

Using UniTime

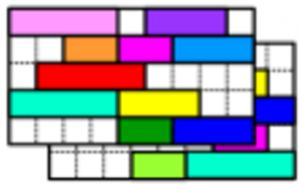
to rebuild schedules
(e.g., due to the pandemic)

Tomáš Müller



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Open Apereo '21

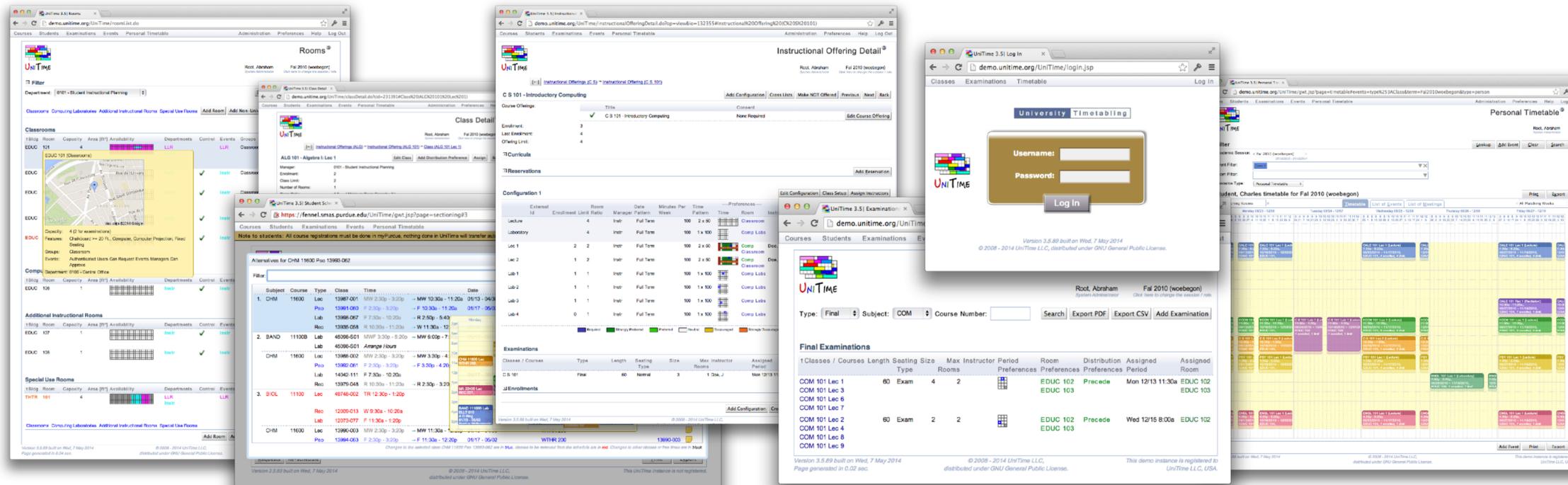
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UNI^TIME

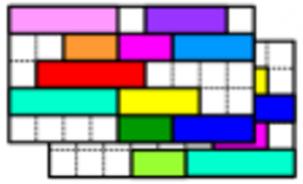
What is UniTime?

- 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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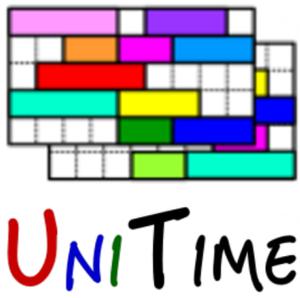
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UNI^TIME

- 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





Making Small Changes

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

UNI TIME Suggestions ?
Solver stopped. Course Timetabling Solver Root, Abraham System Administrator Spring 2015 (ED) [Click here to change the session / role.](#)

Current Assignment of ART 123 Rec 1

Date: Full Term
Time: Th 18:30 - 20:10
Room: Y 1
Instructor: Marshall, Barb
Student Conflicts: 1x MUS 212 Lec 1a Th 17:35 - 20:10 D 36, D 43 [hard] PB-SPE/HV3S, VV3S 01
Available Times: M 7:30, M 8:25, M 9:20, M 10:15, M 11:10, M 12:05, M 13:00, M 13:55, M 14:50, M 15:45, M 16:40, M 17:35, M 18:30, T 7:30, T 8:25, T 9:20, T 10:15, T 11:10, T 12:05, T 13:00, T 13:55, T 14:50, T 15:45, T 16:40, T 17:35, T 18:30, W 7:30, W 8:25, W 9:20, W 10:15, W 11:10, W 12:05, W 13:00, W 13:55, W 14:50, W 15:45, W 16:40, W 17:35, W 18:30, Th 7:30, Th 8:25, Th 9:20, Th 10:15, Th 11:10, Th 12:05, Th 13:00, Th 13:55, Th 14:50, Th 15:45, Th 16:40, Th 17:35, Th 18:30
Available Rooms: A 50, B 5, D 30, D 32, D 35, Y 1
Minimum Room Size: 64

Legend: Required (blue), Strongly Preferred (green), Preferred (light green), Neutral (black), Discouraged (yellow), Strongly Discouraged (orange), Prohibited (red)

Selected Assignment

Class	Date	Time	Room	Objectives
ART 123 Rec 1	Full Term	Th 18:30 → T 8:25	Y 1	Broken Time Patterns: -3.667 Important Student Conflict: +43 Important Student Hard Conflict: +1 Student Conflict: +42 Time Preferences: +22

Conflicting Assignments

Class	Date	Time	Room	Constraint
PED 206 Rec 27	Full Term	T 9:20 → not-assigned	Y 1 → not-assigned	Room Y 1

Suggestions

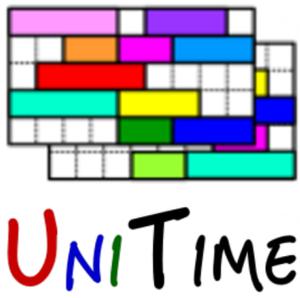
Filter: Search

Score	Class	Date	Time	Room	Students	Objectives
+14.281	ART 123 Rec 1	Full Term	Th 18:30 → T 8:25	Y 1	+49	Broken Time Patterns: -3.667 Distribution Preferences: -4 Important Student Conflict: +50 Important Student Hard Conflict: +1 Room Size Penalty: -72.62 Student Conflict: +49 Time Preferences: +32
+14.348	ART 123 Rec 1	Full Term	Th 18:30 → T 8:25	Y 1	+49	Broken Time Patterns: -3.667 Distribution Preferences: -4 Important Student Conflict: +50 Important Student Hard Conflict: +1 Room Preferences: +1 Room Size Penalty: -104.871 Student Conflict: +49 Time Preferences: +32
+37.394	ART 123 Rec 1	Full Term	Th 18:30 → T 8:25	Y 1	+61	Broken Time Patterns: -1.833 Distribution Preferences: -4 Important Student Conflict: +63 Important Student Hard Conflict: +1 Room Size Penalty: -102.8 Student Conflict: +61 Time Preferences: +60



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Making Small Changes

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.



Class Assignment ?

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	Room Change
ART 123 Rec 1	Marshall, Barb	Full Term	Th 18:30 → T 8:25	B 5
HIST 403 Lec 1	Barrett, Bobby	Full Term → not-assigned	T 9:20 → not-assigned	B 5 → not-assigned
BIOL 987 Lec 1	Butler, Heather	Full Term → not-assigned	T 7:30 → not-assigned	B 5 → not-assigned

Do not unassign conflicting classes:

Assign

Student Conflicts

Students	Class	Date	Time	Room
There are no student conflicts.				

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

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
T 8:25 - 10:05	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: Departmental Order: Name [asc] Apply

Room Types:
 Common Classrooms
 Technical Rooms
 Dramatic Rooms
 Art Studio
 Dramatic Lab
 Sports Complex
 Computer
 Esels
 Notation Board
 Video

Room Groups:
 Art Studio
 Sports Complex
 Computer
 Esels
 Notation Board
 Video

Room Features:
 Computer
 Esels
 Notation Board
 Video

Laboratories
 Ateliers
 Sport Facilities
 Classroom
 Laboratory
 Technical Classroom
 Data Projector
 Interactive Blackboard
 Overhead Projector
 Visualizer

Computer Laboratories
 Music Rooms
 Outside Locations
 Computer Lab
 Music Lab
 DVD
 Microphone
 Piano
 Wheelchair Accessible

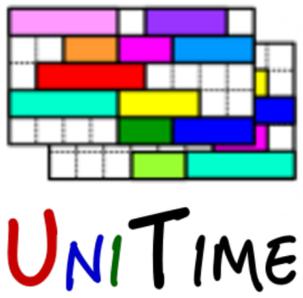
A-50 234 B-5 68 B-30 106 B-32 64 B-35 132 FF 9999
Y-1 120 office 9999



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Making Large Changes

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



Course Timetabling Solver

Input Data Loaded: 3.6.2021 14:11
Status: Solving problem ...
Progress: Improving found solution ... (15,0%)
Solver Configuration: Default
Solver mode: **MPP**
When finished: No Action
Load committed assignments:
Student course demands: Curricula Course Demands
Committed student conflicts: Compute
Allow breaking of hard constraints:
Owner: Art, Biology, Civics, Czech Language and Literature, Distance Learning
Host: local

Course Timetabling Solver ?
Solving problem ...
Root, Abraham
System Administrator
Spring 2015 (ED)
Click here to change the session / role.

Solver mode set to MPP

Best Timetable

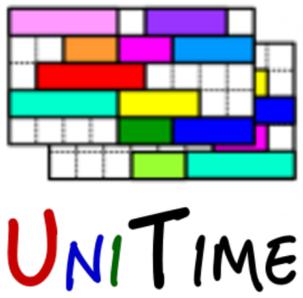
Assigned variables	100.00% (3008/3008)
Overall solution value	17100.34
Time preferences	93.13% (7164.00)
Student conflicts	963 [committed:0, distance:0, hard:277]
Room preferences	77.89% (650)
Distribution preferences	96.50% (811.00)
Back-to-back instructor preferences	100.00% (0)
Too big rooms	15.61% (1878)
Useless half-hours	0.47% (0 + 1005)
Same subpart balancing penalty	70.58
Room Size Penalty	7.14
Perturbation variables	41.01% (1198 + 87)
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%

Perturbations (changes) are one of the optimization criteria



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Minimal Perturbation Problem

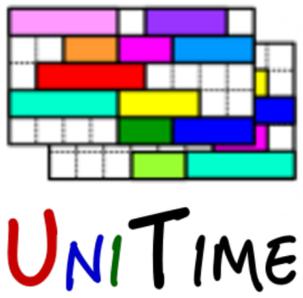
Input Data

- 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



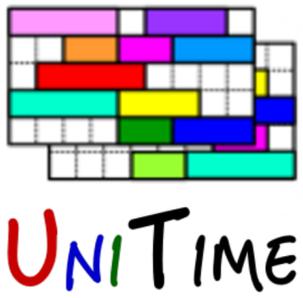


Normal Year at Purdue

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)

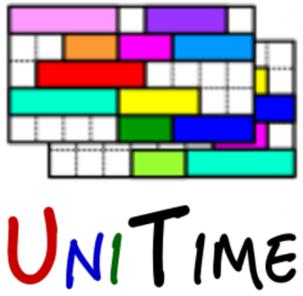




Student Scheduling

- **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)

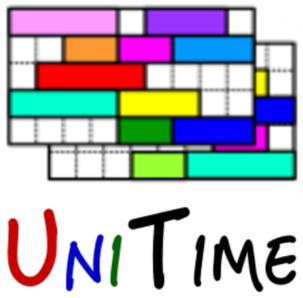




Pandemic Hit

- **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

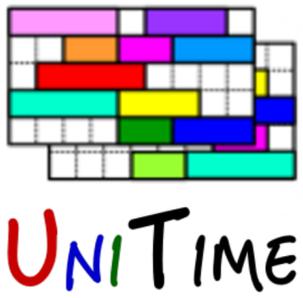




Course Timetabling Changes

- 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 10600OL as an alternative to ENGL 10600
 - Only for students not on campus

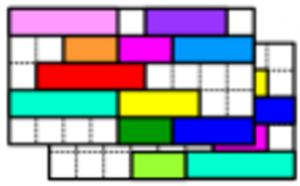




Student Scheduling Changes

- 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)





UNITIME

Fall 2020 Results

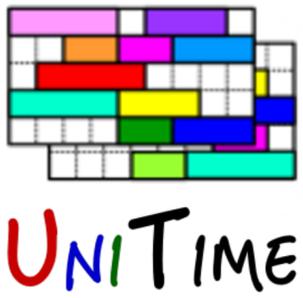
	Continuing Residential	Continuing Online	Incoming Residential	Incoming Online
Number of Students	15,434	2,354	8,013	1,336
Assigned Courses	99.4%	94.8%	94.8%	97.4%
Assigned Critical Courses	100.0%	99.4%	99.4%	99.5%
Satisfied Preferences	93.5%	98.3%	65.2%	96.2%
Students with no face-to-face classes	0.1%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

- Only continuing residential students that needed at least one course re-scheduled are counted (~ 1.8 courses per student needed a change)
- Critical courses are needed by the student to graduate (marked as critical on the degree plan)



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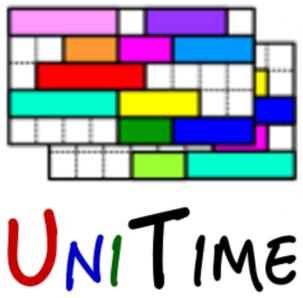
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Additional Challenges

- 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**





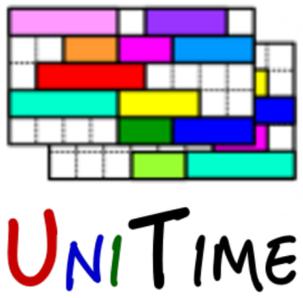
Spring 2021

- 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)
 - Added student priority in UniTime

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



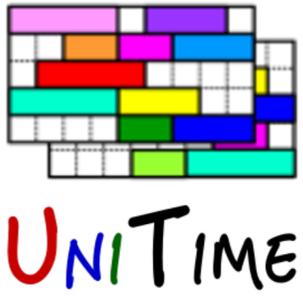


Spring 2021 Results

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





Thank you!



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