - Preemptions

Single Machine Scheduling

The simplest scheduling problem of all is the **single machine scheduling** problem

<u>Example:</u> Given job processing times, p_j:

Jobs	1	2	3	4
p_j	6	4	2	1

What sequence will minimize total completion time?

Single Machine Scheduling

<u>Example:</u> Given job processing times, p_j, and weights, w_j:

Jobs	1	2	3	4
w_j	12	4	8	1
p_j	6	4	2	1

What sequence will minimize the total weighted completion time?

Multiple Machine Scheduling

More complex problems involve multiple machines:

- Parallel machines
- Flow shops
- Job Shops

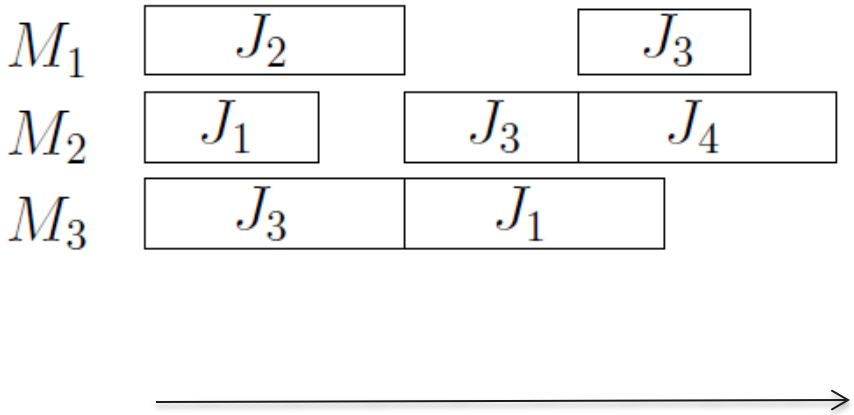
Classification

Classify each of the following:

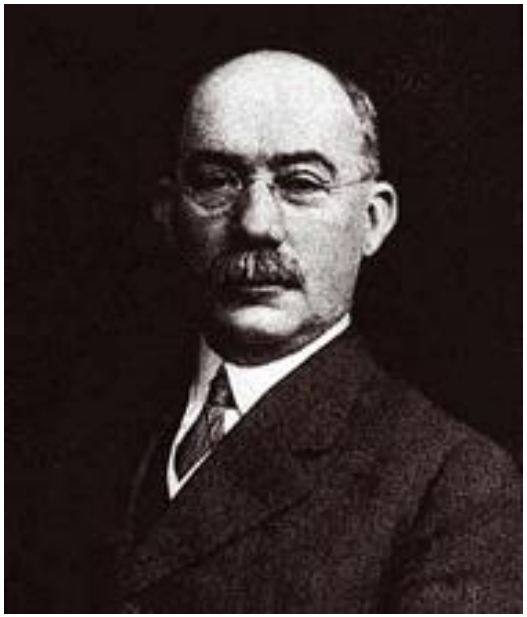
Visualizing a Schedule

A **Gant Chart** illustrates a schedule in a simple form:

Job-Centered



Time



Henry Gant

Parallel Machine Scheduling

<u>Example:</u> Given 2 machines and the following job processing times

Jobs	1	2	3	4	5	6
p_j	5	4	3	7	1	2

and precedence constraints:

Draw a Gant chart for the minimum **makespan** schedule.

Classification

Scheduling problems are described by a triplet:

$$\alpha|\beta|\gamma$$

α defines the machine environment, β defines processing characteristics and constraints, and γ defines the criteria.

Next Time

Read Sections 2.1 and 2.2 of *Pinedo*. Come prepared to classify scheduling problems.

Learn this stuff →

Preview

Next class you will be given several problems to classify like the following:

<u>Problem Description:</u> There are 5 machines in series. Each job must be processed on each machine and all jobs have to follow the same route. Jobs have release dates and due dates and the goal is to minimize average tardiness.

What is the triplet $\alpha|\beta|\gamma$ for this problem?