Open Apereo 2016
100% Open for Education

UniTime 101
Zuzana Müllerová, Tomáš Müller
Workshop Plan

• UniTime
• Introduction of the four modules
• Administration

The UniTime 101 presentation is available at http://goo.gl/aCINuy
What is UniTime?

- Comprehensive academic scheduling solution
- Four components
  - Course timetabling
  - Examination timetabling
  - Student scheduling
  - Event management
- Open source, web-based, written in Java using modern technologies
- Using state-of-the-art optimization algorithms
- Distributed data entry and timetabling in multi-user environments
- First used at Purdue University in 2005
- Apereo project since 2015
Course Timetabling
What is Course Timetabling?

• The process of assigning *times* and *rooms* to *classes*
• Creating a course timetable for *students*
• Respecting various restrictions and preferences
  • Courses: size, room equipment, structure, …
  • Instructors: availability, preferred times, …
  • Students: curricula, pre-registrations, …
  • Other: number of rooms available and their sizes, …
• It is a difficult optimization problem
Course Timetabling

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
• Fairness and satisfaction with the timetable
• What-if scenarios
• Ability to adapt to changes (curriculum, facilities, etc.)
1. Distributed or centralized data entry
   • Rooms, instructors, courses
   • Requirements and preferences

2. Distributed or centralized timetabling
   • Automatically generated timetable
   • Manual computer aided modifications

3. Course management
   • Once a timetable is published
Data Entry

Administrative Tasks

• Academic session setup
• Roll-forward

Data Entry

• Courses
• Instructors
• Rooms
• Relations between courses / classes (distribution preferences)
• Curricula (plans of study)
# Data Entry: Courses

## Instructional Offering

<table>
<thead>
<tr>
<th>Limit</th>
<th>Date 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>
</tr>
</thead>
<tbody>
<tr>
<td>MA 170</td>
<td>40</td>
<td>Statistics I</td>
<td>Introductory statistics</td>
<td>50</td>
<td>1 x 50</td>
<td></td>
<td>Classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STAT 170</td>
<td></td>
<td></td>
<td></td>
<td>------</td>
<td>---------</td>
<td>------</td>
<td>------------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
<td>Full Term</td>
<td>50</td>
<td>1 x 50</td>
<td></td>
<td></td>
<td>Classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td>40</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td></td>
<td></td>
<td>EDUC CompPr</td>
<td>Same Room</td>
<td></td>
</tr>
<tr>
<td>Lec 1</td>
<td>40</td>
<td>Full Term</td>
<td>50</td>
<td>1 x 50</td>
<td></td>
<td></td>
<td>ThtrSeat Classroom</td>
<td>G. Newman</td>
<td></td>
</tr>
<tr>
<td>Lab 1</td>
<td>20</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td></td>
<td></td>
<td>EDUC CompPr</td>
<td>Same Room</td>
<td>J. Smith</td>
</tr>
<tr>
<td>Lab 2</td>
<td>20</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td></td>
<td></td>
<td>EDUC CompPr</td>
<td>Same Room</td>
<td>J. Smith</td>
</tr>
</tbody>
</table>
### Course Offerings

<table>
<thead>
<tr>
<th>Course</th>
<th>Limit</th>
<th>Date Pattern</th>
<th>Minutes</th>
<th>Per Week</th>
<th>Time Pattern</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lecture</td>
<td>40</td>
<td>Full Term</td>
<td>50</td>
<td>1 x 50</td>
<td>Classroom</td>
<td>G. Newman</td>
</tr>
<tr>
<td>Laboratory</td>
<td>40</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td>EDUC CompPr</td>
<td></td>
</tr>
<tr>
<td>Lec 1</td>
<td>40</td>
<td>Full Term</td>
<td>50</td>
<td>1 x 50</td>
<td>ThtrSeat Classroom</td>
<td></td>
</tr>
<tr>
<td>Lab 1</td>
<td>20</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td>EDUC CompPr</td>
<td>Same Room  J. Smith</td>
</tr>
<tr>
<td>Lab 2</td>
<td>20</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td>EDUC CompPr</td>
<td>Same Room  J. Smith</td>
</tr>
</tbody>
</table>
# Data Entry: Courses

## Instructional Offering

### Course Offerings

## Scheduling Subparts

<table>
<thead>
<tr>
<th>Course</th>
<th>Limit</th>
<th>Date Pattern</th>
<th>Minutes</th>
<th>Per Week</th>
<th>Time</th>
<th>Room</th>
<th>Distribution</th>
<th>Instructor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 170</td>
<td>40</td>
<td>Full Term</td>
<td>50</td>
<td>1 x 50</td>
<td></td>
<td>Classroom</td>
<td>Same Room</td>
<td>G. Newman</td>
</tr>
<tr>
<td>STAT 170</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td></td>
<td>EDUC CompPr</td>
<td>Same Room</td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td>40</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td></td>
<td>EDUC CompPr</td>
<td>Same Room</td>
<td>J. Smith</td>
</tr>
<tr>
<td>Lec 1</td>
<td>40</td>
<td>Full Term</td>
<td>50</td>
<td>1 x 50</td>
<td></td>
<td>ThtrSeat Classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab 1</td>
<td>20</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td></td>
<td>EDUC CompPr</td>
<td>Same Room</td>
<td>J. Smith</td>
</tr>
<tr>
<td>Lab 2</td>
<td>20</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td></td>
<td>EDUC CompPr</td>
<td>Same Room</td>
<td>J. Smith</td>
</tr>
<tr>
<td>Lecture</td>
<td>Lab 1</td>
<td>Lab 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>--------</td>
<td>--------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limit</td>
<td>40</td>
<td>20</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pattern</td>
<td>Full Term</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minutes</td>
<td>50</td>
<td>150</td>
<td>150</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Week</td>
<td>1 x 50</td>
<td>3 x 50</td>
<td>3 x 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>Classroom</td>
<td>EDUC CompPr</td>
<td>EDUC CompPr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pattern</td>
<td>ThtrSeat Classroom</td>
<td>Same Room</td>
<td>Same Room</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Room</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
<td>EDUC CompPr</td>
<td>EDUC CompPr</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instructor</td>
<td></td>
<td>J. Smith</td>
<td>J. Smith</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Course Offerings**

- **MA 170**: Statistics I (Introductory statistics)
- **STAT 170**: Statistics I (Introductory statistics)

**Scheduling Subparts**

**Classes**
Data Entry: Dates and Times

Date Patterns

• Weeks of instructions (All weeks, Even/Odd weeks, Week 5, …)

Time Patterns

• Possible time slots within a week
### Data Entry: Rooms

**Rooms**

- Each department may have a different set of rooms
- Some times may be unavailable or given to a different department

**K 73**

<table>
<thead>
<tr>
<th>Mon</th>
<th>Tue</th>
<th>Wed</th>
<th>Thu</th>
<th>Fri</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30a-8:00a</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>8:00a-8:30a</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>8:30a-9:00a</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>9:00a-9:30a</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>9:30a-10:00a</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>10:00a-10:30a</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>10:30a-11:00a</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>11:00a-11:30a</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>11:30a-12:00p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>12:00p-12:30p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>12:30p-1:00p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>1:00p-1:30p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>1:30p-2:00p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>2:00p-2:30p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>2:30p-3:00p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>3:00p-3:30p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>3:30p-4:00p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>4:00p-4:30p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>4:30p-5:00p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>5:00p-5:30p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>5:30p-6:00p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
<tr>
<td>6:00p-6:30p</td>
<td>BIOL</td>
<td>CIVC</td>
<td>CIVC</td>
<td>N/A</td>
</tr>
</tbody>
</table>

- Room coordinates, travel times

<table>
<thead>
<tr>
<th>A 50</th>
<th>D 20</th>
<th>K 73</th>
<th>140A</th>
<th>JAMU</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 50</td>
<td>5</td>
<td>5</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>D 20</td>
<td>5</td>
<td>0</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td>K 73</td>
<td>5</td>
<td>0</td>
<td>17</td>
<td>22</td>
</tr>
<tr>
<td>140A</td>
<td>19</td>
<td>17</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>JAMU</td>
<td>22</td>
<td>20</td>
<td>22</td>
<td>10</td>
</tr>
</tbody>
</table>
Data Entry: Room Preferences

Minimal Room Size

• Calculated from class limit and room ratio

Room Preferences

• Particular room or building
• Room group
• Room feature

<table>
<thead>
<tr>
<th>Room Groups:</th>
<th>Geology Classroom (Department)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td></td>
</tr>
<tr>
<td>Rooms:</td>
<td>B 11</td>
</tr>
<tr>
<td>Buildings:</td>
<td>Y - Porici 7, budova Y</td>
</tr>
<tr>
<td>Room Features:</td>
<td>Data Projector</td>
</tr>
<tr>
<td>Available Rooms:</td>
<td>34 (A 51, A 53, A 54, A 55, ...)</td>
</tr>
</tbody>
</table>
Data Entry: Distributions

Distribution Preferences

- Relationship between two or more classes
- Examples
  - Back-To-Back
  - Same Room
  - Same Days
  - Meet Together
  - At Most 6 Hours A Day
  - Can Share Room
- Set directly between classes / subparts or on an instructor
Instructors

- Each department has a list of instructors
  - Connection between departments through external id
- Instructor availability (prohibited times)
- Instructor preferences & requirements
  - Time, room, distribution
Combination of preferences

- Preferences can be set on scheduling subpart, class, or instructor
- The end result is displayed on the class and used by the solver

<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>
</tr>
</thead>
<tbody>
<tr>
<td>MA 170</td>
<td>40</td>
<td></td>
<td>Statistics I</td>
<td>50</td>
<td>1 x 50</td>
<td></td>
<td></td>
<td></td>
<td>Classroom</td>
<td>Same Room</td>
<td></td>
</tr>
<tr>
<td>STAT 170</td>
<td></td>
<td>Introductory statistics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lecture</td>
<td>40</td>
<td>Full Term</td>
<td>50</td>
<td>1 x 50</td>
<td></td>
<td></td>
<td></td>
<td>Classroom</td>
<td>Same Room</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory</td>
<td>40</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EDUC CompPr</td>
<td>Same Room</td>
<td>J. Smith</td>
</tr>
<tr>
<td>Lec 1</td>
<td>40</td>
<td>Full Term</td>
<td>50</td>
<td>1 x 50</td>
<td></td>
<td></td>
<td></td>
<td>ThtrSeat Classroom</td>
<td>Same Room</td>
<td>G. Newman</td>
<td></td>
</tr>
<tr>
<td>Lab 1</td>
<td>20</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EDUC CompPr</td>
<td>Same Room</td>
<td>J. Smith</td>
</tr>
<tr>
<td>Lab 2</td>
<td>20</td>
<td>Full Term</td>
<td>150</td>
<td>3 x 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>EDUC CompPr</td>
<td>Same Room</td>
<td>J. Smith</td>
</tr>
</tbody>
</table>
Curricula

• For a group of students of the same major and classification
• Requested enrollment
• List of courses and their expected attendance
• Courses can be grouped together (same / different students)

Last year’s enrollments
Pre-registration

Other possible sources: historical enrolments, pre-registrations, or their combination
Importance of having good input data

- The solution will only be as good as the input data
- No preferences
  - A class can end up anywhere (unpopular time, wrong room)
- Too many requirements
  - Impossible to find a complete timetable
  - Too many student conflicts
  - Difficult to make modifications
Constraint-based Solver

• Can be used in modes between manual and fully automated

• State of the art
  ◦ Work published a number of research papers
  ◦ Winner of the International Timetabling Competition 2007

• Easy to extend

Suggestions

<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></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>
<td>POL 101 Lec 3</td>
<td>Full Term</td>
<td>TTh 12:00p → TTh 10:30a</td>
<td>BRNG 2280</td>
<td>+36 (h+3)</td>
</tr>
<tr>
<td>+36.6</td>
<td>POL 101 Lec 3</td>
<td>Full Term</td>
<td>TTh 10:30a → TTh 1:30p</td>
<td>BRNG 2290 → BRNG 2290</td>
<td></td>
</tr>
<tr>
<td>+44.1</td>
<td>POL 101 Lec 3</td>
<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>
<td>Full Term</td>
<td>TTh 10:30a → TTh 7:30a</td>
<td>BRNG 2280</td>
<td></td>
</tr>
<tr>
<td></td>
<td>HIST 342 Lec 1</td>
<td>Full Term</td>
<td>TTh 3:00p</td>
<td>BRNG 2290 → LWSN B155</td>
<td>+34 (h+2)</td>
</tr>
</tbody>
</table>

(all 1571 possibilities up to 3 changes were considered, top 4 of 17 suggestions displayed)
Timetabling: Problem

Model

- Variable: class
- Value: time and room placement
- Constraints: hard and soft
Timetabling: Problem

Model

• Variable: class
• Value: time and room placement

Hard Constraints

• Room size, sharing, availability
• No instructor / room can have two classes at the same time
• Required or prohibited preferences
Timetabling: Problem

Model
- Variable: class
- Value: time and room placement

Hard Constraints
- Room size, sharing, availability
- No instructor / room can have two classes at the same time
- Required or prohibited preferences

Soft Constraint (Objectives)
- Time, room, and distribution preferences
- Student conflicts
- Additional criteria (too big rooms, back-to-back instructors, …)
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.
Using the Solver

1. Make sure the problem has a solution
   - All classes are assigned
   - Using \texttt{check} configuration
   - Conflict-statistics can be used to discover issues

\begin{itemize}
\item 15851\times C S 110 Lec 1
\item 6384\times MW 1:30p - 2:20p Full Term EE 129 KING, ERIC J
\item 6318\times Instructor KING, ERIC J
\item 5771\times C S 110 Lec 2 \Leftarrow MW 1:30p - 2:20p Full Term EE 129 KING, ERIC J
\item 3541\times MW 12:30p - 1:20p Full Term LILY 1105 KING, ERIC J
\item 3019\times Instructor KING, ERIC J
\item 2931\times C S 110 Lec 2 \Leftarrow MW 12:30p - 1:20p Full Term LILY 1105 KING, ERIC J
\item 3467\times MW 12:30p - 1:20p Full Term EE 129 KING, ERIC J
\item 3408\times Instructor KING, ERIC J
\item 2932\times C S 110 Lec 2 \Leftarrow MW 12:30p - 1:20p Full Term EE 129 KING, ERIC J
\item 2459\times MW 1:30p - 2:20p Full Term LILY 1105 KING, ERIC J
\item 1268\times Room LILY 1105
\item 1265\times BIOL 221 Lec 1 \Leftarrow MWF 1:30p - 2:20p Full Term LILY 1105 SANDERS, DAVID
\item 1191\times Instructor KING, ERIC J
\item 1191\times C S 110 Lec 2 \Leftarrow MW 1:30p - 2:20p Full Term LILY 1105 KING, ERIC J
\item 15840\times C S 110 Lec 2
\item 2588\times BIOL 221 Lec 1
\item 338\times AGEC 217 Lec 3
\end{itemize}
Using the Solver

1. Make sure the problem has a solution
2. Run the solver to produce a timetable
   - Using default configuration
   - It is possible to iterate (if needed), or start the solver from the previous timetable
Timetabling: Solver

Using the Solver

1. Make sure the problem has a solution
2. Run the solver to produce a timetable
3. Once there is a decent timetable
   • Make manual changes, using interactive configuration

Solver Configuration: it is possible to tweak solver parameters if needed
(all 1571 possibilities up to 3 changes were considered, top 4 of 17 suggestions displayed)

(there is a tradeoff between times, rooms, distributions, and student conflicts)
Making changes

1. Minimal Perturbation Mode (MPP)
   - When many changes are needed
   - Fully automated (default configuration with the mode set to MPP)
   - Additional criterion: changes from the initial solution
   - Different weights, e.g., time changes are usually more penalized

2. Once there is a timetable saved, use the interactive configuration
   - Can break some constraints
   - Solver provides suggestions, but does not make any decisions

3. When the timetable is published
   - Changes can be made without loading the data into the solver
Decentralized Timetabling

- Defined by solver groups
  - One or more departments that are to be solved together
- Committed solutions of other problems are used as basis
- Multiple problems can be solved together, manual changes can be made separately

Externally Managed Classes

- For instance, distance learning classes are solved separately
- Different set of rooms
- Timetabled before or after the departmental problems
- Other examples: large lecture rooms, computing labs, need room
Publication

• A committed timetable can be published by changing the status on the academic session
• Instructors and students can see the timetable

Next steps
• Export to an external system
• Student scheduling
• Examination timetabling
• Event 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
Workshop Demo Instance

• A college with about 6,000 students
• 24 departments entering the data
• Distributed data entry, centralized timetabling
  • Distance learning timetabled separately
  • For this workshop, the timetabling has been decentralized
• Shared resources (especially rooms)
• Student demands based on curricula
• Loosely based on the College of Education, Masaryk University

• Web: demo.unitime.org/workshop
• Accounts: user001/pwd001 … user051/pwd051
<table>
<thead>
<tr>
<th>User</th>
<th>Department</th>
<th>Courses</th>
<th>Classes</th>
<th>Instructors</th>
</tr>
</thead>
<tbody>
<tr>
<td>20, 26, 48</td>
<td>Art</td>
<td>57</td>
<td>154</td>
<td>43</td>
</tr>
<tr>
<td>38, 40</td>
<td>Biology</td>
<td>33</td>
<td>111</td>
<td>41</td>
</tr>
<tr>
<td>14, 49</td>
<td>Civics</td>
<td>58</td>
<td>95</td>
<td>21</td>
</tr>
<tr>
<td>17, 18, 28, 42</td>
<td>Czech</td>
<td>114</td>
<td>225</td>
<td>32</td>
</tr>
<tr>
<td>15, 30, 36</td>
<td>English</td>
<td>157</td>
<td>250</td>
<td>50</td>
</tr>
<tr>
<td>1, 22</td>
<td>French</td>
<td>56</td>
<td>81</td>
<td>18</td>
</tr>
<tr>
<td>24, 33</td>
<td>Geography</td>
<td>25</td>
<td>43</td>
<td>19</td>
</tr>
<tr>
<td>8, 12, 34</td>
<td>German</td>
<td>78</td>
<td>133</td>
<td>20</td>
</tr>
<tr>
<td>27, 47</td>
<td>Health Ed</td>
<td>21</td>
<td>39</td>
<td>17</td>
</tr>
<tr>
<td>6, 32</td>
<td>History</td>
<td>39</td>
<td>93</td>
<td>49</td>
</tr>
<tr>
<td>4, 45</td>
<td>IT</td>
<td>49</td>
<td>95</td>
<td>20</td>
</tr>
<tr>
<td>9, 10</td>
<td>Language</td>
<td>23</td>
<td>89</td>
<td>14</td>
</tr>
<tr>
<td>23, 25, 29</td>
<td>Mathematics</td>
<td>53</td>
<td>104</td>
<td>27</td>
</tr>
<tr>
<td>41, 51</td>
<td>Music</td>
<td>59</td>
<td>196</td>
<td>17</td>
</tr>
<tr>
<td>37, 46</td>
<td>Pedagogy</td>
<td>17</td>
<td>76</td>
<td>28</td>
</tr>
<tr>
<td>2, 7, 31, 35, 43</td>
<td>Physics</td>
<td>170</td>
<td>416</td>
<td>84</td>
</tr>
<tr>
<td>5, 19</td>
<td>Prime Ped</td>
<td>34</td>
<td>99</td>
<td>16</td>
</tr>
<tr>
<td>16</td>
<td>Psychology</td>
<td>40</td>
<td>109</td>
<td>14</td>
</tr>
<tr>
<td>21, 39</td>
<td>Physical Ed</td>
<td>24</td>
<td>64</td>
<td>16</td>
</tr>
<tr>
<td>11, 50</td>
<td>Russian</td>
<td>83</td>
<td>156</td>
<td>18</td>
</tr>
<tr>
<td>13</td>
<td>Social Ed</td>
<td>89</td>
<td>136</td>
<td>75</td>
</tr>
<tr>
<td>3, 44</td>
<td>Special Ed</td>
<td>135</td>
<td>231</td>
<td>74</td>
</tr>
</tbody>
</table>
Examination Timetabling
What is Examination Timetabling?

- The process of assigning examinations to time periods and locations
- A difficult optimization problem with many competing objectives
  - Student conflicts, faculty requirements, space constraints

Why is it needed?

- The traditional process of mapping lecture times to examination periods does not really work
- More choices for courses mean more potential scheduling conflicts
- Make process easier to manage, fairness and satisfaction, what-ifs

Many flavors

- Final examinations, evening examinations, mid-terms, …
- Additional objectives
### Input Data

- Examinations *(with students enrolled in them)*
- Periods *(not overlapping, can have various durations)*
- Rooms *(with capacities, availabilities, and period preferences)*
- Individual examination requirements and preferences
- Distribution constraints *(same/different room, same/different period, precedence)*

### Evening Examinations

- Mondays - Thursdays
- 6:30p - 7:30p or 8p - 10p
- 3 days & early / late
- 2-3 exams for a course
- Student availability

<table>
<thead>
<tr>
<th>from:</th>
<th>to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00a</td>
<td>10:00a</td>
</tr>
<tr>
<td>10:30a</td>
<td>12:30p</td>
</tr>
<tr>
<td>1:00p</td>
<td>3:00p</td>
</tr>
<tr>
<td>3:30p</td>
<td>5:30p</td>
</tr>
<tr>
<td>7:00p</td>
<td>9:00p</td>
</tr>
</tbody>
</table>

- **Required**
- **Strongly Preferred**
- **Preferred**
- **Neutral**
- **Discouraged**
- **Strongly Discouraged**
- **Prohibited**
### Example Data Entry

#### Final Examinations

<table>
<thead>
<tr>
<th>Classes / Courses</th>
<th>Length</th>
<th>Seating Type</th>
<th>Size</th>
<th>Max Rooms</th>
<th>Instructor</th>
<th>Period Preferences</th>
<th>Room Preferences</th>
<th>Distribution Preferences</th>
<th>Assigned Period</th>
<th>Assigned Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGMT 20000</td>
<td>120</td>
<td>Exam</td>
<td>881</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Thu 12/12 7:00p</td>
<td>LAMB F101</td>
</tr>
<tr>
<td>MGMT 20010 50874-T01</td>
<td>120</td>
<td>Exam</td>
<td>205</td>
<td>4</td>
<td></td>
<td></td>
<td>PHYS 114</td>
<td>PHYS</td>
<td>Mon 12/09 8:00a</td>
<td>WTHR 200</td>
</tr>
<tr>
<td>MGMT 20100</td>
<td>120</td>
<td>Exam</td>
<td>437</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Thu 12/12 3:30p</td>
<td>STEW 183</td>
</tr>
<tr>
<td>MGMT 29000B 23766-002</td>
<td>120</td>
<td>Exam</td>
<td>36</td>
<td>4</td>
<td></td>
<td></td>
<td>KRAN</td>
<td></td>
<td>Fri 12/13 10:30a</td>
<td>KRAN G016</td>
</tr>
<tr>
<td>MGMT 30400</td>
<td>120</td>
<td>Exam</td>
<td>115</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Tue 12/10 1:00p</td>
<td>LILY 1105</td>
</tr>
<tr>
<td>MGMT 30500 23769-001</td>
<td>120</td>
<td>Exam</td>
<td>280</td>
<td>4</td>
<td>RAWL</td>
<td></td>
<td>RAWL</td>
<td>Same Per</td>
<td>Wed 12/11 1:00p</td>
<td>WTHR 200</td>
</tr>
<tr>
<td>MGMT 30500 23771-003</td>
<td>120</td>
<td>Exam</td>
<td></td>
<td></td>
<td>RAWL</td>
<td></td>
<td>RAWL</td>
<td>Same Per</td>
<td>Wed 12/11 1:00p</td>
<td>WTHR 104</td>
</tr>
<tr>
<td>MGMT 30500 23772-004</td>
<td>120</td>
<td>Exam</td>
<td></td>
<td></td>
<td>RAWL</td>
<td></td>
<td>RAWL</td>
<td>Same Per</td>
<td>Wed 12/11 1:00p</td>
<td>WTHR 172</td>
</tr>
<tr>
<td>MGMT 30500 23773-005</td>
<td>120</td>
<td>Exam</td>
<td>70</td>
<td>4</td>
<td>RAWL</td>
<td></td>
<td>RAWL</td>
<td>Same Per</td>
<td>Wed 12/11 1:00p</td>
<td>WTHR 172</td>
</tr>
<tr>
<td>MGMT 30600</td>
<td>120</td>
<td>Exam</td>
<td>236</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mon 12/09 8:00a</td>
<td>STEW 183</td>
</tr>
</tbody>
</table>
Examination Problem

Hard Constraints

• No two exams in the same period and room
• Examination must fit the period and room (or rooms)
• Room must be available
• An exam cannot be placed in a period or a room that is prohibited
• Required *(hard)* distribution constraints must be satisfied
Examination Problem

Soft Constraints / Objectives

- Direct conflicts
- More than two exams on a day
- Back-to-backs
- Period, room, and distribution penalties

... and a few others

- Minimize room splits *(and the distance between these rooms, if an exam is split)*
- Distance to original room *(i.e., the room where the class took place)*
- Large exams first
- Rotation *(average period)*
Examination Solver

Solver

- Same solver as in course timetabling, different model
  (variable: exam, value: period and room placement)
- Can handle large problems
  (e.g., Purdue has around 1900 exams with 120k enrollments and 29 periods)
- Easy to extend and customize

- It is possible to use just the solver (without UniTime user interface)
  - See http://www.unitime.org/cpsolver_examples.php

- It is possible to use UniTime just for exams
- However, because exams take student data from courses and/or classes
  - A course structure with classes is needed (but can be simplified)
  - Students and their class enrollments
Student Scheduling
Student Scheduling

What is Student Scheduling?
• Enrollment of student into classes in a way that maximizes the ability for students to get the courses they need

Why is it needed?
• To ensure that students will be able to get the courses they need in a multi-section environment
• Students who come early may block later students from being able to get the courses they need
• Getting a workable schedule can be a tedious process for a student

Goal
• Student fills in course requests, including alternatives, free times, etc.
• System provides a schedule that meets student needs
• Students have the ability to modify their schedule
Step 1: Course Timetabling

- Minimizing student conflicts together with faculty preferences
- Last-like student course enrollments
- Curricula (e.g., list of courses for each program and year)
- Courses Requests (pre-registration)
- A combination of these
Step 2: Batch Student Scheduling

- After a timetable is produced
- Using pre-registrations and student course demand projections
- To provide students with initial schedules
- An optimization process, using the (student scheduling) solver
- It is possible to iterate
  - With the ability to keep already enrolled students unchanged or to minimize changes
Student Scheduling Process

Step 3: Online Student Scheduling

- Students without pre-registration can enroll online (incoming freshmen and students that did not register)
- All students can make adjustments to their schedules
- Automatically reserve space in sections based on historical data
- Solver provides suggestions
  - Ordered by their quality, with the ability to filter through
Course Requests

- Each requested course can have up to two alternatives (or it can be wait-listed)
- There can also be additional alternate course requests to get the desired number of courses
- There can be free time requests in the list
Student Schedule

- As complete as possible (alternatives are used when a course is not available)
- Priorities are used to resolve conflicts
- The amount of overlapping time is minimized (where allowed)
- Distance conflicts are minimized (consequent classes too far)

Additional Criteria

- Avoid over-expected classes
- Keep previous schedule
- Section balancing
- Avoid arrange hour classes
- Keep students of the same group together (batch)
Other Features

- Expectations (avoid over-expected classes, if possible)
- Automated wait-listing
- Consent of instructor, department
- Linked classes
- Reservations (individual, student group, course, curriculum)
- Allow time conflicts (for a course, for a request, between classes)
- Course management (locking)
- Enrollment deadlines
- Email notifications
- Dashboard, student change logs
- Reports
- User roles, student statuses, mass cancel, customizations, …
Event Management
What is Event Management?

- Booking rooms for events
- Process
  - Anybody can enter a request for reservation
  - Event manager approves / rejects / inquires further
Event Management

Why is it needed?

• Accurate information about room availability
• Searchable information about scheduled student’s or instructor’s activities in one place
  • Course timetable
  • Course related events
• Examinations
• Student’s room reservations
Event Management

Features

• Committed timetables are displayed here
• Lookup of available rooms by certain criteria
• Extensive filtering capabilities
• Personal timetables (students, instructors)
• Export to ical or other formats
Administration
Installation

- Java
- Tomcat
- MySQL or Oracle
- UniTime
- Instructions at http://help.unitime.org/Timetabling_Installation

Authentication

- LDAP, CAS, …
Initial setup of the system

• Instructional types
  • Lecture, Recitation, …

• Status types
  • Possible statuses of the academic session

• Room types
  • Rooms are sorted by their types in Rooms pages

• Position types
  • Positions of instructors; not essential for timetabling

• There are some defaults in the woebegon database
Academic session setup - new session

• Add a new academic session with important dates

Academic session setup - XML

• Departments
• Subject areas
• Buildings and rooms
• Staff
• Courses
• (Academic areas, classifications, majors, curricula)

Information available at http://www.unitime.org/uct_interfaces.php
Academic session setup - manual

- Solver groups
- Managers
- Date patterns
- Time patterns

And you can start!
Academic session roll-forward

- When there already are academic sessions in UniTime
- Roll-forward most of a session’s data
- Possible to combine data from different sessions
- After roll-forward, it is possible to still use XMLs to update the data
UniTime

• Comprehensive system
• We have covered only the basics

For more details, please see us at the conference

• UniTime: State of the Project (Tuesday, 3pm - 3:45pm in KC 912)
• Student Scheduling in UniTime (Wednesday, 11:45am - 12:30pm in KC 912)
• Or visit www.unitime.org

An online demo is available at https://demo.unitime.org