UniTime

Getting Started with UniTime

Tomáš Müller, Zuzana Müllerová

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

UniTime Demo Instance

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

demo.unitime.org/workshop

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

Username:
user001

Password:
pwd001

Username:
user051

Password:
pwd051

Credit: Photo by Environment and Climate Change Canada

UniTime Introduction

Educational Timetabling

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
- …

Credit: Photo by Environment and Climate Change Canada

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*

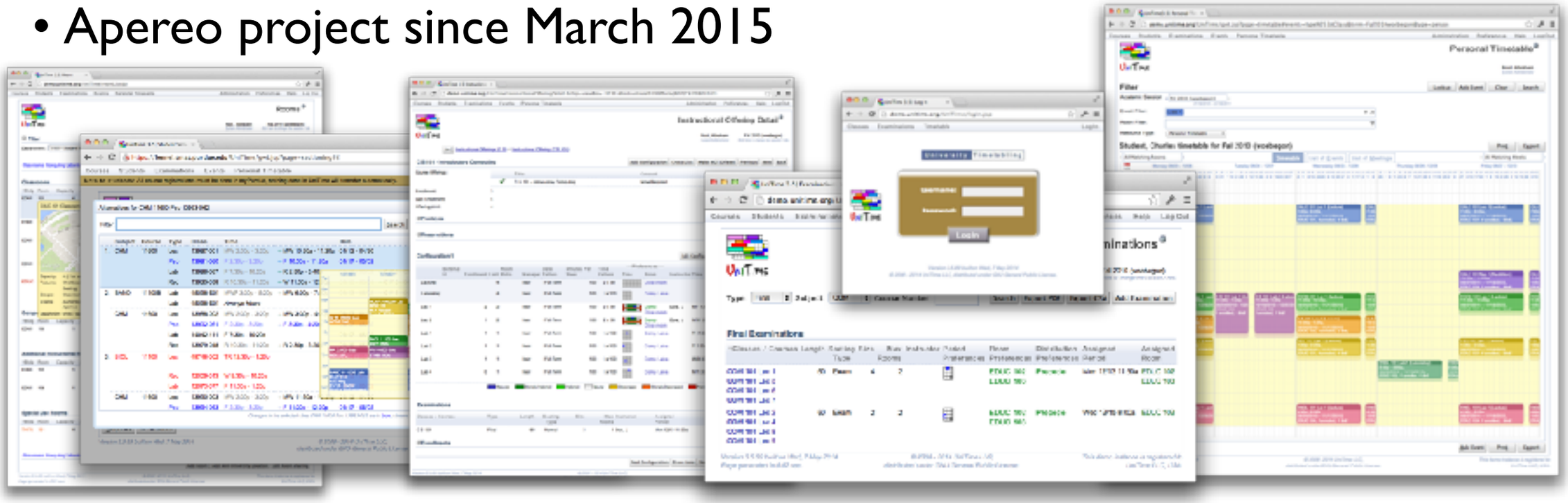
Here is where UniTime comes in place

- 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
- Apereo project since March 2015



Credit: Photo by Environment and Climate Change Canada

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

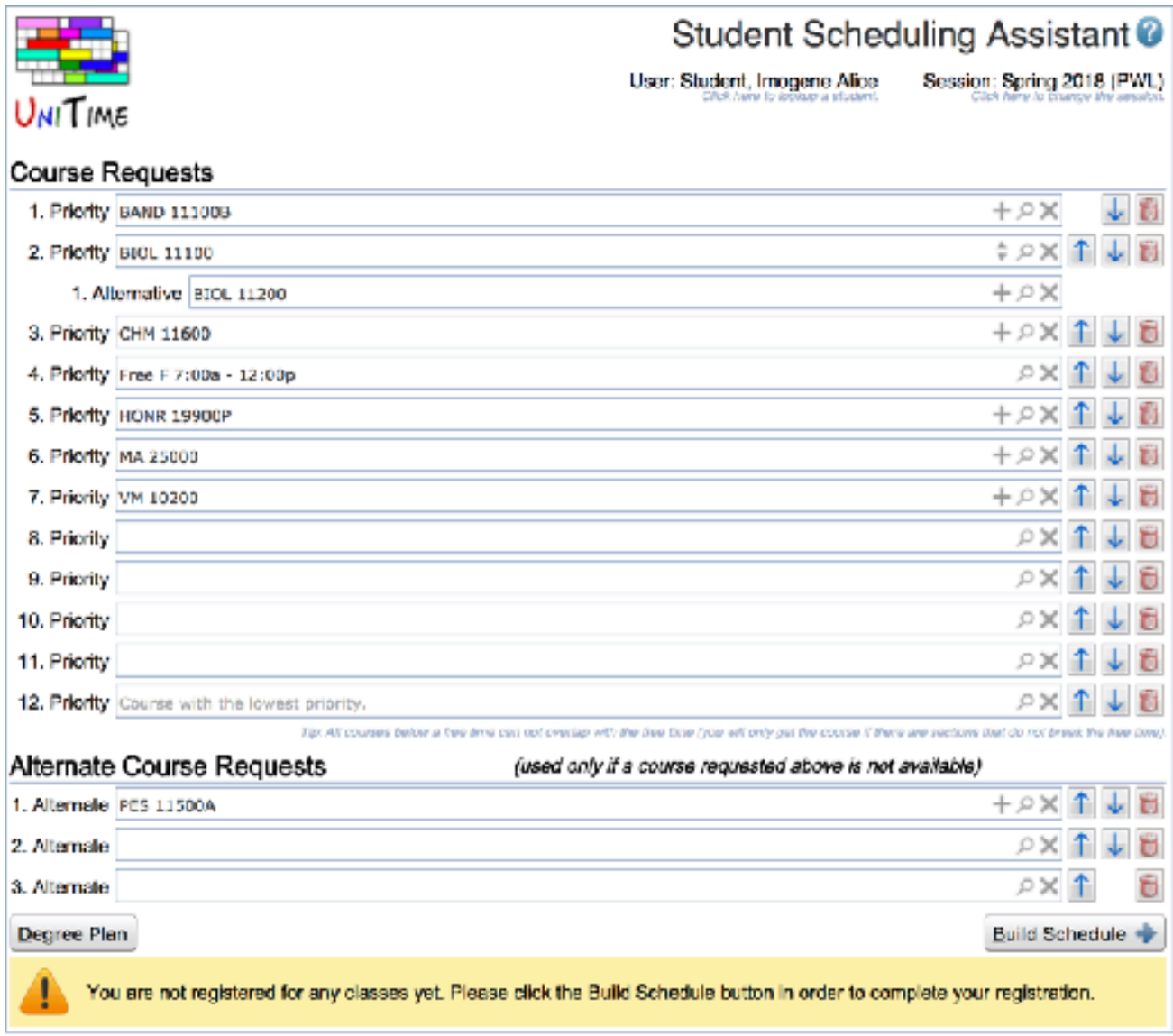
Credit: Photo by Environment and Climate Change Canada

Student Scheduling

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

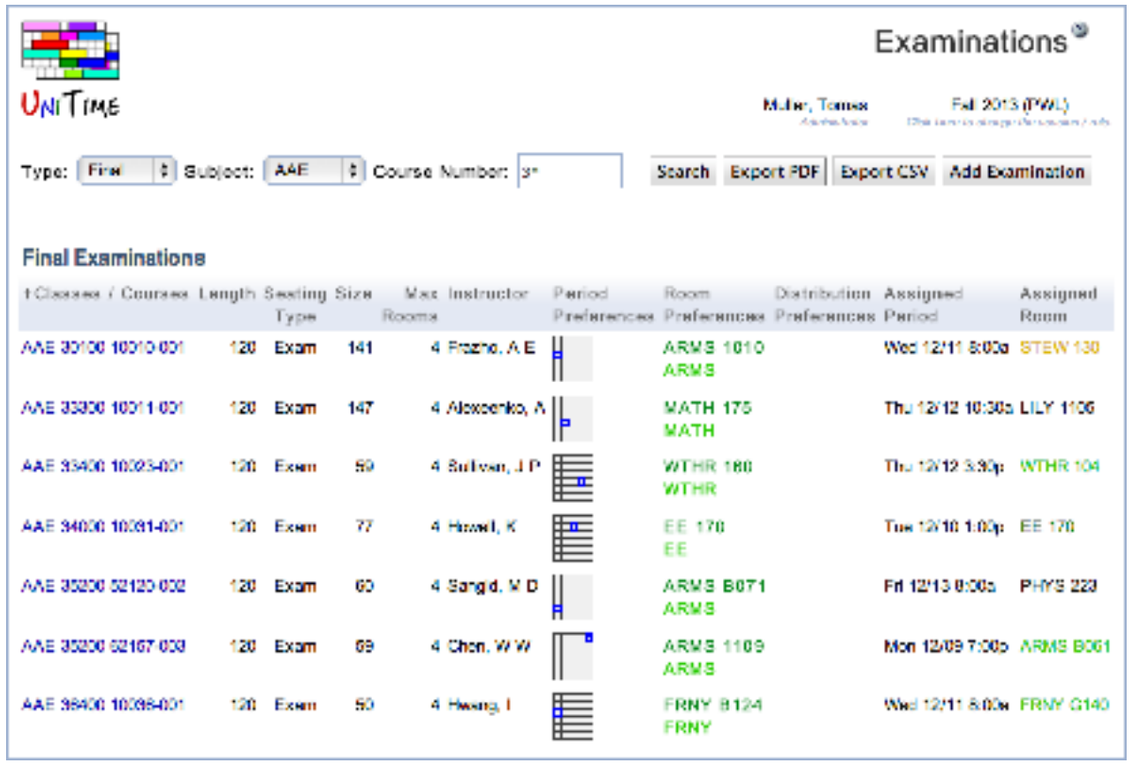


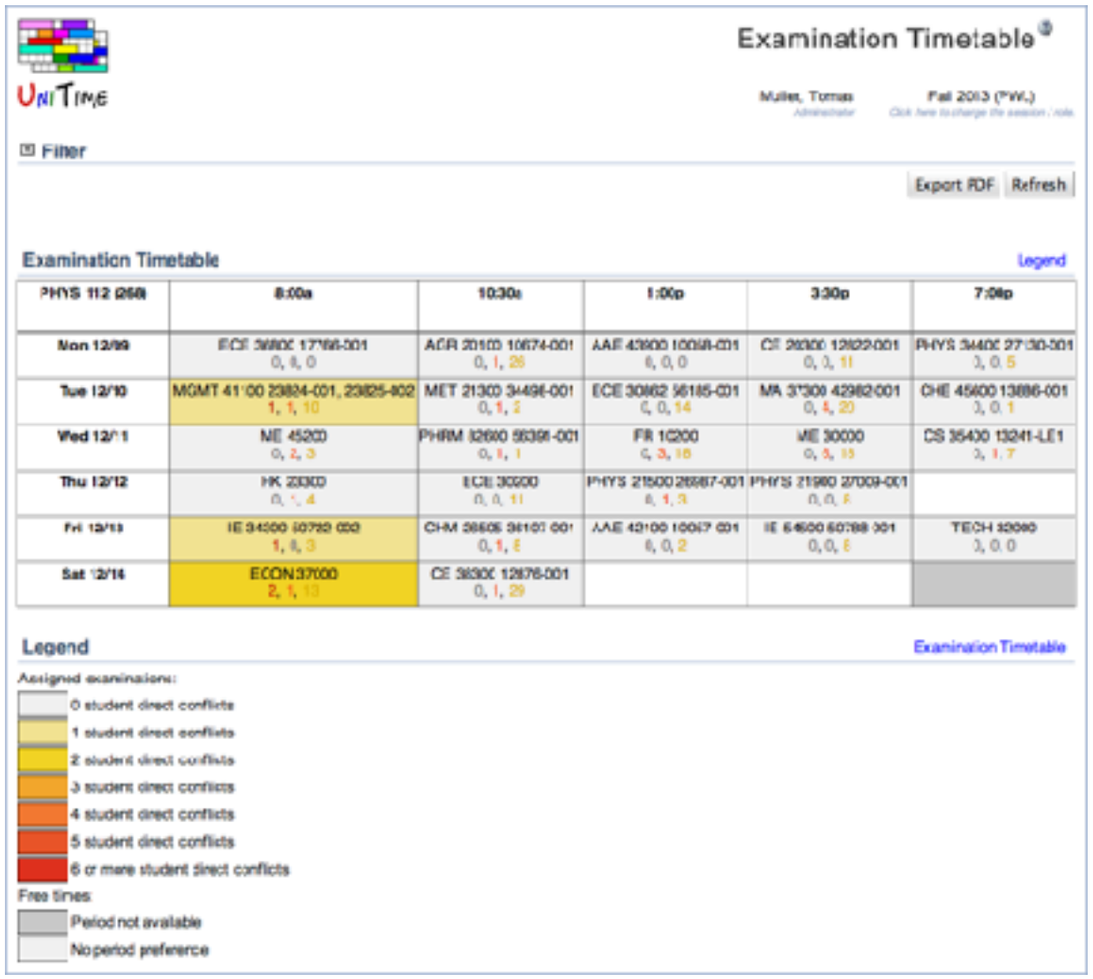
Credit: Photo by Environment and Climate Change Canada

Examinations

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*





Credit: Photo by Environment and Climate Change Canada

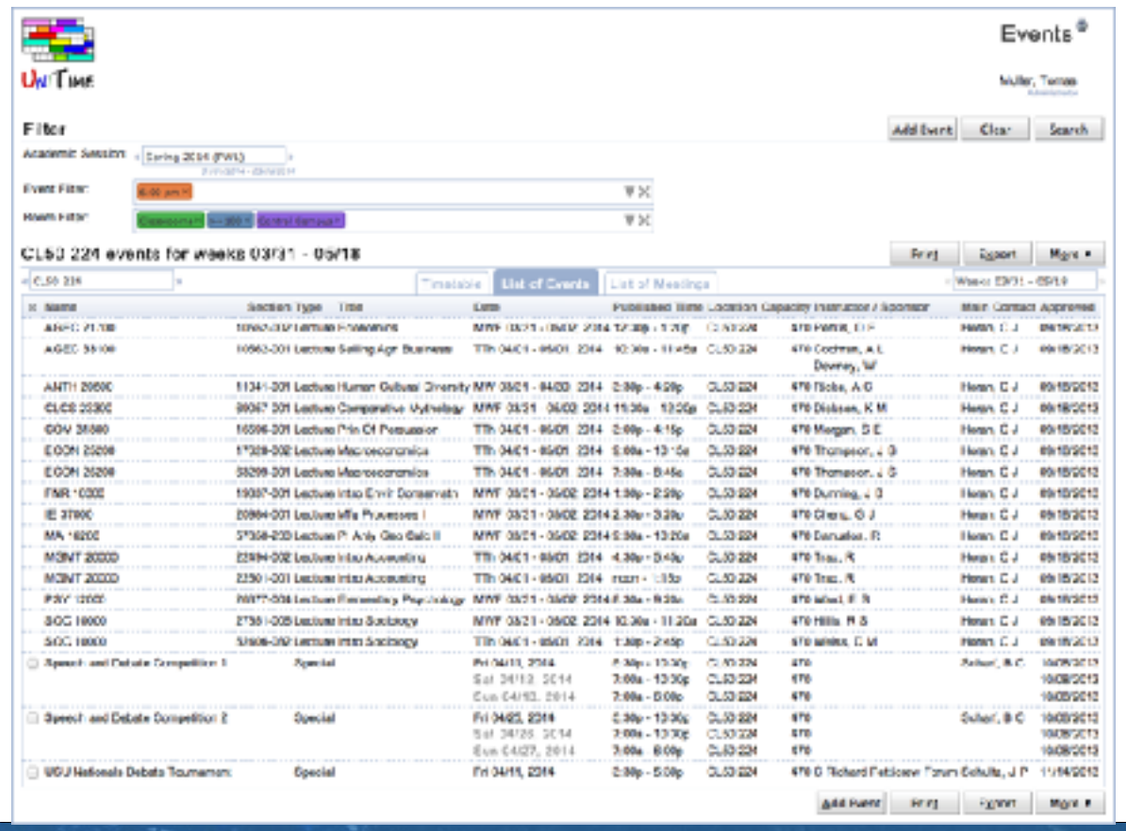
Other Features

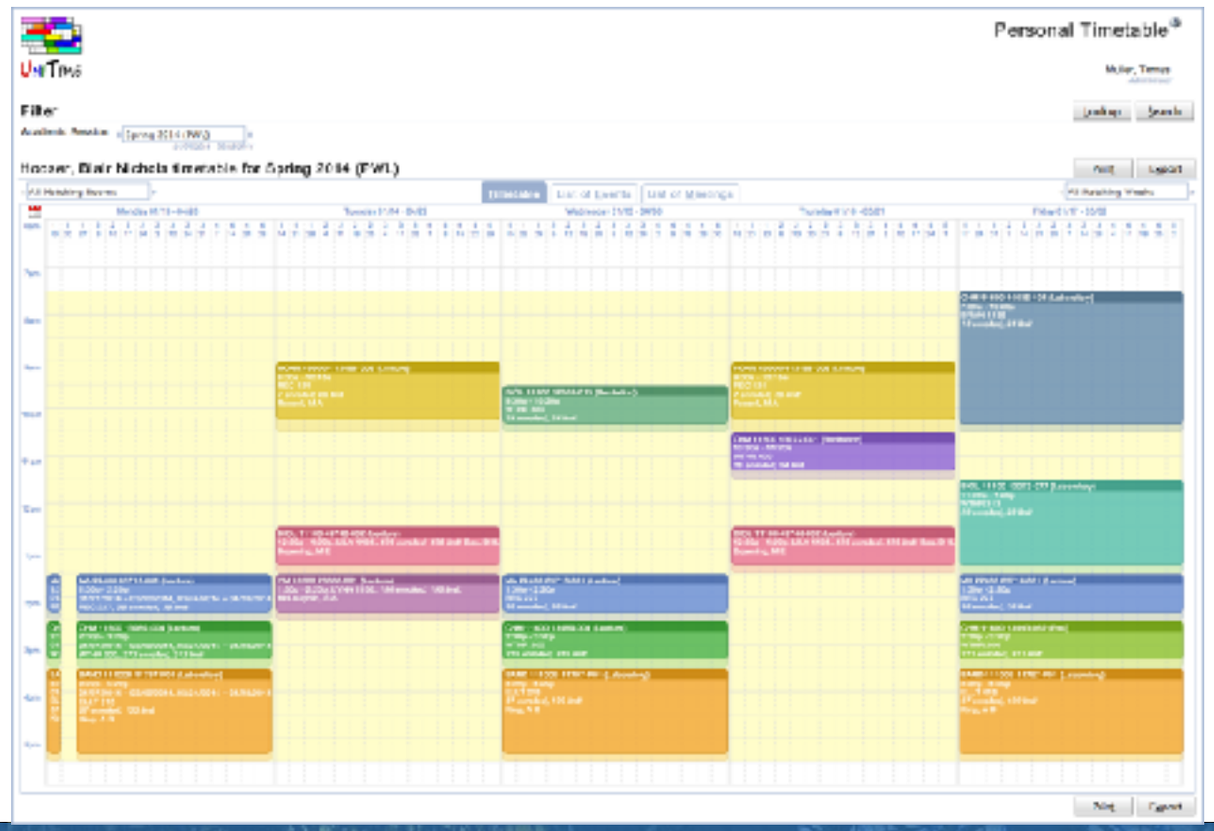
Event management

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

And more

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





Credit: Photo by Environment and Climate Change Canada

UniTime

System Administration

UniTime Setup

Installation

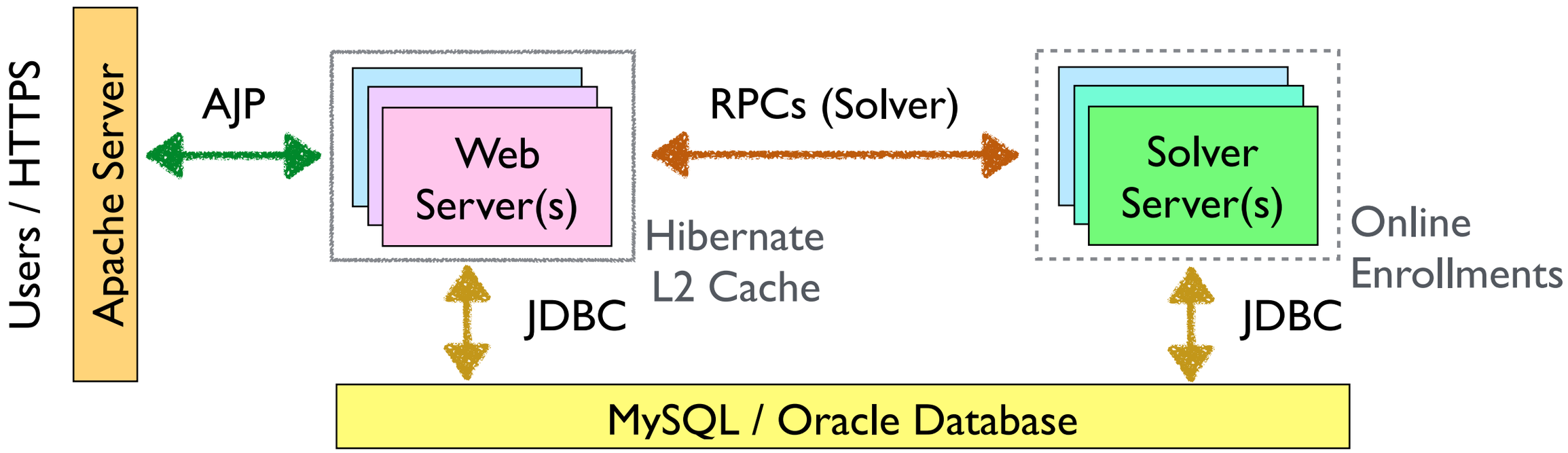
- UniTime can be downloaded from http://builds.unitime.org
- Installation Instructions: help.unitime.org/Timetabling_Installation
  - *See Windows, Linux, or Mac specific notes at the bottom of the page*
- Hardware Requirement
  - Any system capable of running Java and MySQL/Oracle
  - Linux is recommended, 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)

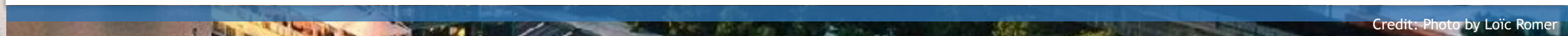
Do not forget the -Xmx parameter and the MySQL/Oracle JDBC driver!

UniTime Setup

Cluster

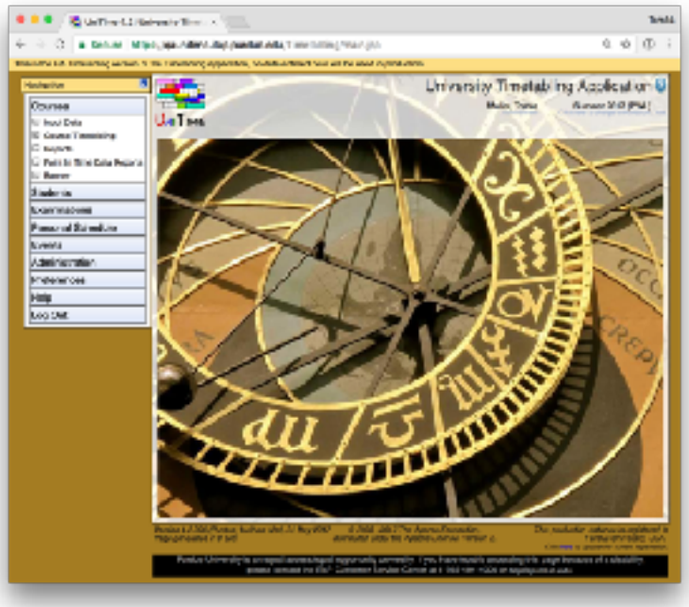
- One or more web servers (Apache Tomcat / UniTime.war)
- One or more remote solver servers (Java)
- JGroups Clusters
  - Hibernate L2 Cache (web servers only)
  - Solver Cluster (RPCs)
  - Online Student Scheduling Server replications (optional)





Credit: Photo by Loïc Romer

UniTime Setup



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.

UniTime Setup

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.

See https://demo.unitime.org/UniTime?locale=cs for UniTime in Czech.

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.

Credit: Photo by Tourisme Montréal, Stéphan Poulin

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

UniTime Data Organization

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

Users and Roles

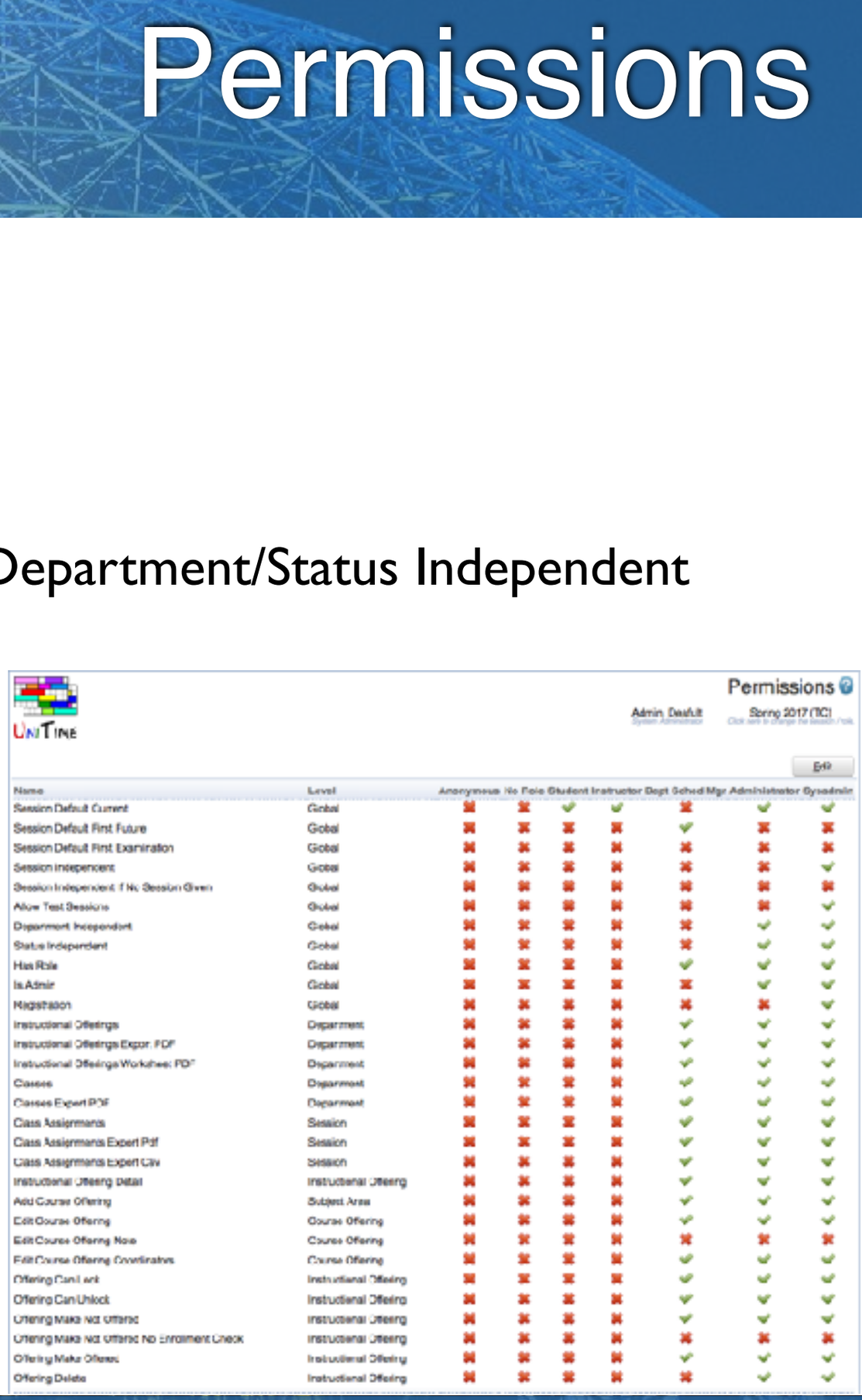
- Timetable Managers
  - All administrative users (administrators, schedule managers,…)
  - Session independent, but with relation to departments
  - One or more roles (one primary)
- Instructors
  - One instructor can belong to multiple departments
- Students
  - Related only to an academic session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

Using external id of the authenticated user

Permissions

Permissions

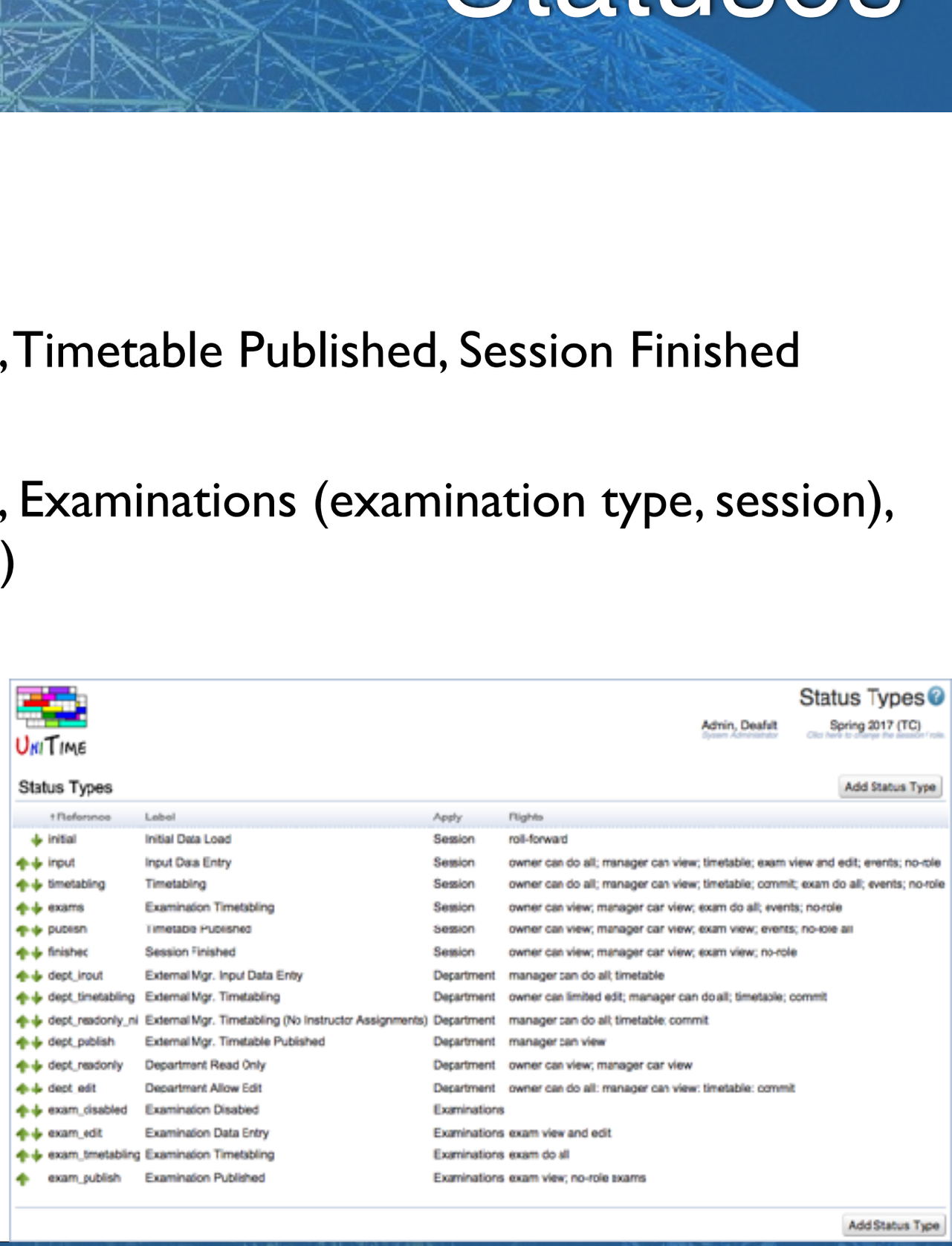
- Defined for each role
  - For each page/operation
  - Few special: Session Default, Session/Department/Status Independent
  - Applies to an object in question
- Permission Check
  - Relation to the user's department
  - Status of session/department
- Example: Class Edit
  - Controlling Department
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



Statuses

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



Credit: Photo by Environment and Climate Change Canada

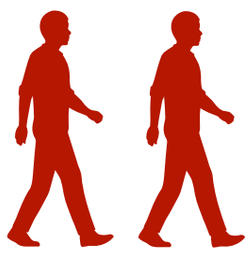
Manager Roles

System Administrator

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

University Level
(IT Department)

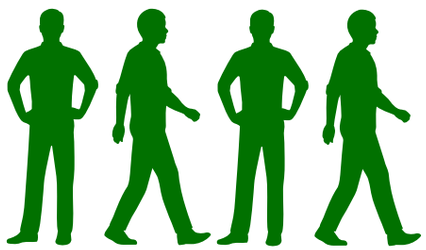
Session Administrator



Academic Session Setup
Roll-forward, Data Exchange
(Administration > Acad. Session)
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)

Credit: Photo by Environment and Climate Change Canada

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

Makes Timetable Changes
Publishes Timetable

Next Academic

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

Creates Academic Session
Roll-Forward
Imports (Catalog, Students)
Academic Session Setup (Changes)
Support Schedule Managers

Collects Faculty Requirements
Instructors
Courses & Classes
Requirements & Preferences

University Level
(IT Department)

Campus Level
(Registration Office)

Departmental Level
(One or more departments)

Credit: Photo by Environment and Climate Change Canada

User Responsibilities (B)

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

Departmental Schedule Manager

Collects Faculty Requirements
Instructors
Courses & Classes
Requirements & Preferences

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

Verifies Input Data
Creates Timetable (Runs Solver)
Makes Timetable Changes

Verifies Timetable
Communicates with Faculty

Makes Timetable Changes
Publishes Timetable

Next Academic

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

Creates Academic Session
Roll-Forward
Imports (Catalog, Students)
Academic Session Setup (Changes)
Support Schedule Managers

Collects Faculty Requirements
Instructors
Courses & Classes
Requirements & Preferences

University Level
(IT Department)

Campus Level
(Registration Office)

Departmental Level
(One or more departments)

Data Exchange

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.

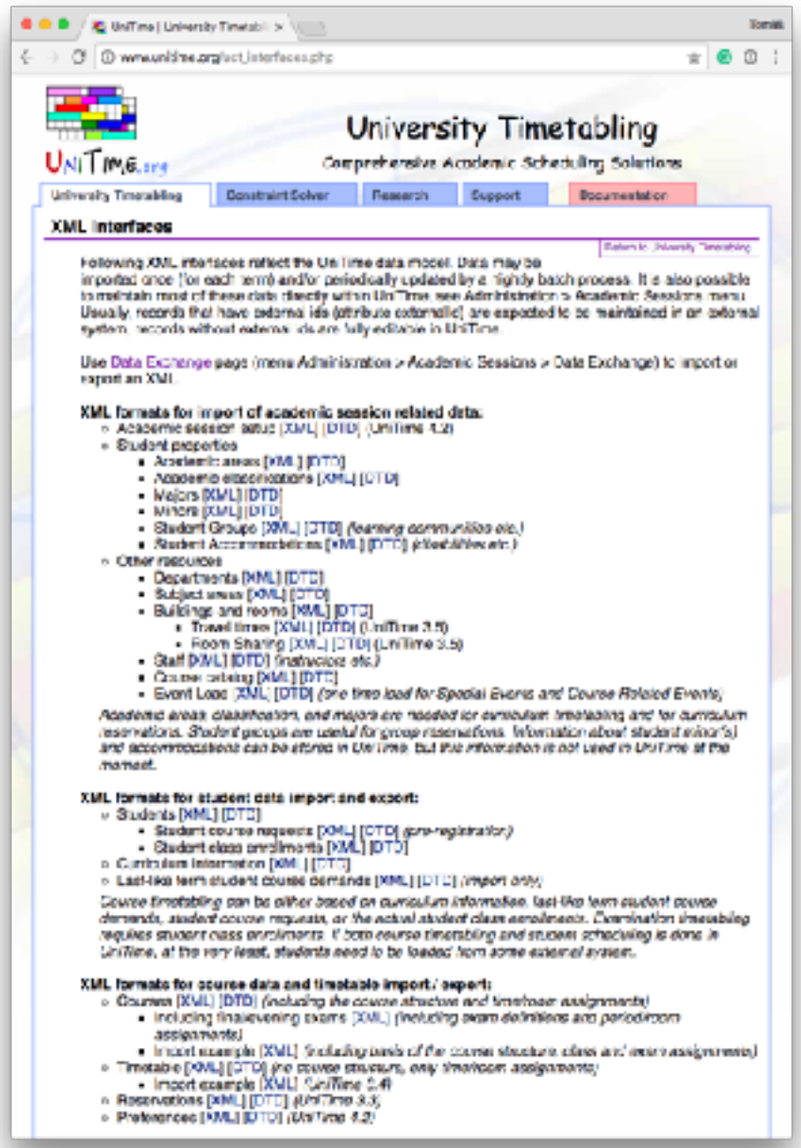
XML Interfaces

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, Exports, Other

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

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

Department

Most of the UniTime data are related to a particular department

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

Credit: Photo by Susan Moss

Time-related Setup

Date Patterns

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

March 2015

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
10	1	2	3	4	5	6	7
11	8	9	10	11	12	13	14
12	15	16	17	18	19	20	21
13	22	23	24	25	26	27	28
14	29	30	31				

April 2015

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
14				1	2	3	4
15	5	6	7	8	9	10	11
16	12	13	14	15	16	17	18
17	19	20	21	22	23	24	25
18	26	27	28	29	30		

May 2015

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
18						1	2
19	3	4	5	6	7	8	9
20	10	11	12	13	14	15	16
21	17	18	19	20	21	22	23
22	24	25	26	27	28	29	30
23	31						

Time Patterns

- Possible time slots within a week

2h

from: / to:	7:30a 9:10a	8:25a 10:05a	9:20a 11:00a	10:15a 11:55a	11:10a 12:50p	12:05p 1:45p	1:00p 2:40p	1:55p 3:35p	2:50p 4:30p	3:45p 5:25p	4:40p 6:20p	5:35p 7:15p	6:30p 8:10p
Mon													
Tue													
Wed													
Thu													

Required
Strongly Preferred
Preferred
Neutral
Discouraged
Strongly Discouraged
Prohibited

Credit: Photo by Susan Moss

Departments Setup

Departments

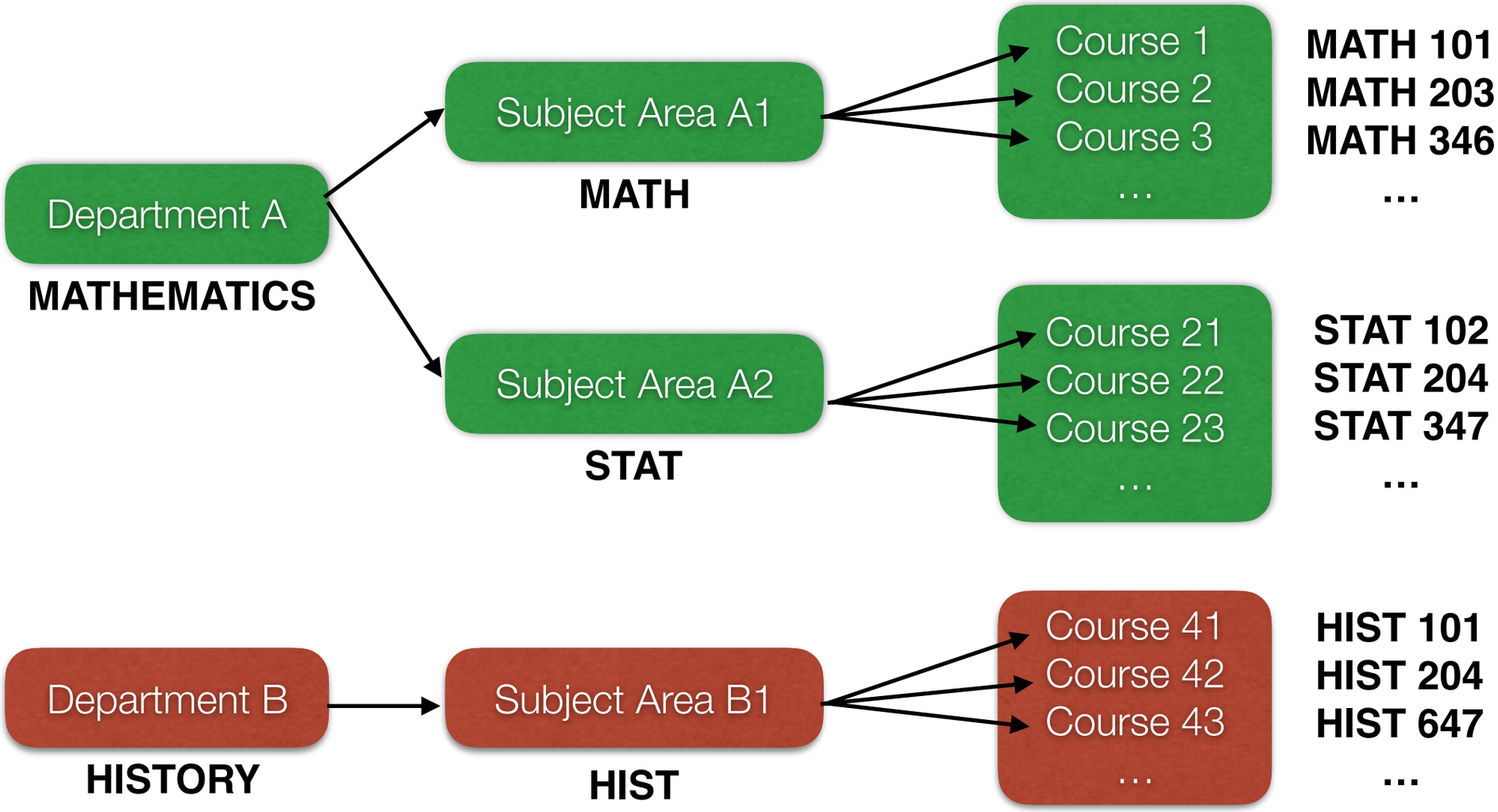
- **Organizational units** at a campus
- **Courses** are offered by departments
- **Rooms** and **staff** are related to departments
- **Users** are related to departments
- Some **permissions** (event management, data entry, etc.) can be set on the departmental level
- **Course timetables** are created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

Credit: Photo by Susan Moss

Subject Areas Setup

Subject Areas

- Help organize courses from a department to meaningful group



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

Credit: Photo by Susan Moss

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

Credit: Photo by Susan Moss

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

	A 50	D 20	K 73	140A	JAMU	
A 50		5	5	19	22	A 50
D 20	5		0	17	20	D 20
K 73	5	0		17	22	K 73
140A	19	17	17		10	140A
JAMU	22	20	22	10		JAMU
	A 50	D 20	K 73	140A	JAMU	

Credit: Photo by Susan Moss

Data Entry: Rooms

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)

Credit: Photo by Susan Moss

Solver Groups

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

Credit: Photo by Susan Moss

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**

Credit: Photo by Susan Moss

UniTime Setup

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 timetabling
- 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

Course Timetabling

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

Course Structure

Instructional Offering

	Limit	Date Pattern	Minutes Per Week	Time Pattern	Time	Room	Distribution	Instructor
						----Preferences----		
MA 170	40	**Statistics I**						
STAT 170		Introductory statistics						
Lecture	40	Full Term	50	1 x 50		Classroom		
Laboratory	40	Full Term	150	3 x 50		EDUC CompPr	Same Room	
Lec 1	40	Full Term	50	1 x 50		ThtrSeat Classroom		G. Newman
Lab 1	20	Full Term	150	3 x 50		EDUC CompPr	Same Room	J. Smith
Lab 2	20	Full Term	150	3 x 50		EDUC CompPr	Same Room	J. Smith

Course Structure

Instructional Offering

Course Offerings

	Limit	Date Pattern	Minutes Per Week	Time Pattern	Time	Room	Distribution	Instructor
						----Preferences----		
MA 170 STAT 170	40	**Statistics I** Introductory statistics						
Lecture	40	Full Term	50	1 x 50		Classroom		
Laboratory	40	Full Term	150	3 x 50		EDUC CompPr	Same Room	
Lec 1	40	Full Term	50	1 x 50		ThtrSeat Classroom		G. Newman
Lab 1	20	Full Term	150	3 x 50		EDUC CompPr	Same Room	J. Smith
Lab 2	20	Full Term	150	3 x 50		EDUC CompPr	Same Room	J. Smith

Credit: Photo by Environment and Climate Change Canada

Course Structure

Instructional Offering

Course Offerings

Scheduling Subparts

	Limit	Date Pattern	Minutes Per Week	Time Pattern	Time	----Preferences---- Room	Distribution	Instructor
MA 170 STAT 170	40	**Statistics I** Introductory statistics						
Lecture	40	Full Term	50	1 x 50		Classroom		
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Credit: Photo by Environment and Climate Change Canada

Course Structure

Instructional Offering

Course Offerings

Scheduling Subparts

Classes

	Limit	Date Pattern	Minutes Per Week	Time Pattern	Time	----Preferences---- Room	Distribution	Instructor
MA 170	40	**Statistics I**						
STAT 170		Introductory statistics						
Lecture	40	Full Term	50	1 x 50		Classroom		
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Lab 2	20	Full Term	150	3 x 50		EDUC CompPr	Same Room	J. Smith

Credit: Photo by Environment and Climate Change Canada

Dates and Times

Date Patterns

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

March 2015

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
10	1	2	3	4	5	6	7
11	8	9	10	11	12	13	14
12	15	16	17	18	19	20	21
13	22	23	24	25	26	27	28
14	29	30	31				

April 2015

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
14				1	2	3	4
15	5	6	7	8	9	10	11
16	12	13	14	15	16	17	18
17	19	20	21	22	23	24	25
18	26	27	28	29	30		

May 2015

	Sun	Mon	Tue	Wed	Thu	Fri	Sat
18						1	2
19	3	4	5	6	7	8	9
20	10	11	12	13	14	15	16
21	17	18	19	20	21	22	23
22	24	25	26	27	28	29	30
23	31						

Time Patterns

- Possible time slots within a week

2h

from: / to:	7:30a 9:10a	8:25a 10:05a	9:20a 11:00a	10:15a 11:55a	11:10a 12:50p	12:05p 1:45p	1:00p 2:40p	1:55p 3:35p	2:50p 4:30p	3:45p 5:25p	4:40p 6:20p	5:35p 7:15p	6:30p 8:10p
Mon													
Tue													
Wed													
Thu													

Required
Strongly Preferred
Preferred
Neutral
Discouraged
Strongly Discouraged
Prohibited

Credit: Photo by Environment and Climate Change Canada

Rooms

Rooms

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

K 73

Workdays × Daytime

from: / to:	7:30a 8:00a	8:00a 8:30a	8:30a 9:00a	9:00a 9:30a	9:30a 10:00a	10:00a 10:30a	10:30a 11:00a	11:00a 11:30a	11:30a 12:00p	12:00p 12:30p	12:30p 1:00p	1:00p 1:30p	1:30p 2:00p	2:00p 2:30p	2:30p 3:00p	3:00p 3:30p	3:30p 4:00p	4:00p 4:30p	4:30p 5:00p	5:00p 5:30p	5:30p 6:00p	6:00p 6:30p
Mon																						
Tue	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL	BIOL
Wed	CIVC	CIVC	CIVC	CIVC	CIVC	CIVC	CIVC	CIVC	CIVC													
Thu	CIVC	CIVC	CIVC	CIVC	CIVC	CIVC	CIVC	CIVC	CIVC													
Fri	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

- Room coordinations, travel times

	A 50	D 20	K 73	140A	JAMU	
A 50		5	5	19	22	A 50
D 20	5		0	17	20	D 20
K 73	5	0		17	22	K 73
140A	19	17	17		10	140A
JAMU	22	20	22	10		JAMU
	A 50	D 20	K 73	140A	JAMU	

Credit: Photo by Environment and Climate Change Canada

Room Preferences

Minimal Room Size

- Calculated from class limit and room ratio

Room Preferences

- Particular room or building
- Room group
- Room feature

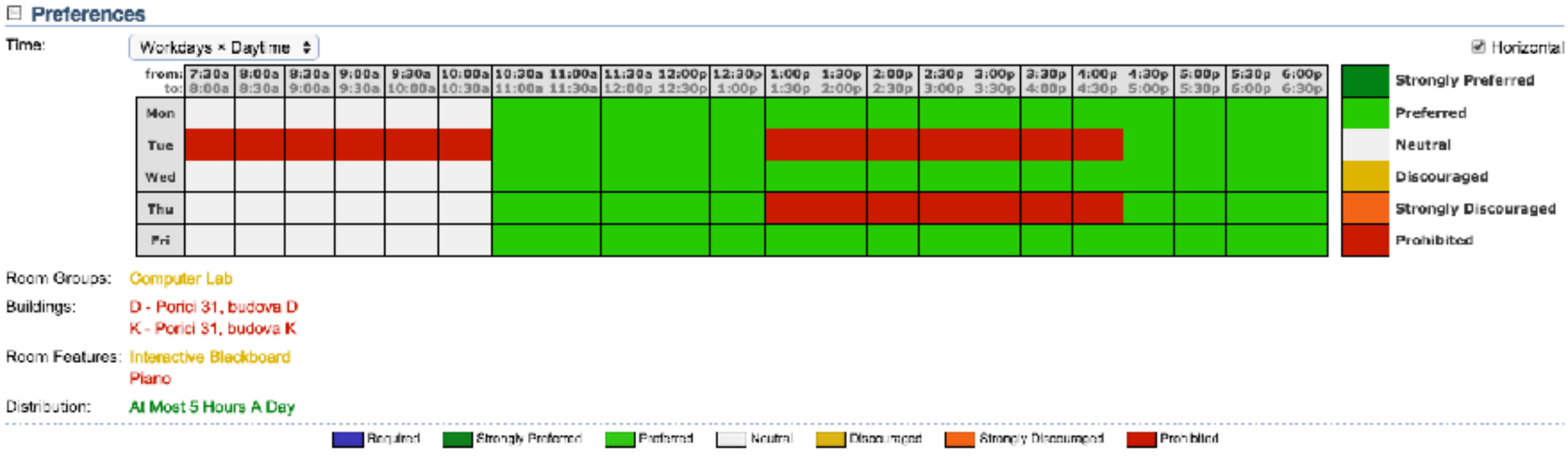
Room Groups:	Geology Classroom (Department) Classroom
Rooms:	B 11
Buildings:	Y - Porici 7, budova Y
Room Features:	Data Projector
Available Rooms:	34 (A 51, A 53, A 54, A 55, ...)

Required | Strongly Preferred | Preferred | Neutral | Discouraged | Strongly Discouraged | Prohibited

Instructors

Instructors

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



Preferences

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

	Limit	Date Pattern	Minutes Per Week	Time Pattern	Time	----Preferences---- Room	Distribution	Instructor
MA 170	40	**Statistics I**						
STAT 170		Introductory statistics						
Lecture	40	Full Term	50	1 x 50		Classroom		
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Lab 1	20	Full Term	150	3 x 50		EDUC CompPr	Same Room	J. Smith
Lab 2	20	Full Term	150	3 x 50		EDUC CompPr	Same Room	J. Smith

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

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)

Course Projections

Group	Course	01
Required	ALG 101	100.0%
Required	CALC 101	100.0%
Elective	ENGL 101	60.0%
Elective	SPAN 101	40.0%
	BIOL 101	10.0%
	CHM 101	20.0%

Course Projections

Group	Course	01
M1 and M2 M or N or O	M1	50.0%
M1 and M2	M2	50.0%
N1 and N2 M or N or O	N1	30.0%
N1 and N2	N2	30.0%
O1 and O2 M or N or O	O1	20.0%
O1 and O2	O2	20.0%

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

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)

Credit: Photo by Environment and Climate Change Canada

Data Entry: Instructors

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.

Data Entry: Preferences

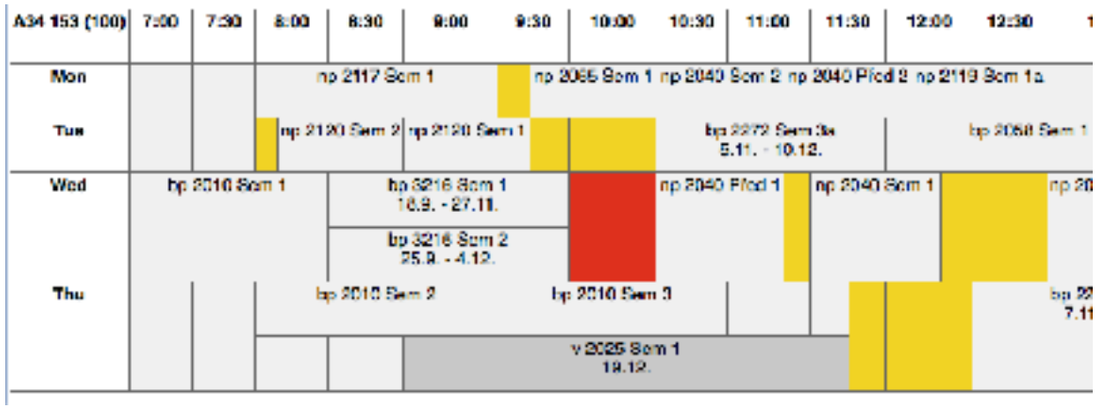
Best Practices: Courses

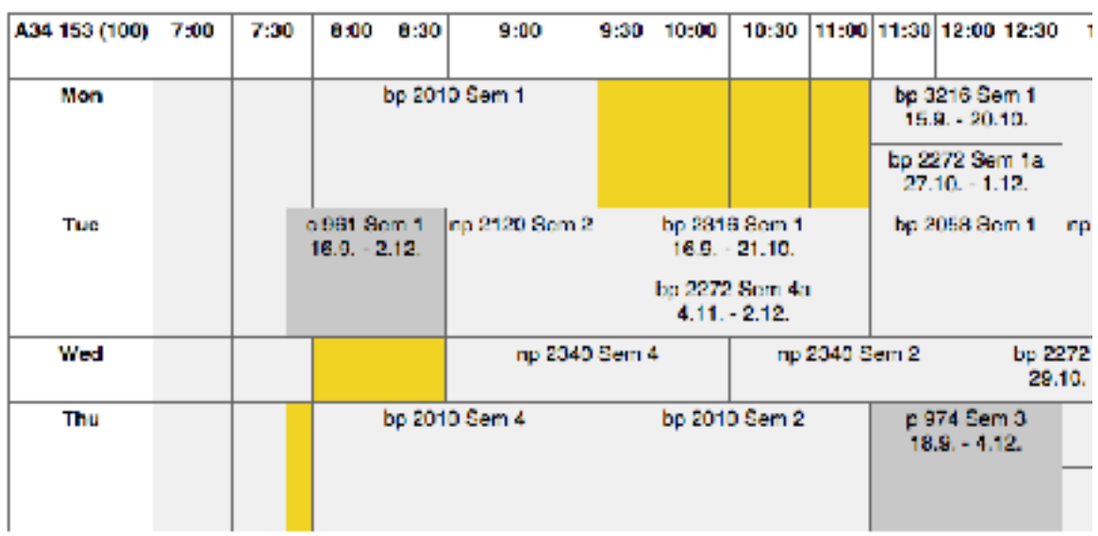
- There can be multiple configurations
  (with different instructional method, e.g., traditional x online)
- If a class does not follow a standard time pattern, it could be split
- Reservations can be used to direct students to the appropriate configurations / classes
- Use cross-lists whenever a course 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

Data Entry: Preferences

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





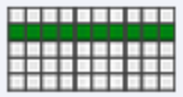
Credit: Photo by Environment and Climate Change Canada

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

unitime.preferences.highlightClassPrefs

	Limit	Date Pattern	Minutes Per Week	Time Pattern	Time	----Preferences---- Room	Distribution	Instructor
MA 170	40	**Statistics I**						
STAT 170		Introductory statistics						
Lecture	40	Full Term	50	1 x 50		Classroom		
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Credit: Photo by Environment and Climate Change Canada

Input Data

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

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

Score	Class	Date	Time	Room	Students
+15.2	POL 101 Lec 3	Full Term	TTh 12:00p → TTh 7:30a	BRNG 2280	+11
+31.7	POL 101 Lec 3	Full Term	TTh 12:00p → TTh 10:30a	BRNG 2280	+36 (h+3)
	HIST 342 Lec 1	Full Term	TTh 10:30a → TTh 1:30p	BRNG 2280 → BRNG 2290	
+36.6	POL 101 Lec 3	Full Term	TTh 12:00p → TTh 10:30a	BRNG 2280	+36 (h+4)
	HIST 342 Lec 1	Full Term	TTh 10:30a → TTh 7:30a	BRNG 2280	
+44.1	POL 101 Lec 3	Full Term	TTh 12:00p → TTh 10:30a	BRNG 2280	+34 (h+2)
	HIST 342 Lec 1	Full Term	TTh 10:30a → TTh 3:00p	BRNG 2280 → BRNG 2290	
	OBHR 330 Lec 1	Full Term	TTh 3:00p	BRNG 2290 → LWSN B155	

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

Search Deeper

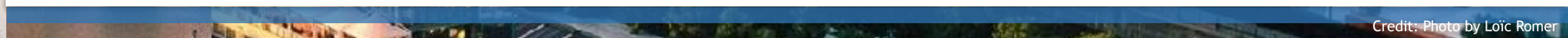
Credit: Photo by Loïc Romer

UniTime

Problem

Model

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



Credit: Photo by Loïc Romer

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

Credit: Photo by Loïc Romer

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)

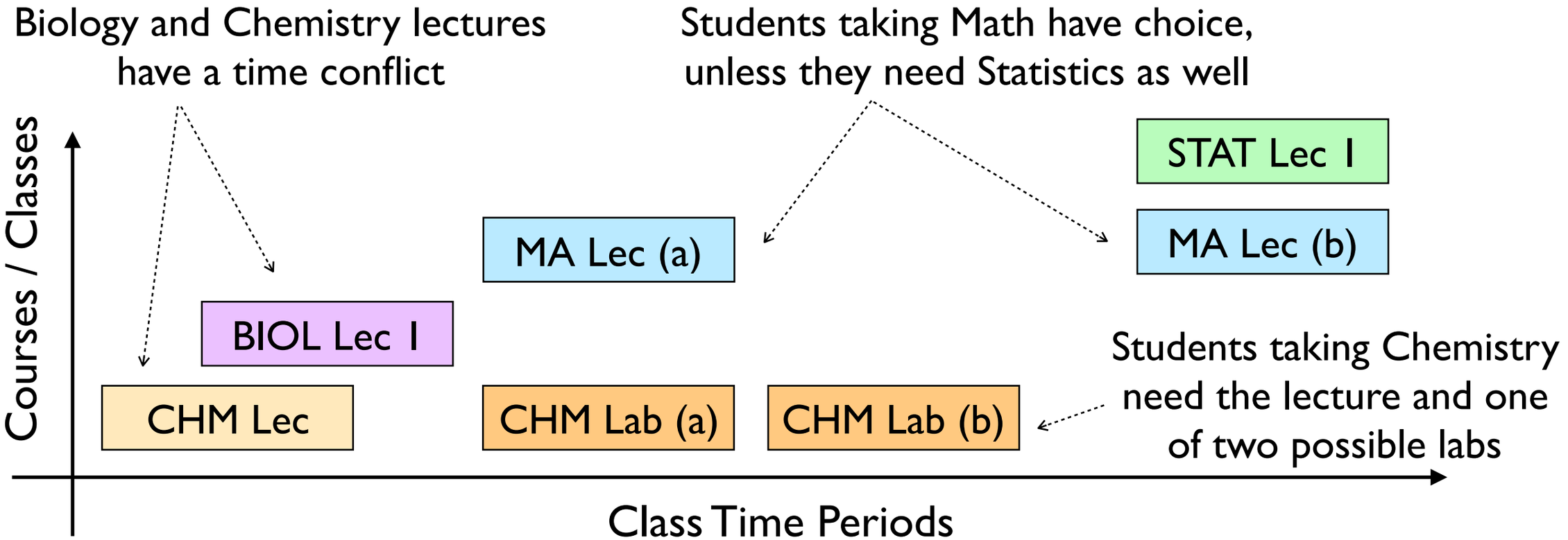
- Time, room, and distribution preferences
- Student conflicts
- Additional criteria (too big rooms, back-to-back instructors, …)

Credit: Photo by Loïc Romer

Student Conflicts

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



Credit: Photo by Loïc Romer

Timetabling: Step 1

Using the Solver

1. Make sure the problem has a solution
   - All classes are assigned
   - Using **check** configuration
   - Conflict-statists can be used to discover issues

Timetabling: Step 2

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

Type	Course Timetabling Solver
Solver	Solving problem ...
Phase	Improving found solution ...
Progress	5 of 100 (5.0%)
Owner	A. Root as ART & BIOL & CIVC & CZ & ENG & FRN &...
Host	local
Session	Spring 2016 (ED)
Version	4.0.16
Assigned variables	100.00% (1813/1813)
Overall solution value	-17554.24
Time preferences	91.26% (-36722.00)
Student conflicts	807 [committed:0, distance:1, hard:177]
Room preferences	93.31% (-1385)
Distribution preferences	96.37% (-525.00)
Back-to-back instructor preferences	99.98% (1)
Too big rooms	19.84% (1280)
Useless half-hours	0.63% (0 + 1316)
Same subpart balancing penalty	36.58
Room Size Penalty	17.36
Perturbation variables	9.60% (154 + 8)
Perturbations: Total penalty	330.10
Time	0.06 min
Iteration	1940
Memory usage	1791.38M
Speed	520.45 /s
Block Constraints	100% (0)
Important student conflicts	495 [hard: 34]

Credit: Photo by Loïc Romer

Timetabling: Step 3

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

Suggestions

Score	Class	Date	Time	Room	Students
+15.2	POL 101 Lec 3	Full Term	TTh 12:00p → TTh 7:30a	BRNG 2280	+11
+31.7	POL 101 Lec 3	Full Term	TTh 12:00p → TTh 10:30a	BRNG 2280	+36 (h+3)
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	HIST 342 Lec 1	Full Term	TTh 10:30a → TTh 3:00p	BRNG 2280 → BRNG 2290	
	OBHR 330 Lec 1	Full Term	TTh 3:00p	BRNG 2290 → LWSN B155	

(all 1571 possibilities up to 3 changes were considered, top 4 of 17 suggestions displayed) Search Deeper

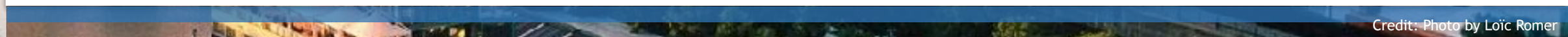
Solver Configuration: it is possible to tweak solver parameters if needed
(there is a tradeoff between times, rooms, distributions, and student conflicts)

Credit: Photo by Loïc Romer

Timetabling: Making Changes

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



Credit: Photo by Loïc Romer

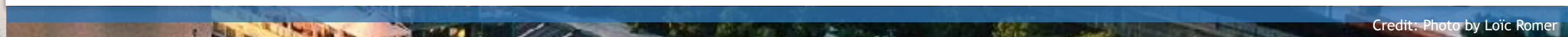
Cooperation on Timetabling

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

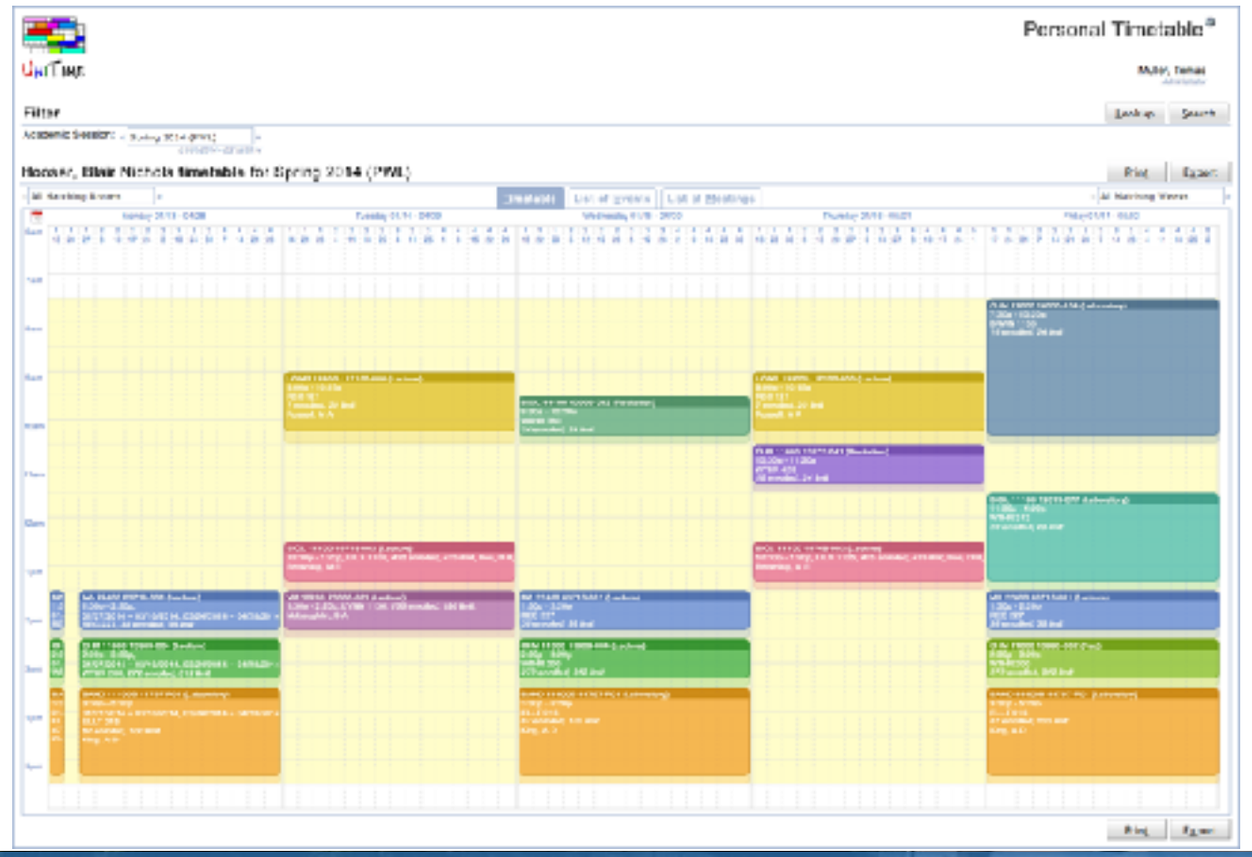
- For instance, distance learning classes are solved separately
- Different set of rooms
- Timetabled before or after the departmental problems
- Other examples: large lecture rooms, computing labs, need room



Credit: Photo by Loïc Romer

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: Timetabling

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: Timetabling

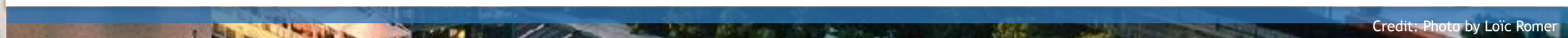
Best practices: Solver parameters

- 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: Timetabling

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



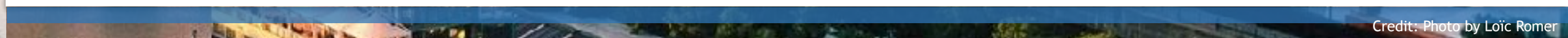
Credit: Photo by Loïc Romer

Publishing Timetable

Solution Commit

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 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

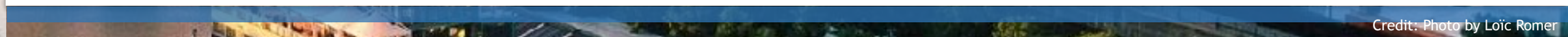


Credit: Photo by Loïc Romer

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



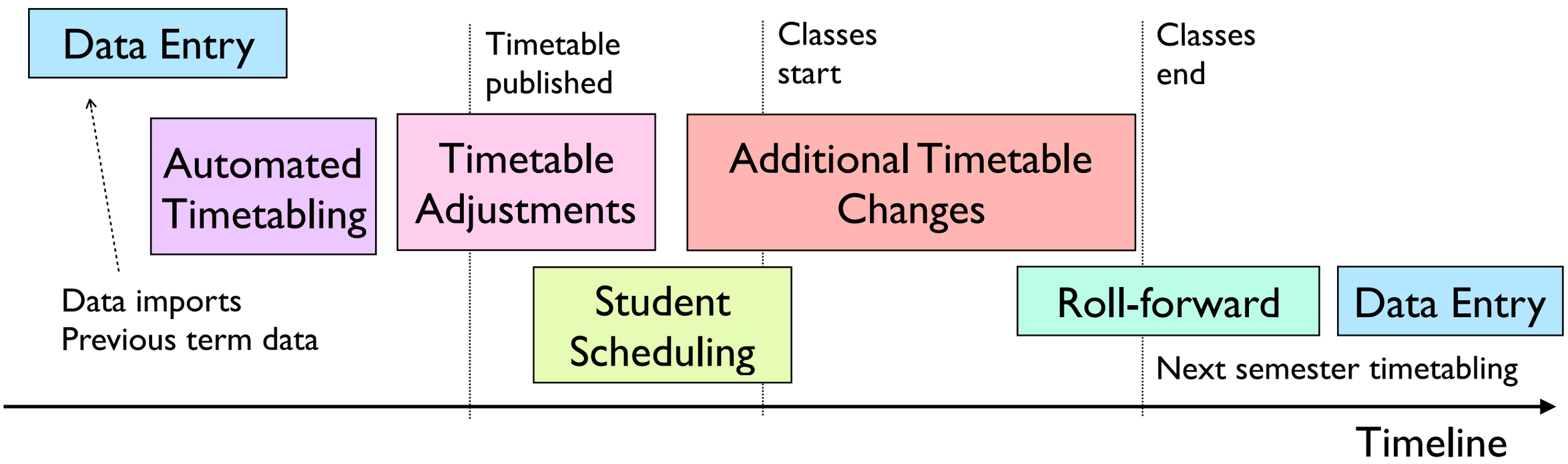
Credit: Photo by Loïc Romer

Course Management

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



Credit: Photo by Loïc Romer

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

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

Credit: Photo by Environment and Climate Change Canada

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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

Credit: Photo by Environment and Climate Change Canada

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Why is it needed?

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- Make process easier to manage, fairness and satisfaction, what-ifs

Many flavors

- Final examinations, evening examinations, mid-terms, …
- Additional objectives

Examination Data

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)*

from: / to:	8:00a 10:00a	10:30a 12:30p	1:00p 3:00p	3:30p 5:30p	7:00p 9:00p
Mon 12/09					
Tue 12/10					
Wed 12/11					
Thu 12/12					
Fri 12/13					
Sat 12/14					

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

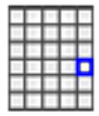
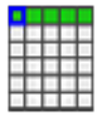
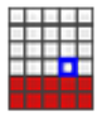
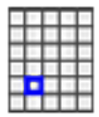
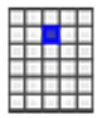
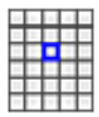
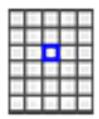
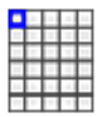
Evening Examinations

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

Credit: Photo by Environment and Climate Change Canada

Example Data Entry

Final Examinations

↑Classes / Courses	Length	Seating Type	Size	Max Rooms	Instructor	Period Preferences	Room Preferences	Distribution Preferences	Assigned Period	Assigned Room
MGMT 20000	120	Exam	881	4					Thu 12/12 7:00p	LAMB F101
MGMT 20010 50874-T01	120	Exam	205	4			PHYS 114 PHYS		Mon 12/09 8:00a	WTHR 200
MGMT 20100	120	Exam	437	4					Thu 12/12 3:30p	STEW 183
MGMT 29000B 23766-002	120	Exam	36	4			KRAN		Fri 12/13 10:30a	KRAN G016
MGMT 30400	120	Exam	115	4					Tue 12/10 1:00p	LILY 1105
MGMT 30500 23769-001 MGMT 30500 23771-003 MGMT 30500 23772-004 MGMT 30500 23770-002	120	Exam	280	4			RAWL 1086 Same Per RAWL		Wed 12/11 1:00p	WTHR 200 WTHR 104
MGMT 30500 23773-005	120	Exam	70	4			RAWL 1062 Same Per RAWL		Wed 12/11 1:00p	WTHR 172
MGMT 30600	120	Exam	236	4					Mon 12/09 8:00a	STEW 183

Required | Strongly Preferred | Preferred | Neutral | Discouraged | Strongly Discouraged | Prohibited

Credit: Photo by Environment and Climate Change Canada

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

} student conflicts

- 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)*

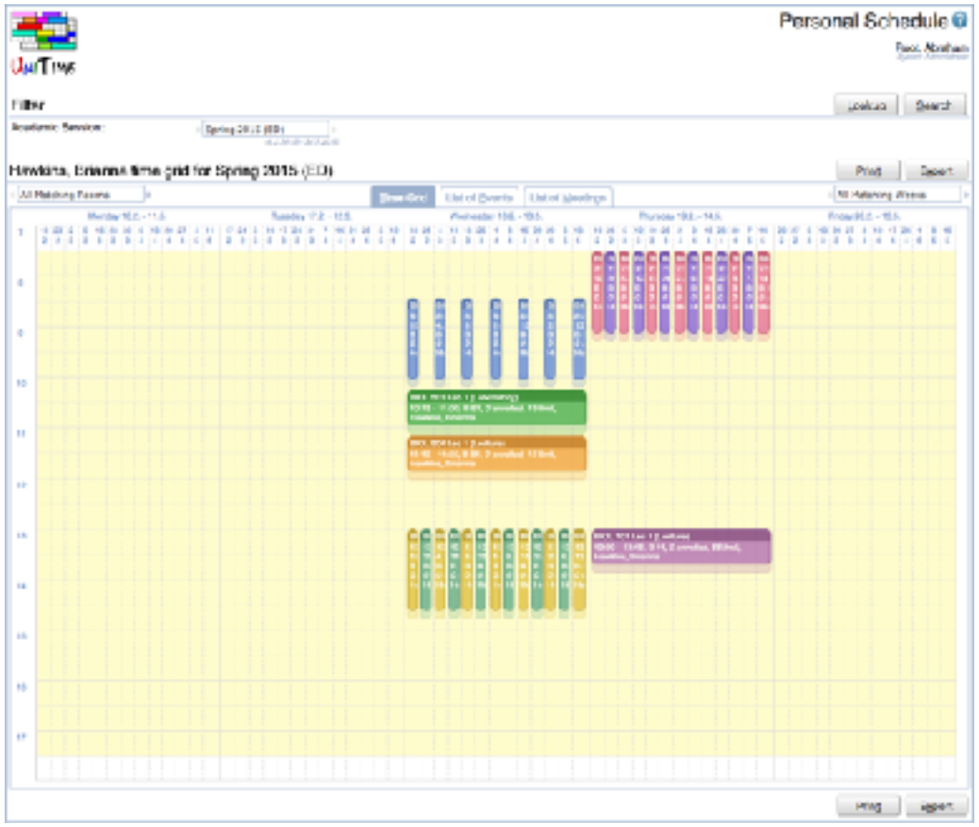
Event Management

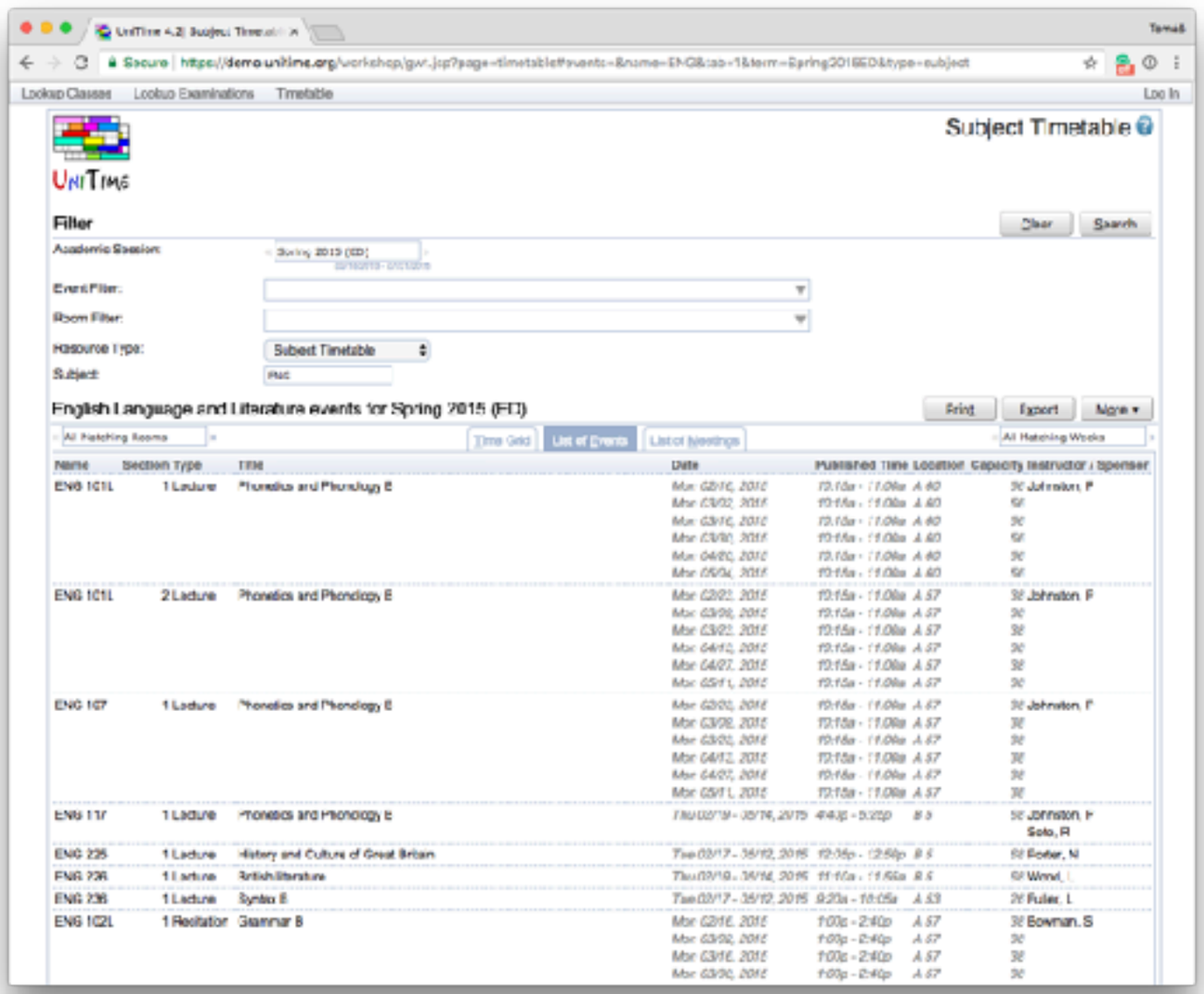
- Management of the remaining classroom space
- Fully distributed, including an approval process
- No billing etc. (just room reservations)

Classes / Exams

Published Timetable

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





Credit: Photo by Susan Moss

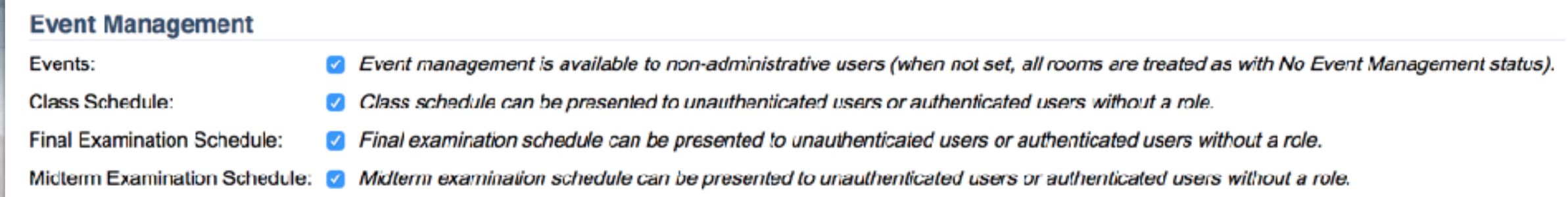
Published Schedule

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



Credit: Photo by Susan Moss

Other Events

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

Credit: Photo by Susan Moss

Event Setup

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)


Credit: Photo by Susan Moss

Examples

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
  http://www.purdue.edu/registrar/documents/scheduling/Instructions-Sheet.pdf

UniTime

Reporting

Exports

Exports

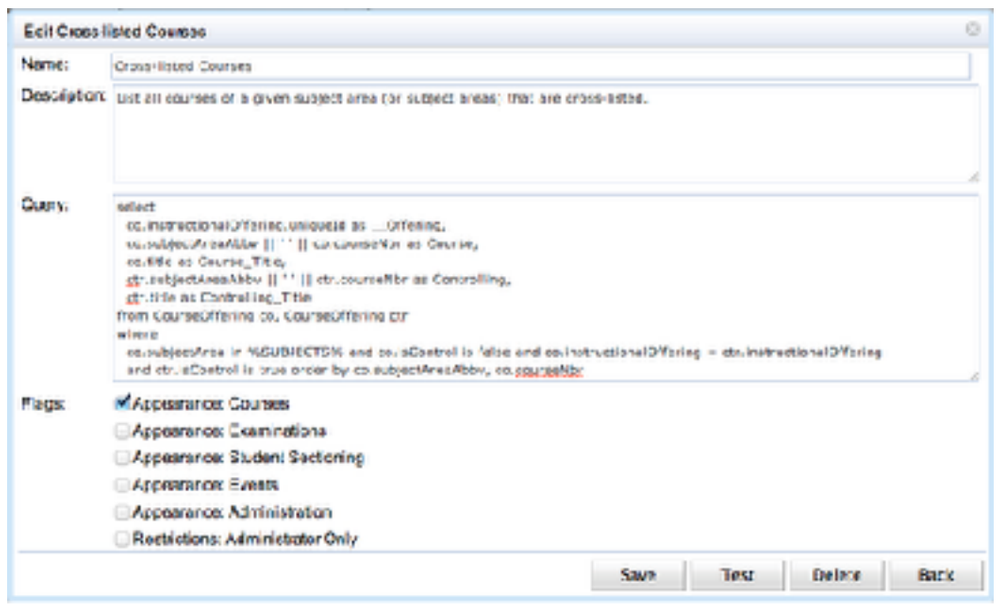
- Many pages have Export PDF or Export CSV buttons
- Events can be exported to iCalendar format
- For events and rooms, it is possible to subscribe to an export URL

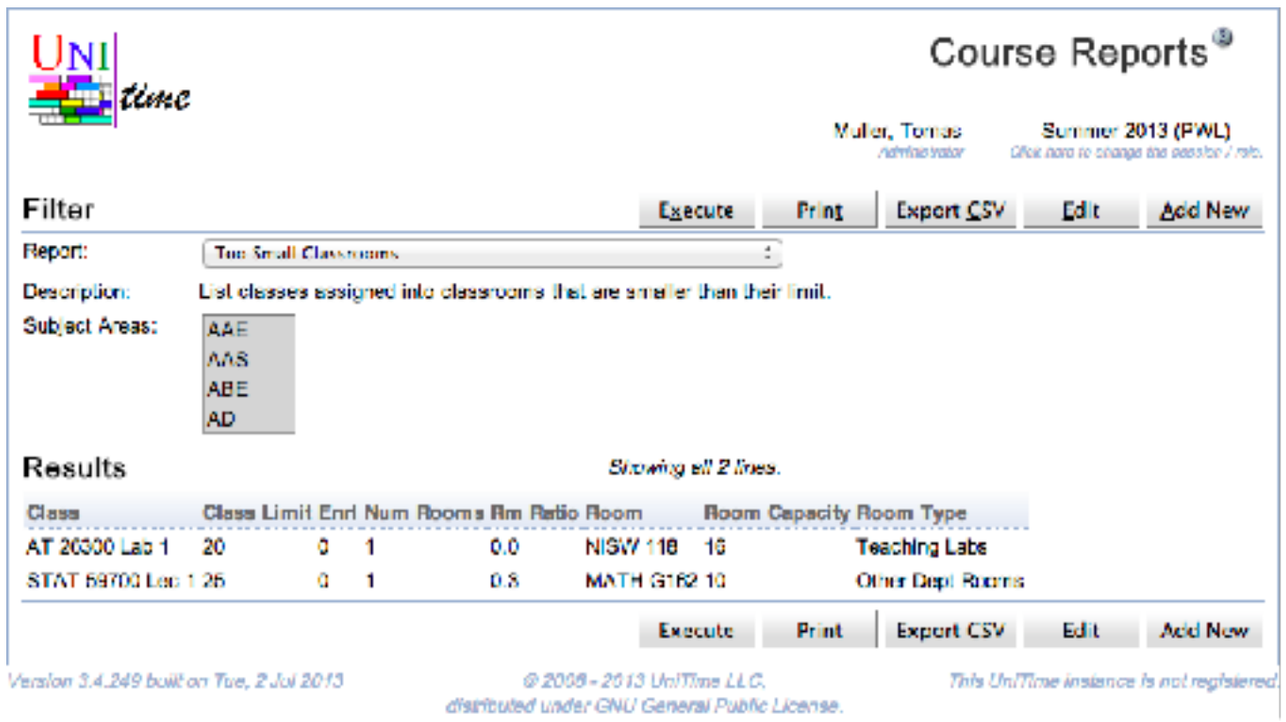
Credit: Photo by Loïc Romer

HQL Reports

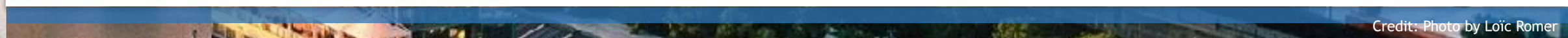
Custom Reports

- 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.



Credit: Photo by Loïc Romer

Scripts

Scripts

- Using JSR 223: Scripting for the Java Platform
- JavaScript or Python, can call UniTime methods
  - For Python, put Jython Standalone JAR to Tomcat/libs
- 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/ufqW1t
- 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

Conclusion

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