Getting Started with UniTime

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Agenda

• Short introduction to UniTime
• System administration
• Data organization
• Users, roles, permissions, and statuses
• Data exchange
• Academic session setup
• Course timetabling (demo)
• Examination timetabling
• Event management

This presentation is available at www.unitime.org/present/apereo18-intro.pdf
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
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UniTime Introduction
What is educational timetabling?

- The process of assigning classes (or exams) in time and space
- A difficult optimization problem with many competing objectives
  - Student conflicts, faculty requirements, space constraints

Why is it needed?

- Minimize student conflicts, thus help students receive degrees on time
- Help use resources more effectively
- Makes process easier to manage (knowledge transfer and cooperation)
- Fairness and satisfaction with the timetable
- What-if scenarios
- Ability to adapt to changes
- …
Introducing UniTime

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 problems

Here is where UniTime comes in place

-Began as a research project in 2000
  - Goal of producing an automated course timetabling solution for a large university
- Became an enterprise system meeting many university timetabling needs
Introducing UniTime

What is UniTime?

• Comprehensive academic scheduling solution
• Four components: course timetabling, examination timetabling, student scheduling and 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
• Apero project since March 2015
Course Timetabling

Constraints

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

Goal

• Assign class times and locations such that
  • All hard constraints and other requirements are met
  • 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
Goal

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

- Student fills in course requests
  - Including priorities, alternatives, and their availabilities
- System suggests a schedule that best meets student needs
- Students have the ability to modify their schedule
Examination timetabling

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

- Management of the remaining classroom space
- Fully distributed, including an approval process

And more

- Data exchange, room distances (travel times), date patterns, …
UniTime Setup

Installation

• UniTime can be downloaded from http://builds.unitime.org
• Installation Instructions: help.unitime.org/Timetabling_Installation
  • See Windows, Linux, or Mac specific notes at the bottom of the page
• Hardware Requirement
  • Any system capable of running Java and MySQL/Oracle
  • Linux is recommended, should have enough memory, could be a VM
  • E.g.: 8 cores, 12 GB RAM, 100 GB drive
  • Oracle database is recommended for production environments
• Prerequisites
  • Java, MySQL or Oracle Database, Apache Tomcat
  • Cluster containing web servers and remove solver serves
  • For larger institutions (and especially when students can access)

Do not forget the -Xmx parameter and the MySQL/Oracle JDBC driver!
UniTime Setup

Cluster

- One or more web servers (Apache Tomcat / UniTime.war)
- One or more remote solver servers (Java)
- JGroups Clusters
  - Hibernate L2 Cache (web servers only)
  - Solver Cluster (RPCs)
  - Online Student Scheduling Server replications (optional)
Customization

• Custom properties
  • Application Configuration page
  • Custom properties file
• Custom CSS, welcome message, disclaimer, menu content & style
• Much more, see the Application Configuration page for the list

Authentication

• By default, the Users page is used
• CAS or LDAP can be configured (or anything else using Spring Security)
• We need an external ID of an authenticated user
  • Students, Instructors, Advisors, Timetable Managers
  • No match: No Role or Anonymous (can be disabled)

See http://help.unitime.org/Customizations for more details.
Localization

- Current locales: en, en_UK, cs
- Use en_UK to switch UniTime to use 24h times and dd.mm.yyyy dates
- Default can be set using unitime.locale property
  - Can be changed per user (User Settings),
  - or for HTTP session with the locale parameter

Translations

- Translations are provided in property files
- Zanata can be used to provide translations
- Czech, French, Polish, Turkish, and a few other (less complete)

See http://help.unitime.org/Localization for more details.
UniTime Data Organization
UniTime Data Organization

Academic Session Independent

• User Roles & Permissions
  • Each permission contains a check (e.g., a schedule manager can only edit classes of his/her department when allowed by session status)
• Statuses (Initial Data Load, Data Entry, Timetabling, Published, Closed)
• Instructional Types (Lecture, Lab, Recitation, …)
• Room Types (Classroom, Computing Lab, Outside Location, …)
• Room Feature Types (Seating Type, Room Configuration, A/V, …)
• Many more (course types, instructional methods, position types, …)
  • See items under Administration > Other menu
• Solver Configuration (could be done much later, based on the data)

UniTime contains good default data for these.
UniTime Data Organization

Academic Session Dependent

- Time Patterns, Date Patterns
- Academic Areas, Classifications, and Majors
- Buildings, Rooms, Room Features, and Room Groups
- Administrative Users (Timetable Managers)
- Departments
- Application Configuration Properties (when needed)
- Examination Periods
Department Dependent

- Users and their permissions
  - Depends on the role (e.g., Session Administrator is a department independent role)
- Subject Areas
  - Courses and their classes
  - Though some classes can be timetabled by a different department (external manager)
- Room Sharing
- Instructors
- Solver Groups
  - A solver group defines what departments are to be timetabled together
Users, Roles, Permissions, Statuses
Users and Roles

• Timetable Managers
  • All administrative users (administrators, schedule managers,…)
  • Session independent, but with relation to departments
  • One or more roles (one primary)
• Instructors
  • One instructor can belong to multiple departments
• Students
  • Related only to an academic session
• Advisors
  • Many to many with students
• No Role (authenticated, but without UniTime role)
• Anonymous (not authenticated)

Using external id of the authenticated user
Permissions

• Defined for each role
  • For each page/operation
  • Few special: Session Default, Session/Department/Status Independent
• Applies to an object in question
• Permission Check
  • Relation to the user’s department
  • Status of session/department
• Example: Class Edit
  • Controlling Department
  • Managing Department (e.g., LLR)
• Department Status
• Online Student Scheduling
Statuses

- Progress of the term
  - Data Entry, Course Timetabling, Timetable Published, Session Finished
- Various levels
  - Academic Session, Department, Examinations (examination type, session), Events (department, room type)
- Helps Control
  - Data Entry (Courses, Exams)
  - Timetabling
  - Student Scheduling
  - Event Management
- Schedule Publication
Manager Roles

System Administrator
- Installation / Updates
- Common Configuration
- Solver Configuration
  (Administration > Other)
- IT Support

University Level
(IT Department)

Session Administrator
- Academic Session Setup
  (Administration > Acad. Session)
- Roll-forward, Data Exchange
- Rooms and Sharing
- Creates Timetable (Runs Solver)
- Makes Timetable Changes
- Supports Schedule Managers

Campus Level
(Registration Office)

Departmental Schedule Manager
- Collects Faculty Requirements
  Instructors
- Courses & Classes
- Requirements & Preferences
- Verifies Timetable

Departmental Level
(One or more departments)
**User Responsibilities (A)**

**System Administrator**
- Installation / Updates
- Common Configuration (Administration > Other)
- Solver Configuration
- Provides IT Support

**Session Administrator**
- Academic Session Setup
- Imports (Catalog, Students) (Administration > Acad. Session)
- Rooms and Sharing
- Support Schedule Managers
- Verifies Input Data
- Creates Timetable (Runs Solver)
- Makes Timetable Changes

**Departmental Schedule Manager**
- Collects Faculty Requirements
- Instructors
- Courses & Classes
- Requirements & Preferences
- Verifies Timetable
- Communicates with Faculty

**University Level**
- (IT Department)

**Campus Level**
- (Registration Office)

**Departmental Level**
- (One or more departments)

**Next Academic**
User Responsibilities (B)

Installation / Updates
Common Configuration
(Administration > Other)
Solver Configuration
Provides IT Support

Session Administrator

Academic Session Setup
Imports (Catalog, Students)
(Administration > Acad. Session)
Rooms and Sharing
Support Schedule Managers

Makes Timetable Changes
Publishes Timetable

Next Academic

University Level
(IT Department)

System Administrator

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Session Administrator

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Imports (Catalog, Students)
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Rooms and Sharing
Support Schedule Managers

Support Schedule Managers

Provides Assistance & Coordination
(may run & commit the solver for all first)

College Level
(Registration Office)

Makes Timetable Changes
Publishes Timetable

Instructors

Campus Level
(Registration Office)

Collects Faculty Requirements
Instructors
Courses & Classes
Requirements & Preferences

Support Schedule Managers

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Next Academic

Instructors
UniTime

Data Exchange
Data Exchange

• A lot of the data can be imported via XML
• Departments, subject areas, rooms, staff, …
• Beware: rooms and staff do not get imported directly
  • Rooms: use Update Data on the Buildings page
  • Staff: use Manage Instructor List on the Instructors page
• Course Offerings XML can be used to import just courses, the whole structure, or anything in between

APIs

• Mostly to get data out of UniTime in real time
• Can be extended as needed

See http://www.unitime.org/uct_interfaces.php for the list of XML interfaces.
See https://goo.gl/L1sEVN for UniTime 4.2 APIs.
XML Interfaces

First Year

• Academic Session Setup
• Date Patterns, Time Patterns,
• Departments, Subject Areas, Solver Groups
• Academic Areas, Classifications, and Majors
• Building and Rooms
• Staff (Instructors)
• Course Catalog
• Student Course Demands

Following Years

• Course Catalog
• Student Course Demands
APIs
• Restful APIs, mostly to get data out of UniTime in real time
• Basic authentication or an API key
• Can be also used to import or export an XML file
• Script execution, HQL reports

Exports
• Mostly CSV or PDF
• Events Management also iCalendar
• A lot of filtering capabilities (especially room and event exports)

Other
• Academic Session Backup/Restore
• Solver XML export

See https://goo.gl/EqG5AA for UniTime 4.2 Exports.
Academic Session Setup

- Dates
  - Session start date
  - Examination start date,
  - Holidays, …
- Date Patterns
- Time Patterns
- Departments
- Subject Areas
- Buildings and Rooms
- Solver Groups
- Timetabling Managers

Most of the UniTime data are related to a particular department

See the online demo http://demo.unitime.org for some examples.
Date Patterns

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

Time Patterns

- Possible time slots within a week

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Departments

- **Organizational units** at a campus
- **Courses** are offered by departments
- **Rooms** and **staff** are related to departments
- **Users** are related to departments
- Some **permissions** (event management, data entry, etc.) can be set on the departmental level
- **Course timetables** are created for courses of a department
Subject Areas

- Help organize courses from a department to meaningful group

- Each course has one subject area, each subject area belongs to one department
Room-related Setup

Buildings

• Buildings can only be entered by the session (or system) administrator
• Usually they are imported from an external source for the first semester and then rolled forward from one semester to the next one
• Mandatory fields: Name, Abbreviation, External ID
Room-related Setup

Rooms

- Rooms within buildings
  - Non-university locations (which are not a part of buildings) can be entered by the departmental schedule managers
- Capacity
- Types of rooms
- Room sharing, availability
- Global room features (available to all departments)
- Global room groups (available to all departments)
- Preference (for each department)
- GPS Coordinates, Travel times, Room pictures, …
- Event department and status
Room-related Setup

Travel times

• Time it takes to get from one location to the other
• Calculated from GPS coordinates or entered in a matrix
• Important for students and instructors

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</tbody>
</table>
Best Practices: Rooms

- Room features can be categorized by feature types (seating type, desk arrangements, audio/video, ...)
- Having good room groups and room features helps with preferences
  - Think about the faculty preferences you may get (E.g., I want a room with a white board and a data projector, which could be used both at the same time)
- Approved events can be used to block certain times in a room.
- There can be pseudo rooms that do not check for overlaps (E.g., off-campus, instructor’s office, hospital)
- Dept. room preferences are useful to minimize use of a room
  - Prohibited … cannot be used (for what-if scenarios)
  - Strongly Discouraged … only when there is a direct preference
  - Discouraged … minimize use of the room (avoid if possible)
Solver Groups

- A solver group consists of **one or more departments** for which a **timetable** should be created
- A timetable can be created for more solver groups together
  - Each solver group can then modify their timetable separately
- Typical cases
  - Campuses with centralized timetabling have one solver group
  - Larger campuses (such as the pilot college) with decentralized timetabling have several solver groups
Student Properties

- Academic Area
  - Program of study (Agriculture, Chemistry, Computer Science)
- Classification
  - Semester / year of study (Freshmen, Sophomore, Junior, Senior)
- Major
  - Field of study / specialization (Databases, Computer Vision, …)
  - Related to academic areas
- A student can have multiple ACMs
- Useful for display & reporting, reservations, in curriculum timetabling, and student grouping (keep students of the same curriculum/group together)

- Minors, Student Groups, Student Accommodations
Best Practices: UniTime Setup

• Make sure UniTime has enough memory, especially for the solver
• Departments & subject areas need to be carefully defined
  • Instructors, room sharing, data entry / access
• Distributed or centralized data entry and/or timetabling
  • Most often: distributed data entry, centralized timetabbling
• Student Course Demands
  • Last-like demands are the easiest to get, but may not be as good
  • Student course requests allows for individual students to be considered
  • Curricula are good, when available
    (can be combined with last-likes for optional course estimates)
Course Timetabling: Data Entry
Data Entry

- Courses
- Rooms
- Instructors
- Relations between courses / classes (distribution preferences)
- Student course demands

Timetabling

- Running the solver
- Manual changes

Additional Administrative Tasks

- Academic session setup
- Roll-forward
### Instructional Offering

<table>
<thead>
<tr>
<th>Course</th>
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<th>Date</th>
<th>Pattern</th>
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# Course Structure

## Instructional Offering

### Course Offerings

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## Instructional Offering

### Course Offerings

#### Scheduling Subparts

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## Course Structure

### Instructional Offering

#### Course Offerings

### Scheduling Subparts

#### Classes

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</table>
**Dates and Times**

**Date Patterns**

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

**Time Patterns**

- Possible time slots within a week

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**March 2015**

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**Time slots**

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**Color codes**

- **Required**
- **Strongly Preferred**
- **Preferred**
- **Neutral**
- **Discouraged**
- **Strongly Discouraged**
- **Prohibited**

Credit: Photo by Environment and Climate Change Canada
Rooms

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

K 73

**Room coordinations, travel times**

<table>
<thead>
<tr>
<th></th>
<th>A 50</th>
<th>D 20</th>
<th>K 73</th>
<th>140A</th>
<th>JAMU</th>
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</table>

K 73
Minimal Room Size

- Calculated from class limit and room ratio

Room Preferences

- Particular room or building
- Room group
- Room feature

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<th>Room Groups:</th>
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<tr>
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<td>Buildings:</td>
<td>Y - Porici 7, budova Y</td>
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<td>Room Features:</td>
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<tr>
<td>Available Rooms:</td>
<td>34 (A 51, A 53, A 54, A 55, ...)</td>
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</table>
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>
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</tbody>
</table>
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

Credit: Photo by Environment and Climate Change Canada
Student Course Demands

Curricula

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

Other possible sources: historical enrollments, course requests, or their combination

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Student Course Demands

Student Course Requests

• A list of courses for each student
  • The courses the student would like to enroll into
  • Ordered by priority (example: mandatory courses first)
• Can be used as input for the student scheduling (that is, creating a schedule of classes for each individual student)
Best Practices: Instructors

• Use instructor preferences in combination with subpart preferences
  • Especially time availability and preferences
• Useful Distribution Preferences *
  • Max N Hours
  • N Hour Work Day
  • Max Blocks
  • Max Breaks
  • N Days a Week

*) Some need to be registered first, see https://goo.gl/ufqW1t for the scripts.
Best Practices: Courses

- There can be multiple configurations
  
  (with different instructional method, e.g., traditional x online)

- If a class does not follow a standard time pattern, it could be split

- Reservations can be used to direct students to the appropriate configurations / classes

- Use cross-lists whenever a course is offered under multiple names

- Meet together constraint can be useful, but use it wisely

- Externally managed departments can be used to timetable some classes as a different problem (large lecture rooms, computing labs)
  
  - It is possible to move control of such classes from the department of the course to the external department with a status change
Best Practices: Subparts and Classes

- Minimal room size: room ratio times class limit
- Classes of a scheduling subpart are spread in time (can be disabled)
- Only matching time patterns are visible
  - *E.g.*, minutes per week = number of meetings × minutes per meeting
- Too many start times result in a bad timetable
  - Too many small holes, hard to swap rooms
# Data Entry: Preferences

## Best Practices: Preferences

- Preferences can be set on scheduling subpart, class, or instructor
- The end result is displayed on the class and used by the solver
- Put as many preferences as possible on instructors and subparts
  - Class overrides can be highlighted in yellow

### Preferences Table

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

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

(all 15/1 possibilities up to 3 changes were considered, top 4 of 1/ suggestions displayed)
Problem

Model

• Variable: class
• Value: time and room placement
• Constraints: hard and soft
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
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 check configuration
   - Conflict-statistics can be used to discover issues
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
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

<table>
<thead>
<tr>
<th>Suggestions</th>
<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>+15.2</td>
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</tr>
<tr>
<td></td>
<td>+36.6</td>
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<td>Full Term</td>
<td>TTh 10:30p → TTh 1:30p</td>
<td>BRNG 2280 → BRNG 2290</td>
<td>+36 (h+4)</td>
</tr>
<tr>
<td></td>
<td>+44.1</td>
<td>HIST 342 Lec 1</td>
<td>Full Term</td>
<td>TTh 10:30p → TTh 7:30a</td>
<td>BRNG 2280</td>
<td>+34 (h+2)</td>
</tr>
</tbody>
</table>

(all 1b/1 possibilities up to 3 changes were considered. top 4 of 17 suggestions displayed)

Solver Configuration: it is possible to tweak solver parameters if needed
(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
Cooperation on Timetabling

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
Best practices: Solver

• Multiple problems can be timetabled together
• Multiple solutions can be saved
• It is important to commit a solution when you wish the assignments to show in other problems
• Use distribution preference priority for problems that are solved before or after the departmental problems (see Departments page)
• Use Reload Input Data when there is a change in the inputs

• Use Chameleon if you want to run several solvers at once
• Create several timetables, then choose the best one
Best practices: Solver parameters

- Optimization can usually be achieved by setting up a combination of solver parameters
- Example: Hard conflict weights
- Example: No student conflicts
- Example: Times are way more important than rooms
- Distance conflict settings (student speed, distances between non back-to-back classes, …)
- Automatic distribution constraints
- …
- Try experiment with various solver settings
Best practices: Making Changes

- Use the Interactive solver (from the Timetables page) to be able to break some hard constraints
- MPP penalization can tell the solver what changes are hard
- Do not use the solver when students are already being enrolled, use Class Assignment page instead
Publishing Timetable
Solution Commit

• There can be multiple solutions saved for each problem (solver group)

• The final one needs to be committed
  • This will tell the other problems what times are taken
  • This will create course related events
  • This will send the class schedule to Banner
  • Other departmental schedule managers will be able to see the schedule (Class Assignments, Events)

• A commit may fail if there is a conflict

• It is still possible to make changes

• Students and instructors cannot see the schedule just yet
Solution Commit

Other Considerations

• If you like the solution, use Save & Commit (especially if multiple rooms are being shared)
  • Room sharing: Free For All
  • Instructor sharing: same external Id

• If some critical resources are being shared, it is advised to
  • run the solver for multiple departments first,
  • save and commit,
  • and then let each department make changes
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
Making Changes

Once there are students enrolled

- It is no longer practical to run the solver to make a change
- Most changes are room swaps
- Use Class Assignment page instead
  - Select a new time and/or room
  - Conflicts are checked
  - It is possible to override a lot of constraints
- Student conflicts are displayed
- Class Detail > Class Assignment
UniTime

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
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
Examination Timetabling

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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

---

### Examination Data

#### Required

<table>
<thead>
<tr>
<th>Time</th>
<th>Monday 12/09</th>
<th>Tuesday 12/10</th>
<th>Wednesday 12/11</th>
<th>Thursday 12/12</th>
<th>Friday 12/13</th>
<th>Saturday 12/14</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10:00a</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>12:30p</td>
<td></td>
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<tr>
<td>1:00p</td>
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<td></td>
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<tr>
<td>3:00p</td>
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<tr>
<td>5:30p</td>
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<tr>
<td>7:00p</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Strongly Preferred

#### Preferred

#### Neutral

#### Discouraged

#### Strongly Discouraged

#### Prohibited

Credit: Photo by Environment and Climate Change Canada
# 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 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>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>PHYS 114</td>
<td></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>PHYS</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>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>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></td>
<td>RAWL 1086</td>
<td>Same Per RAWL</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>
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<td></td>
</tr>
<tr>
<td>MGMT 30500 23772-004</td>
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<tr>
<td>MGMT 30500 23770-002</td>
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<td>Exam</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>MGMT 30500 23773-005</td>
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<td>70</td>
<td>4</td>
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<td>Same Per RAWL</td>
<td>Wed 12/11 1:00p</td>
<td>WTHR 172</td>
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<tr>
<td>MGMT 30600</td>
<td>120</td>
<td>Exam</td>
<td>236</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td>Mon 12/09 8:00a</td>
<td>STEW 183</td>
</tr>
</tbody>
</table>

- **Required**
- **Strongly Preferred**
- **Preferred**
- **Neutral**
- **Discouraged**
- **Strongly Discouraged**
- **Prohibited**
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)

} student conflicts
Event Management

- Management of the remaining classroom space
- Fully distributed, including an approval process
- No billing etc. (just room reservations)
Published Timetable

- Academic session in Timetable Published state
- Events > Timetable
- Personal Schedule
- PDF, CSV, iCalendar Exports
Timetable Managers

- Can use the Events pages to see a schedule once it is committed

Other Users

- Students, Instructors, No Role (authenticated users without a UniTime role), or even anonymous users (no authentication)
- Schedule must be committed
- Class Schedule: session status must allow for Class Schedule
- Examination Schedule: allow Final/Midterm Examination Schedule
- See Administration > Other > Status Types
- Permissions: user role must have Events permission
Other Events

- Need event management to be enabled
- Special Events (name, contact(s), meetings)
- Course-Related Events
- Not-Available Events

Approval Workflow

- Pending, Approved, Rejected, Cancelled
- Pending meeting can be deleted, approved can be only cancelled

Permissions

- Based on Event Department, Room Type pairs
- Can be overridden on individual rooms
- Request: authenticated users, departmental users, event managers
- Approval: automatically approved, event managers, no approval
Event Departments

- Academic session status must allow for Event Management
- Department must allow for events (Departments page)
- Rooms must be associated with an event department (Rooms page)
- Event status not *No Event Management* (Event Statuses, Rooms page)

Event Manager

- Event Manager role (usually related to one or more departments)
- May delegate other users (instructors) from the department

Other Properties

- Event confirmation emails (Application Configuration page)
- Can edit / approve past events (Permissions page)
- Allow modification of class or examination events (Permissions page)
Examples

• Display schedule of a room, and a personal schedule
• Request a special event
• Approve an event

More Details

• Event Manual https://goo.gl/QMQeoR
• Event instruction sheet from Purdue University
Exports

• Many pages have Export PDF or Export CSV buttons

• Events can be exported to iCalendar format

• For events and rooms, it is possible to subscribe to an export URL
Custom Reports

• Custom reports can be written using HQL
• May contain parameters
  • E.g., %DEPARTMENT% will create a drop down with departments
• Requires a good knowledge of the UniTime data model

See http://help.unitime.org/Course_Reports for more details.
Scripts

• Using JSR 223: Scripting for the Java Platform
  • JavaScript or Python, can call UniTime methods
    • For Python, put Jython Standalone JAR to Tomcat/lib
  • Can have parameters (including a file)
  • Can produce a file
  • Convenient for additional administrative tasks, custom CSV imports and exports, etc.
• Some examples are available at https://goo.gl/ufqW1†
• Permission (users with the given permission can run the script)
• Requires knowledge of the UniTime code base
• Allows for automation (new in UniTime 4.3)
• Script API (new in UniTime 4.3)

See http://help.unitime.org/Scripts for more details.
Conclusion

UniTime

• Comprehensive system
• A lot to configure, customize, or otherwise to do
• But the defaults work well

For more details, please see us at the conference

• Getting Started with UniTime (Sunday, 9 am in Liszt)
• UniTime: State of the Project (Monday, 2:30 pm in Debussy)
• UniTime Introduction (Monday, 5:30 pm, Showcase Reception)
• Student Scheduling at Purdue University (Tuesday, 11:15am in Debussy)
• Internationalization of UniTime (Wednesday 11:00 am in Debussy)

• Or visit www.unitime.org

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

• Online Help help.unitime.org
  • Installation Instructions help.unitime.org/Timetabling_Installation
  • Customizations help.unitime.org/Customizations
  • Localization help.unitime.org/Localization
  • Authentication help.unitime.org/CAS and help.unitime.org/LDAP
• Research Publications www.unitime.org/publications.php
• Presentations www.unitime.org/presentations.php
• Webinars www.unitime.org/webinars.php
• GitHub github.com/UniTime
• Downloads & Nightly Builds builds.unitime.org

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