Educational Timetabling

What is Educational Timetabling?

• The process of assigning classes (or exams) to times and locations
• A difficult optimization problem with many competing objectives
  ◦ Student conflicts, faculty requirements, space constraints
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Why is it Needed?

• Minimize student conflicts to help students receive degrees on time
• Help use limited resources more effectively
• Make process more transparent and sustainable (no one point of failure)
• Fairness and satisfaction with the timetable
• What-if scenarios
• Ability to adapt to changes (curriculum, facilities, etc.)
Currently there is a Gap Between Research and Practice

• Practice: timetables are created manually
  ◦ Often reuse prior timetable as much as possible
• Research: the problem has been extensively studied
  ◦ Subject of a lot of focus over the last two decades
  ◦ Numerous useful algorithms have been developed that can be applied
  ◦ Computers are becoming fast enough to solve large scheduling problems
Introducing UniTime

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How UniTime Bridges this Gap

• Began as a research project in 2000
  ◦ Goal of producing an automated course timetabling solution for a large university
  ◦ Makes use of latest timetabling research
• Has become a useful enterprise system meeting university timetabling needs
Introducing UniTime

Comprehensive Academic Scheduling Solution

- Course and exam timetabling, individual student schedules, and events
- System uses state-of-the-art optimization algorithms
- Open Source, web-based, written in Java using modern technologies
- Distributed data entry and timetabling in multi-user environments
Course Timetabling

Constraints

• Rooms sizes, equipment, and availability
• Faculty time and room preferences
• Structures of courses that are offered
• Student course demands
  ◦ Curricula, pre-registration, last-like course enrollments, etc.

Goal

• Assign class times and locations such that
  ◦ All required constraints are met
  ◦ Other desirable objectives are satisfied as much as possible
    - Minimize student conflicts
    - Accommodate time and room preferences
    - Allow preferred class time distributions
    - Fairness
    - Minimize travel times
A student cannot take a combination of courses

1. Classes overlap in time
   - or one after the other in rooms that are too far apart

2. There is not enough space in a non-overlapping combination of classes

- Biology and Chemistry lectures have a time conflict
- Students taking Math have choice, unless they need Statistics as well
- Students taking Chemistry need the lecture and one of two possible labs
Course Structure

Classes are Organized by the Course Structure

- Intuitive data entry and display of classes and their requirements
- Helps to define how students can enroll into the course
- Additional relations can be derived from the structure

<table>
<thead>
<tr>
<th>Course</th>
<th>Limit</th>
<th>Date</th>
<th>Pattern</th>
<th>Minutes</th>
<th>Per Week</th>
<th>Time</th>
<th>Pattern</th>
<th>Time</th>
<th>Room</th>
<th>Distribution</th>
<th>Instructor</th>
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<tbody>
<tr>
<td>MA 170</td>
<td>40</td>
<td>Statistics I</td>
<td>Introductory statistics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Classroom</td>
<td>Same Room</td>
<td>G. Newman</td>
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<tr>
<td>STAT 170</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EDUC</td>
<td>CompPr</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>ThtrSeat</td>
<td>Classroom</td>
<td></td>
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<tr>
<td>Lab 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td>CompPr</td>
<td>J. Smith</td>
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<tr>
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<td>CompPr</td>
<td>J. Smith</td>
</tr>
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</table>
Constraint-based Solver

- Can be used in modes between manual and fully automated
- State of the art methods
  - Work published in refereed journals
  - Winner of the International Timetabling Competition 2007
- Easy to extend

<table>
<thead>
<tr>
<th>Score</th>
<th>Class</th>
<th>Date</th>
<th>Time</th>
<th>Room</th>
<th>Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>+15.2</td>
<td>POL 101 Lec 3</td>
<td>Full Term</td>
<td>TTh 12:00p → TTh 7:30a</td>
<td>BRNG 2280</td>
<td>+11</td>
</tr>
<tr>
<td>+31.7</td>
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<td>Full Term</td>
<td>TTh 12:00p → TTh 10:30a</td>
<td>BRNG 2280</td>
<td>+36 (h+3)</td>
</tr>
<tr>
<td></td>
<td>HIST 342 Lec 1</td>
<td>Full Term</td>
<td>TTh 10:30a → TTh 1:30p</td>
<td>BRNG 2280 → BRNG 2290</td>
<td></td>
</tr>
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<td>Full Term</td>
<td>TTh 12:00p → TTh 10:30a</td>
<td>BRNG 2280</td>
<td>+36 (h+4)</td>
</tr>
<tr>
<td></td>
<td>HIST 342 Lec 1</td>
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<td>BRNG 2280</td>
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<td></td>
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<td>TTh 3:00p</td>
<td>BRNG 2290 → LWSN B155</td>
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</table>

(all 1571 possibilities up to 3 changes were considered, top 4 of 17 suggestions displayed)
Multi-user Environment

- Allows for distributed timetabling with sharing of resources
  - Rooms, instructors, and students
- Typical use: distributed data entry + centralized timetabling
  - Data are entered by schedule managers in each academic unit
  - Course timetable is produced by a central timetabling office
Course Management

Lifecycle of a Course Timetable

1. Data entry
2. Automated timetabling (solver is used to compute a timetable)
3. Timetabling adjustments (interactive changes)
4. Student scheduling, classes start
5. Additional, ad-hoc (mostly room) changes made throughout the term
6. Roll-forward of selected data into the next like term
Why is Scheduling Needed?

- To ensure that students will be able to get the courses they need when multiple sections are offered
  - Earlier enrolling students may block later students from being able to get needed courses

Classes MA Lec (b) and CHM Lab (b) fill early

Students can no longer take Math and Chemistry combination
Student Scheduling

Goal

Enroll students to classes in a way that maximizes the ability of students to get the courses they need

- Student fills in course requests
  - Including priorities, alternatives, and their own time availability
- System suggests a schedule that best meets student needs
- Students can make later modifications to schedule
Option I: Batch (one time)
• All students are scheduled at one time after the timetable is produced based on student pre-registrations
• An optimization process, using the (student scheduling) solver

Option II: Online (real-time)
• Students without pre-registrations (e.g., incoming freshmen) can enroll online
• All students can make adjustments to their schedules
• Automatically hold space in sections based on expected student demand
• Reservations, automated wait-list processing, instructor consents, advisor roles, etc.
Other Features

Examination Timetabling

- An exam can be offered for a class, a course, or a combination of these
- Multiple examination problems (final exams, mid-term exams, etc.)
- Each exam is assigned to an examination period and one (or more) rooms
- Student conflicts are minimized
  - Direct conflicts, more than two exams on a day, back-to-back exams
Other Features

Event Management

• Management of the remaining classroom space
• Fully distributed, including an (optional) approval process

And more

• Data exchange, room distances (travel times), date patterns, …
UniTime Provides a State-of-the-Art Timetabling Solution

- Can be used for course timetabling, examination timetabling, student scheduling, and event management
- Is very general and can be used on many higher education institutions
- Is easy to extend and/or customize
- Has been applied at large institutions (up to 40,000 students)
- Is gaining interest from institutions around the world
- Has recently entered the Apereo incubation process

For more details, please see us at the conference

- Tech Demo Reception Tuesday at 5:30p
- Or visit www.unitime.org

An online demo is available at http://demo.unitime.org
Questions
Thank You