IO543: Scheduling

Lecture 23

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Announcements

Project presentations next week

-Plan for 8 minutes to leave time for 1-2 questions or comments

-Send me your slides <u>no later than 10am</u> the morning of the presentation (bring a backup on a flashdrive)

Project Schedule

April 12:

Semiconductor Manufacturing: Yixing Lu, Yuzhi Wan, Xue Huang

Scheduling Commercials on TV: David Sachs, Bevin Mathew

Learning Effects in Scheduling: Ling Ken, Chao Xia, Wensi Wang and Chengwei Zhai

Ship Production Scheduling: Lauren Claus, Daniel Kilcullen, Seng-Hsiang Lin

Patient Scheduling in Clinics: Armando Bernal, Victor Fuentes, Seok Joo Kwak, Jamie Yap

Job Shop Problems with Earliness and Lateness Objective: Wenbo Sun, Qi He

Airport Runway Scheduling: Michael Bruk, Martha Neubauer, and Eleanore An.

Project Schedule

April 14

Uber Dispatching: Zhengyang Wun, Ji Wu, Xiaoying Qing

Scheduling in the Olympics: Christine Abney, Amada Bayagich, Eric Buchsbaum, Lauren Fitzpatrick

Nurse Scheduling: Kelly Ogiesoba, Matt Rouhana, Joe Scherping

Baseball Scheduling: Maria Lopez, Anthony Sciuto, Alejandro Vigo

Medical Procedure Scheduling: Esmaeil Keyvanshokooh, Ece Sanci, Karmel Shehadeh

The South U Dilemma: Olivia Melendez, Jacob Villareal, Mitch McKinstry

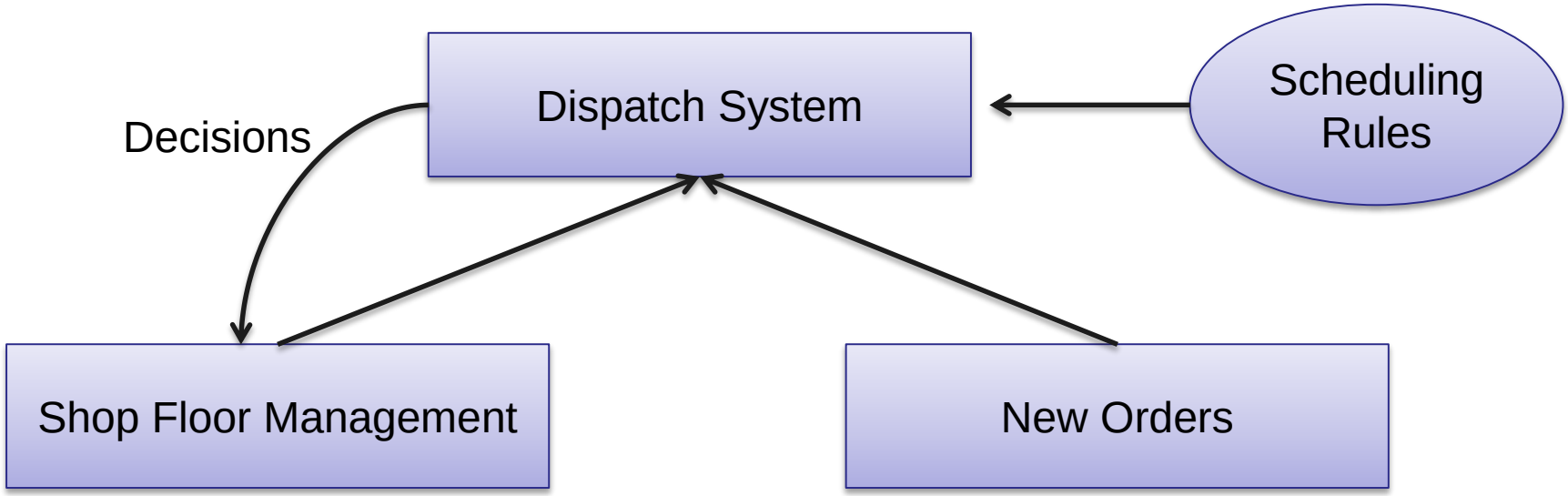
Today

Last IOE543 lecture!

- Scheduling in practice
- Differences between service and manufacturing systems
- Final exam

Dispatching Rules in Practice

In practice, dispatch rules often use limited data to make decisions at discrete “trigger points” in time



Dispatching

Dispatching rules are sequencing rules that define a priority list of jobs waiting in queue at a machine:

- Each machine acts **autonomously**, maintaining its own priority list
- Rules can be **static** or **dynamic**
- Some dispatching rules **look ahead** to other machine queues

Dispatching Rules

Examples of dispatching rules:

	RULE	DATA	ENVIRONMENT	SECTION
1	EDD	d_j	$1\|\|L_{max}$	3.2
2	SPT	p_j	$P_m\|\|\sum C_j$	5.3 ; 6.1
3	WSPT	w_j, p_j	$P_m\|\|\sum w_j C_j$	3.1; 5.3
4	LPT	p_j	$P_m\|\|C_{max}$	5.1
5	JR	p_j	$F_2\|\|C_{max}$	6.1
6	CP	p_j,$prec$	$P_\infty\|prec\|C_{max}$	5.1
7	SST	s_{jk}	$1\|s_{jk}\|C_{max}$	4.4

Dispatching Rules

Following is an example of a dispatching rule that adapts to the system state:

Example: The Minimum Slack (MS) rule is **a dynamic dispatching rule** that orders all jobs waiting in queue at time *t* according to $max(d_j - p_j - t, 0)$

At some time *t* job *j* may have a higher priority than job *k*, but at a later time the jobs may have the same priority allowing for a different rule to break ties (e.g. EDD to minimize max lateness).

Example

Given a set of jobs with due dates:

	J1	J2	J3	J4	J5	J6	J7
p_j	3	1	5	1	2	4	4
d_j	4	6	2	1	3	5	6

What is the sequence at t=0, t=1, ….?

Dispatching Rules

Composite rules combine dispatching rules into a single rule to address multiple criteria

Example: $1 \mid \mid \sum w_j T_j$ can be solved via branch-and-bound, but this may be computationally prohibitive. Potential heuristics include:

- MS (optimal when due dates are loose)
- WSPT (optimal when release dates and due dates are zero)

These rules can be combined using a single index:

$$I_j(t) = \frac{w_j}{p_j} \exp\left(-\frac{\max(d_j - p_j - t, 0)}{K}\right)$$

Dispatching Rules

Dispatching rules may be **local** or **global**

- EDD is an example of a **local rule**
  - Only the current machines queue is considered
- The shortest queue at the **next operation** (SQNO) rule is an example of a **global rule**
  - Every time a machine is freed the job with the shortest queue on the **next machine** is selected

Service Systems

What characteristics distinguish scheduling of service systems from manufacturing systems?

Service Systems

"Jobs" and
"Machines" don't care about **fairness** but people do

Customers:

- Waiting time
- Quality of Service

Servers:

- Overtime
- Workload

Service Systems

In some cases the **perception** of waiting can be changed:

Examples:

- Pediatric hospitals
- Automotive services
- Dental practices

Service Systems

Human behavior plays a role in service scheduling

Often there are opportunities to "**game**" a service system

Examples:

- Schedule adherence
- Priority Adherence

Other behavioral considerations

- Customer no-shows, server no-shows
- Service system characteristics may change over time due to:
  - Learning effects
  - Fatigue
  - Response to service system congestion

Final Exam

IOE543 Final Exam: April 27, 10:30-12:30, Room 1610 IOE

The final exam will cover all topics but the focus will on material since the midterm

You may bring:

- a single 8.5”x11” sheet of paper with notes on both sides
- calculator without wireless capability

Grading

Summary grades up on ctools soon

I will drop the worst in-class and homework assignment

Course grading:

- Homework Assignments 15% of final grade
- Midterm Exam: 30% of final grade
- In-Class assignments: 10%
- Presentations: 5%
- Final exam: 40% of final grade

Studying for the Exam

Things to use for studying:

- Lecture materials
- In-class and homework assignments
- Assigned readings in Pinedo

Come to office hours with questions

Structure of the Final

Some short answer questions such as:

- True or False…
- Why does the XXXX Heuristic tend to work well?
- Provide an example of $Pm||Cmax$ for which LPT is suboptimal

Some questions similar to assignment and midterm questions (except no AMPL)

Class Evaluations

Please complete your class evaluations if you have not already