ITC 2019

Results Using the UniTime Solver

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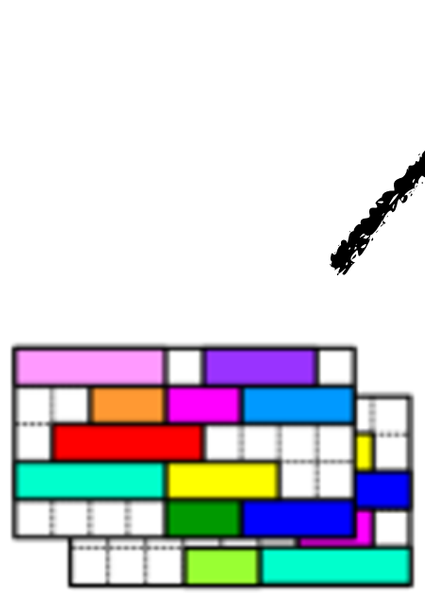
August 2022

UniTime

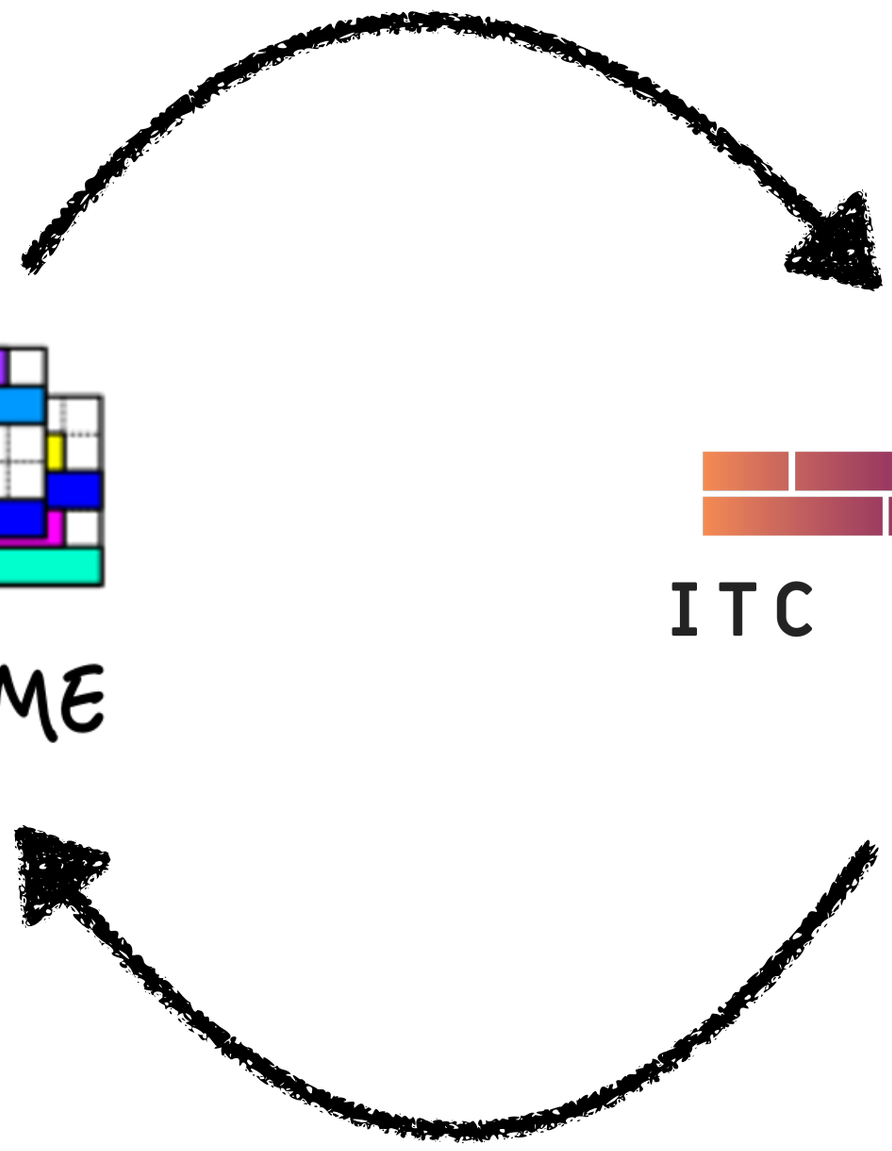
PATAT 2022

ITC 2019

Overview



UniTime



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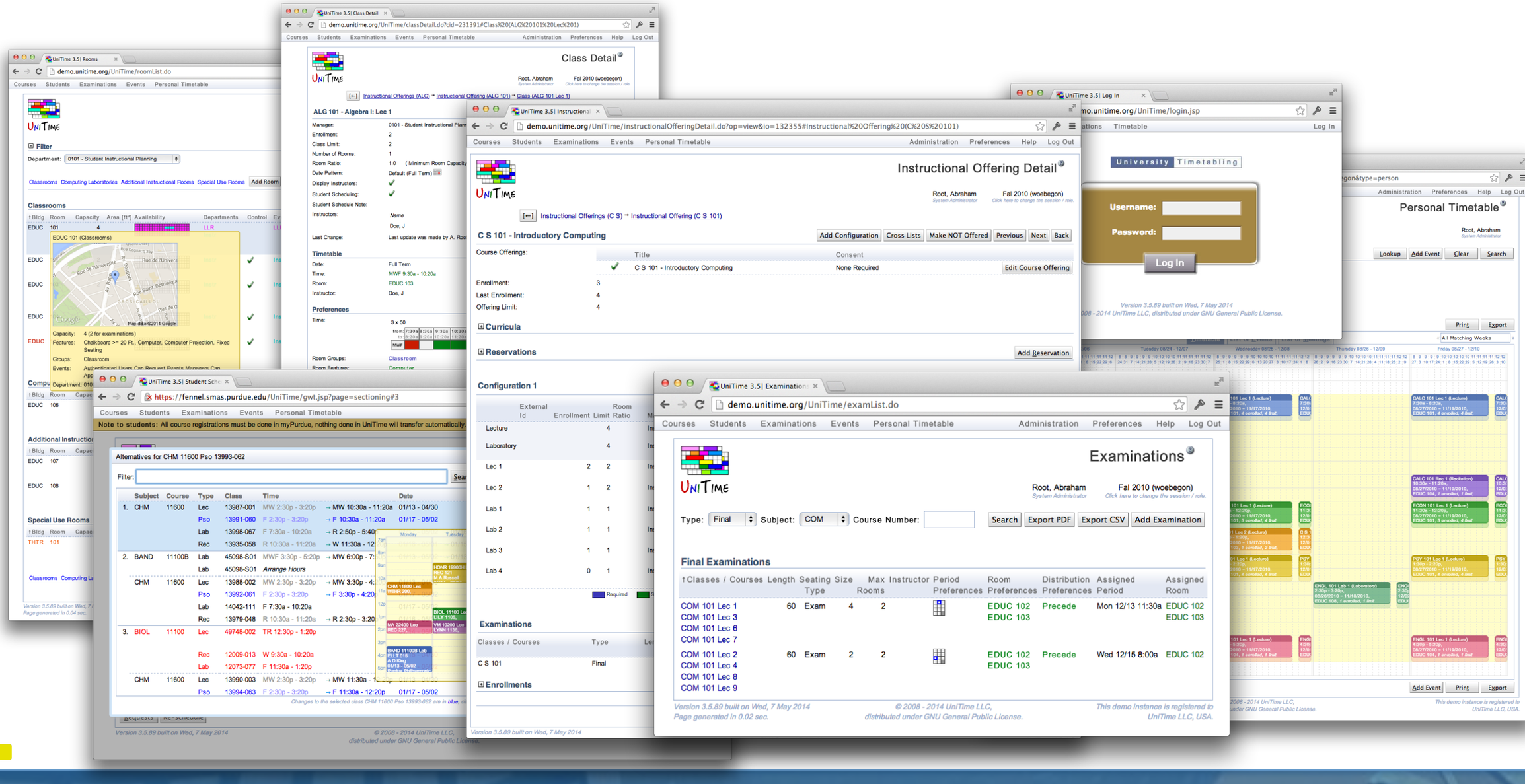
Introducing UniTime

What is UniTime?

- Comprehensive academic scheduling solution



Introducing UniTime

What is UniTime?

- Comprehensive academic scheduling solution
- Five components

Courses: time & rooms
- time preferences / availability
- room requirements
- course structure
- avoid time clashes
- student course demand
- distributions

Events: room bookings
- course-related events
- personal schedule
- approval process
- unavailabilities

Exams: period & rooms
- minimise student conflicts
- period & room prefs
- distributions
- multiple rooms
- room sharing

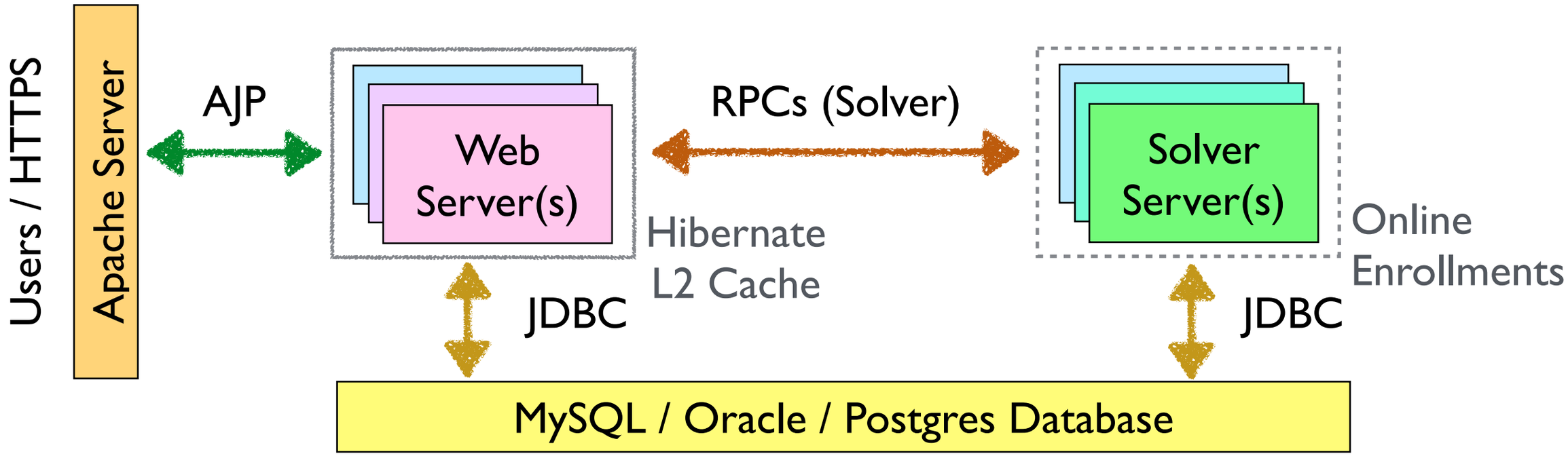
Instructors: teaching assignments
- teaching load
- qualifications / skills
- preferences
- course spreading

Students: class schedule
- course requirements
- alternatives / free times
- reservations
- section balancing
- schedule quality

Introducing UniTime

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



Introducing UniTime

What is UniTime?

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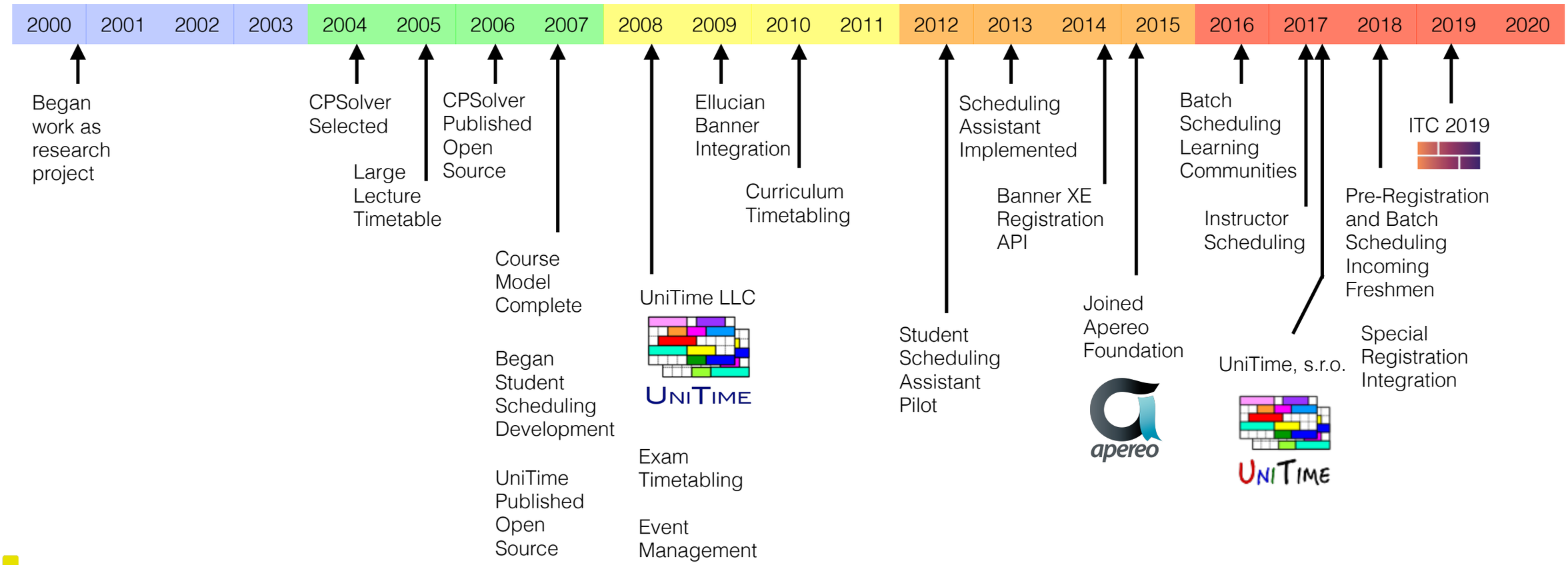
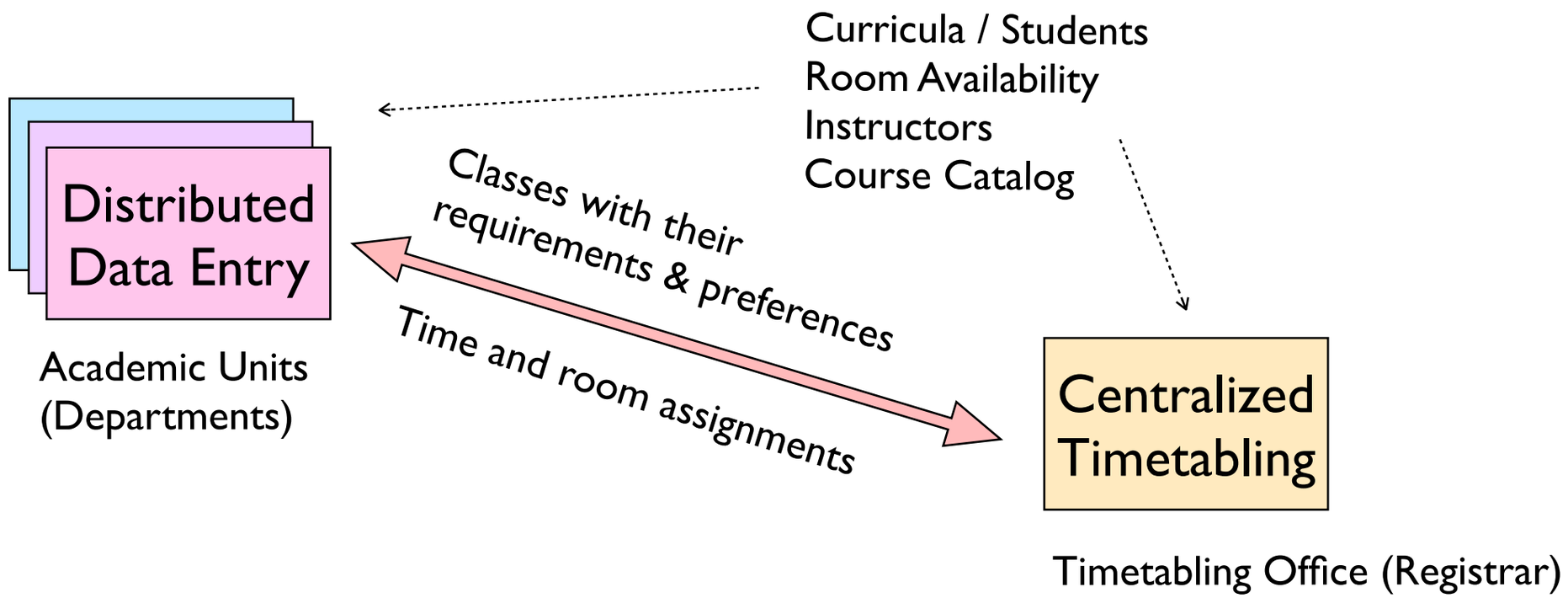
- Five components: course timetabling, examination timetabling, student scheduling, instructor scheduling, and event management
- Open Source, web-based, written in Java using modern technologies
- Over two decades of research & development



Introducing UniTime

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
- Over two decades of research & development
- Distributed data entry and timetabling in a multi-user environment



UniTime Users

Word cloud

- Over 500 voluntary registrations
- 97 institutions have indicated that they use UniTime in production
- 45 new registrations during the last 12 months
- 10 institutions from 4 continents has provided data for the ITC 2019 competition

as of May 2022

UniTime Solver: CPSolver

- Open source: https://github.com/UniTime/cpsolver
- Java library that can be used outside of UniTime
- Constraint programming-like modelling / framework
  - Variables, values, hard and soft constraints, optimisation criteria
  - Search algorithms and heuristics using abstract classes
  - Automatically ensures feasibility
- For each problem
  - Constraint model, optimisation criteria, additional neighbourhoods
- Iterative Forward Search
  - Takes one variable at a time and assigns it, conflicts are unassigned
  - Conflicts-based statistics used to escape local optima
- Other techniques can be used
  - Local-search based like Great Deluge, Simulated Annealing, etc.
- Default: IFS until a complete solution is found, Great Deluge afterward

UniTime

ITC 2019

International Timetabling Competition 2019

- Course timetabling component
  - Time and room assignment of classes
  - Student sectioning (students request courses, put in classes)
- Ten institutions donated their data
  - Anonymised, asked for at least two terms each (e.g., Fall and Spring)
- Simplified problem formulation
  - Easier model without loosing computational complexity
- XML data format
  - Different from what UniTime is using
  - Only containing information needed

Simplified Problem Formulation

International Timetabling Competition 2019

- Times & Rooms
  - At most one room, simplified room sharing, overlaps not allowed
  - GPS coordinates and travel times in minutes converted
  - Date patterns > weeks
- Instructors
  - No instructors in ITC2019, using *SameAttendees* distribution instead
- Students
  - No student reservations, hard student conflicts, student weights/priorities
- Distributions
  - Carefully selected distribution constraints (e.g., avoiding BTB)
  - Small changes in soft constraint penalisations
- Objectives
  - Only the four most important optimisation criteria
  - Removed: minimise extra space in rooms, keep students together, etc.

Using UniTime Solver

Using UniTime/CPSolver on ITC 2019 instances

- Open source: https://github.com/tomas-muller/cpsolver-itc2019
- Default configuration *(that comes with UniTime)*
  - 2 hour time limit, single CPU thread, 10 independent runs
  - Weights of the four criteria adjusted according to the instance
- Load/save of the competition format
- UniTime penalisation of soft distribution constraints
  - Bonus for satisfying a distribution constraint fully
  - MaxBreak use quadratic penalisations
  - MaxBlock penalisation considers block length
- UniTime student sectioning
  - Initial sectioning during the data load
    - Similar students are kept together
  - Final sectioning at the end of the solver run
    - Great Deluge with single student moves, and two student swaps
  - Smaller weight on student conflicts between classes with alternatives

Results: Late

Late	UniTime		Best Result at ITC2019.org					
Instance	2h Best	Average	Holm	Rappos	Gashi	Er-rhaimini	Lemos	Müller
agh-fal17	130 635	133 754.9	140 194		184 030	153 236	142 687	**117 627**
bet-spr18	352 249	353 373.5	**348 524**	360 057	360 437	373 039	353 920	348 533
iku-spr18	40 765	43 082.0	**25 863**	36 711	85 969	70 932	45 537	35 184
lums-fal17	398	411.1	**349**	386	486	558	813	366
mary-fal18	4 924	5 101.4	**4 331**	5 637	7 199	6 944	44 097	4 795
muni-fi-fal17	3 506	3 789.5	**2 837**	3 794	4 712	4 820	4 161	3 166
muni-fspsx-fal17	12 455	15 639.9	10 645	33 001	41 933	104 625	101 317	**10 014**
muni-pdfx-fal17	117 382	125 200.6	**82 258**	151 464	159 203	191 887	151 461	96 312
pu-d9-fal19	46 067	47 441.5	**38 834**	134 009	82 757	70 450	47 543	44 440
tg-spr18	16 140	20 418.2	**12 704**	12 856	15 992	19 738	31 900	14 548

as of August 2022

- Best known solution is in **bold**
- Solutions improved after the competition are underlined
- Second best solution within the finalists is blue
- UniTime results better than the second best are purple

Results: Middle

Middle	UniTime		Best Result at ITC2019.org					
Instance	2h Best	Average	Holm	Rappos	Gashi	Er-rhaimini	Lemos	Müller
agh-ggos-spr17	3 905	4 789.9	**2 855**	6 320	9 328	7 725	79 745	3 385
agh-h-spr17	22 655	24 867.0	**21 161**	26 159	25 081	25 745	55 887	22 161
lums-spr18	105	108.6	**95**	114	107	178	547	97
muni-fi-spr17	4 201	4 365.0	**3 738**	4 289	4 692	5 433	18 080	3 953
muni-fsps-spr17c	4 036	4 925.0	**2 594**	3 303	9 222	23 520	618 217	2 951
muni-pdf-spr16	22 038	23 804.6	**17 159**	24 318	40 074	38 826	310 994	19 768
nbi-spr18	19 403	19 858.7	**18 014**	19 055	26 517	30 309	49 924	18 627
pu-d5-spr17	15 303	15 565.8	15 842	18 813	19 440	20 242	15 733	**15 184**
pu-proj-fal19	120 594	124 043.6	147 712	561 194	237 909	176 039	128 370	**117 169**
yach-fal17	1 799	2 000.6	1 135	1 844	1 727	3 181	32 198	**1 074**

as of August 2022

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Results: Early

Early	UniTime		Best Result at ITC2019.org					
Instance	2h Best	Average	Holm	Rappos	Gashi	Er-rhaimini	Lemos	Müller
agh-fis-spr17	4 022	4 630.3	**2 985**	4 557	6 799	5 709	35 139	3 342
agh-ggis-spr17	46 809	48 964.4	**34 285**	36 616	77 932	56 755	161 118	36 305
bet-fal17	293 839	294 907.0	**289 656**	295 427	299 205	313 812	296 015	289 954
iku-fal17	27 112	28 178.4	**18 968**	26 840	50 613	44 482	29 929	23 096
mary-spr17	15 207	15 494.2	**14 910**	15 021	15 894	16 698	51 147	15 122
muni-fi-spr16	4 131	4 227.4	**3 752**	3 844	5 006	5 207	19 314	4 039
muni-fsps-spr17	883	1 794.9	**868**	883	1 938	4 135	211 142	879
muni-pdf-spr16c	50 074	53 157.3	**33 331**	37 487	58 206	77 573	53 803	39 344
pu-llr-spr17	11 404	11 872.3	**10 038**	13 385	16 874	19 231	68 003	10 772
tg-fal17	5 337	5 816.5	**4 215**	**4 215**	8 044	7 358	6 774	**4 215**

as of August 2022

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Conclusions

ITC 2019: Results Using the UniTime Solver

- One 2h run is usually enough for the users (default is 30 mins)
- Better results can be achieved with longer run times and some parameter tuning
  - But the UniTime solver would not beat the winner *(at its current state with just parameter tuning and longer run time)*
  - It is to be seen if the winner algorithm could be used in practice
- ITC 2019 was a success
  - All the five finalist were able to produce solutions that were on par of better than what UniTime would produce out of the box
  - There is still a lot of interest in the competition data

Thank you!

For more details about UniTime please see https://www.unitime.org