

Using UniTime to rebuild schedules (e.g., due to the pandemic)

Tomáš Müller



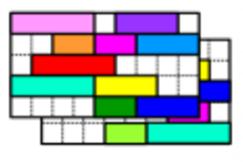




Open Source and the **Next Normal Open** Apereo '21





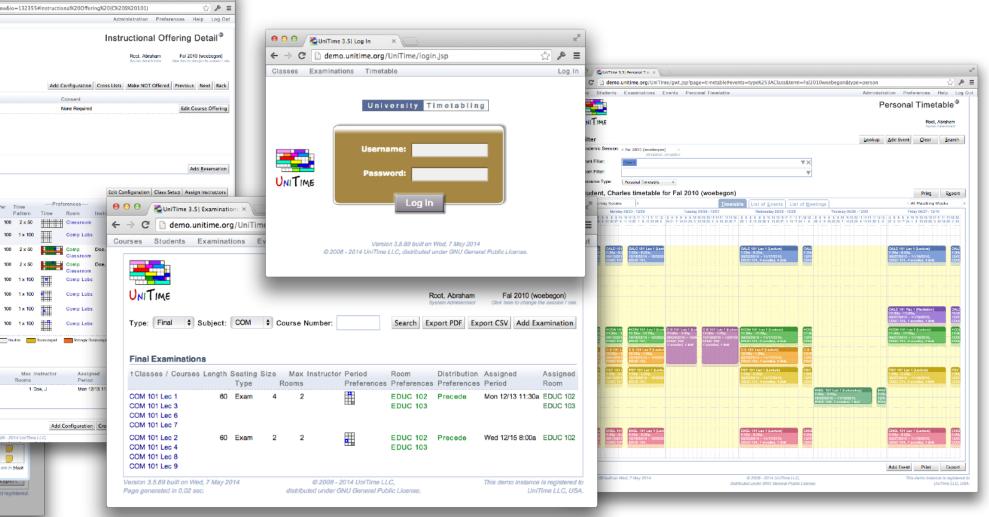


- Comprehensive academic scheduling solution
- Five components: course timetabling, examination timetabling, student scheduling, instructor scheduling, and event management
- Open Source, web-based, written in Java using modern technologies • Using state of the art optimization algorithms
- Distributed data entry and timetabling in a multi-user environment

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What is UniTime?



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june 7th - 9th | entirely online







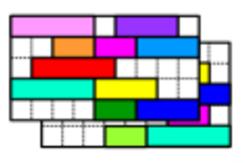
- UniTime can be used not only to build schedules, but also to make changes
- Example from Purdue University
 - How the timetabling is done usually
 - Fall 2020 scheduling changes due to COVID-19
 - Results
- Short demo
 - Please see us at the software communities Expo
- Discussion











Suggestions page

- Manual changes, e.g., after the solver has finished
- Using the course timetabling solver
- All decisions are on the operator, UniTime provides suggestions
 - Available rooms, possible class swaps, etc.
- Interactive configuration: time/room hard constraints can be violated
- Also perfect for checking unassigned classes



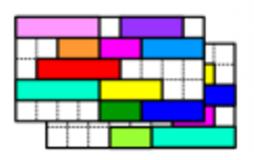


Making Small Changes

UNITI	•			Solv Course	er stopped. Timetabling Solver	Root, Abraham System Administrator	Click
	t Assignment		lec 1				
Date:		Full Term					
Time:		Th 18:30 - 20:10 Y 1					
Room: Instructor		Marshall, Barb					
Student (1a Th 17:35 - 20:10 D 3	C D 42 (bard) D		1/20 01	
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VITIME

Class Assignment page

- Once the timetabling is done and there is a solution already published
- Course timetabling solver is not needed
- All decisions are on the operator, UniTime check constraints
 - Available rooms, student/instructor conflicts, etc.
- Perfect for rooms swaps, adding new sections, etc.





Making Small Changes



Class ART 123 Rec 1

Manager:	ART - Department of Art
Class Limit:	80
Number of Rooms:	1
Room Ratio:	0,8 (Minimum Room Capacity: 64)
Conflict Checked Instructor(s):	Marshall, Barb
Assigned Dates:	Full Term 🔳
Assigned Time:	Th 18:30 - 20:10
Assigned Room:	B 5
Selected Dates:	Full Term 🔳
Selected Time:	T 8:25 - 10:05
Selected Room:	B 5

New Assignment(s

Class	Instructor	Date Change	Time Change	Ro
送 ART 123 Rec 1	Marshall, Barb	Full Term	Th 18:30 → T 8:25	В 5
HIST 403 Lec 1	Barrett, Bobby	Full Term → <i>not-assigned</i>	T 9:20 → <i>not-assigned</i>	В 5
BIOL 987 Lec 1	Butler, Heather	Full Term → <i>not-assigned</i>	T 7:30 → <i>not-assigned</i>	В 5
Do not unassign conflictir	na classes: 🗆			

Student Conflict

Students	Class	Date	Time	Room
There are no student conflicts.				

Showing projected student conflicts, click here to change to the actual class enrollment

Available Times for ART 123 Rec 1

M 7:30 - 9:10 0 T 7:30 - 9:10 0 W 7:30 - 9:10 0 Th 7:30 - 9:10 0 M 8:25 - 10:05 0 **0** W 8:25 - 10:05 **0** Th 8:25 - 10:05 **0** M 9:20 - 11:00 **0** T 9:20 - 11:00 **0** W 9:20 - 11:00 0 Th 9:20 - 11:00 0 M 10:15 - 11:55 0 T 10:15 - 11:55 0 W 10:15 - 11:55 0 Th 10:15 - 11:55 0 M 11:10 - 12:50 0 T 11:10 - 12:50 0 W 11:10 - 12:50 0 Th 11:10 - 12:50 0 M 12:05 - 13:45 0 T 12:05 - 13:45 0 W 12:05 - 13:45 0 Th 12:05 - 13:45 0 M 13:00 - 14:40 0 T 13:00 - 14:40 0 W 13:00 - 14:40 0 Th 13:00 - 14:40 0 M 13:55 - 15:35 0 T 13:55 - 15:35 0 W 13:55 - 15:35 0 Th 13:55 - 15:35 0 M 14:50 - 16:30 0 T 14:50 - 16:30 0 W 14:50 - 16:30 0 Th 14:50 - 16:30 0 M 15:45 - 17:25 0 T 15:45 - 17:25 0 W 15:45 - 17:25 0 Th 15:45 - 17:25 0 M 16:40 - 18:20 0 T 16:40 - 18:20 0 W 16:40 - 18:20 0 Th 16:40 - 18:20 0 M 17:35 - 19:15 0 T 17:35 - 19:15 0 W 17:35 - 19:15 0 Th 17:35 - 19:15 0 M 18:30 - 20:10 0 T 18:30 - 20:10 0 W 18:30 - 20:10 0 Th 18:30 - 20:10 0 not-assigned

Available Rooms for ART 123 Rec 1 (selected size: 68 of 64)

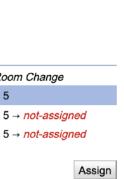
Size: 64 -	Filter:	Allow conflicts: 🗹 Rooms: Departme	ental ✔ Order: Name [a
Room Types:	Common Classrooms	Laboratories	Computer Labor
	Technical Rooms	□ Ateliers	Music Rooms
	Dramatic Rooms	Sport Facilities	Outside Location
Room Groups:	Art Studio	Classroom	Computer Lab
	Dramatic Lab	Laboratory	Music Lab
	Sports Complex	Technical Classroom	
Room Features:	Computer	Data Projector	
	Easels	Interactive Blackboard	Microphone
	Notation Board	Overhead Projector	Piano
	🗌 Video	Uisualizer	Wheelchair Acce
A 50 234 <u>B 5</u> 68	D 30 106 D 32 64 D 35	132 FF 9999	

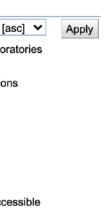
Y1 120 office 9999

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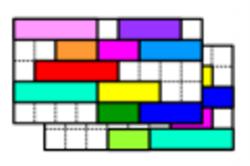












MPP mode of the Solver

- For example
 - a building goes offline,
 - what-if scenarios,
 - reduced room capacities due to the social distancing
- Minimal Perturbation Problem mode of the solver
 - Solution to a new (modified) problem
 - As close as possible to the previous (published) solution





Making Large Changes

local ∨





Course Timetabling Solver

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Host:

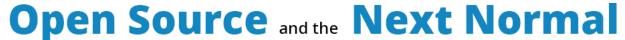
Best Timetable

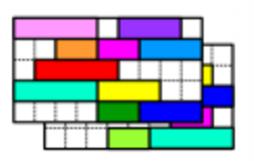
Assigned variables	100.00% (3008/3008)	
Overall solution value	17100.34	
Time preferences	93.13% (7164.00)	
Student conflicts	963 [committed:0, distance:0, hard:277]	
Room preferences	77.89% (650)	Perturba
Distribution preferences	96.50% (811.00)	reiturba
Back-to-back instructor preference	s 100.00% (0)	
Too big rooms	15.61% (1878)	(changes) a
Useless half-hours	0.47% (0 + 1005)	
Same subpart balancing penalty	70.58	of the optir
Room Size Penalty	7.14	•
Perturbation variables	41.01% (1198 + 87)	criter
Perturbations: Total penalty	2886.20	
Time	4.45 min	
Iteration	176880	
Memory usage	1388.49M	
Speed	663.05 it/s	
Block Constraints	100%	
Important student conflicts	457 [hard: 71]	
Student groups	93.79%	

Open Apereo '21 the open source conference for june 7th - 9th | entirely online



Root. Abraham







Input Data

- Previous/Initial solution
 - Schedule of classes, students already registered for their classes
- Modified input data
 - Room capacity changes, some classes offered online
 - Some students cannot come to campus
 - Most of the previous constraints apply (time requirements, limits, etc.)

New Solution

- Solves the modified input problem
- Minimizes changes to the initial solution
 - Some changes may be allowed (e.g., room swaps), different weights
- Optimization has two components
 - Preferences and requirements given by the problem
 - Changes to the initial solution

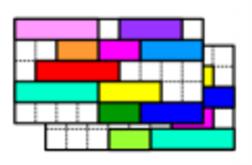


Minimal Perturbation Problem









Course Timetabling

- Courses are rolled-forward from the previous like term • Last year's student course enrollments (+ curriculum projections)
- Different stages
 - Classes needing large rooms are timetabled first, centrally
 - Individual departments build they timetables
 - Most classrooms are allocated to departments
 - Some classes may be left if additional classroom space is needed
 - Overflow departmental classes are timetabled centrally
 - Computing labs are timetabled last, also centrally
- The whole process takes about a month (~February for Fall term)

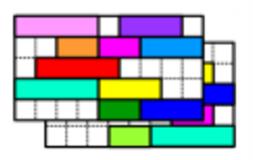




Normal Year at Purdue







Student Scheduling

- Continuing Students
 - Some students pre-register (~5.8k for Fall 2020)
 - Student's fill in their course requests (February March)
 - UniTime builds student schedules (mid April)
 - Students can make changes (mid April May)
 - Other students can register directly for classes (starting in March) • Graduate students, students that started before Fall 2019
- Incoming students (~9.3k for Fall 2020)
 - Fill in their pre-registration in (June)
 - Day on campus orientation program (STAR)
 - UniTime builds student schedules (mid July)
- All students can make changes (mid July through the term)



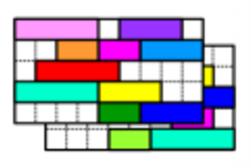
Normal Year at Purdue



june 7th - 9th | entirely online







Pandemic Hit

- Spring 2020 became online (existing times, no in-person classes)
 - No schedule changes
- Fall 2020 schedule of classes was already built
 - Continuing students were already registered for classes
- It was decided to offer some face-to-face classes in Fall 2020
 - Various safety rules (testing, contact tracing, masks, etc.)
 - Room capacity reduced (50%, not more than 150 seats)
 - Students have a choice to come to campus, or get a fully online
 - Some courses may be offered in an asynchronous manner

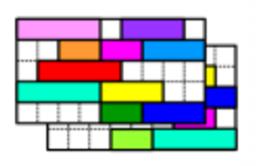




Fall 2020 Pandemic







Course Timetabling Changes

- Keep the existing times as much as possible
 - Some classes are taught online (~1.6k)
 - Some classes are fully face-to-face (~1.3k larger room, ~0.4k sections added) • Some classes have partial attendance (~5.6k)

 - Additional rooms added
- UniTime MPP solver (~8.6k classes)
 - Simulations, build the final schedule
- Offer additional courses that would be fully online • E.g., ENGL 106000L as an alternative to ENGL 10600

 - Only for students not on campus



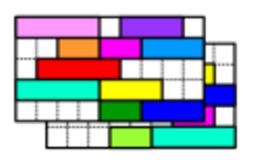
Fall 2020 Pandemic











Student Scheduling Changes

- Continuing students have to be re-scheduled
 - Pre-registration for courses they had enrolled, class preferences Dropped from courses that needed to be re-scheduled
 - - Courses where the students needed to be moved around
 - Students not allowed to make changes till after the re-batch (July)
- Incoming students
 - STAR fully online
 - Pre-registered accordingly (residential or OL courses)
- Students that have chosen to be off campus (both STAR and cont.) Pre-registration with incoming students
- All students batched together (mid July)
- All students can make changes (mid July through the term)

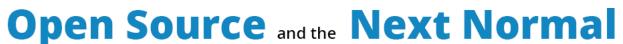


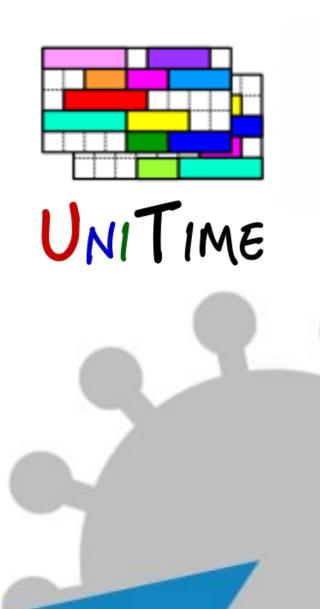
Fall 2020 Pandemic

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Open Apereo '21









	Continuing Residential	Continuing Online	Incoming Residential	Incoming Online
Number of Students	15,434	2,354	8,013	1,336
Assigned Courses	99.4%	94.8%	94.8%	97.4%
Assigned Critical Courses	100.0%	99.4%	99.4%	99.5%
Satisfied Preferences	93.5%	98.3%	65.2%	96.2%
Students with no face-to-face classes	0.1%		0.4%	
Students with <50% classes face-to-face	23.4%		43.4%	

- counted (~ 1.8 courses per student needed a change)

Fall 2020 Results

• Only continuing residential students that needed at least one course re-scheduled are

• Critical courses are needed by the student to graduate (marked as critical on the degree plan)















Additional Challenges

- Various improvements in UniTime needed
 - Scripts and reports to help automate the process of making changes
 - Course timetabling MPP with fixed times
 - Student scheduling MPP with fixed enrollments
- Class attendance for classes with split attendance
 - A different project at Purdue, needed for contact tracing
- Ensuring that each student on campus gets some face-to-face classes
 - Course modality reporting
 - Preferably, at least half of his/her schedule
 - Additional optimization criteria in UniTime

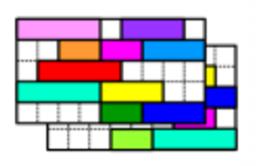




Fall 2020 Pandemic







Spring 2021

- Added student priority in UniTime
- Same policies as for Fall 2020 (room capacity, online-only, etc.) Build from the beginning without the need to re-schedule • More focus on ensuring enough classes are offered face-to-face • All classes that need a classroom timetabled centrally (~4k) • All undergraduate students pre-registered and were batched (~31k)

Fall 2021

- Back to normal (no off campus students, pre-COVID room caps)
- All undergraduate students pre-registered and were batched in April (~24k) • Incoming students are registering right now (~10k, VSTAR only) Unexpected increase in the number of incoming students



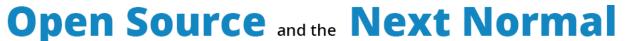
Back to Normal













	Residential	Online	Priority	Graduating (100+ credit)	Seniors (60+ credit)	Other
Number of Students	28,439	2,444	4,478	7,244	8,325	10,836
Assigned Courses	96.1%	96.4%	98.1%	97.8%	95.5%	94.7%
Assigned Critical Courses	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Satisfied Preferences	76.4%	86.8%	76.7%	78.7%	78.0%	72.6%
Students with no face-to-face classes	2.6%		1.4%	5.2%	2.2%	1.5%
Students with <50% classes face-to-face	32.5%		29.8%	29.4%	28.7%	40.0%

- Over 1/3 of courses are filled up to their limit



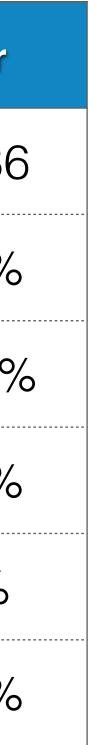


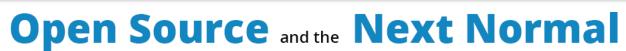
Spring 2021 Results

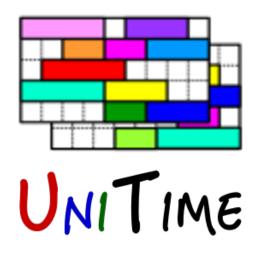
• Same students split two-ways: residential / online, and by priority











Thank you!





Open Source and the **Next Normal Open** Apereo '21

