



Space Management & Academic Scheduling

Comprehensive Approach to Student Sectioning

PATAT 2008

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Student Sectioning Problem

- What is Student Sectioning?
 - Student requests courses, system determines classes (sections)
 - Respects course structure, reservations, student preferences, etc.
- Why is Student Sectioning needed?
 - Multi section courses, optimization of student class enrollments, dynamic reservations of space in sections with excess demand

	Туре	Course / Free Time	Waitlist	1st Alternative Course	2nd Alternative Course
1.	Course 💌	ENGL 💌 106 💌		*	
2.	Course 💌	BIOL 💌 110 💌		BIOL 💌 111 💌	BIOL 💌 112 💌 🎓 🖊 🗂
3.	Free Time 💌	3 x 50 💌 MWF 💌 7:30a - 8:20a 💌			1 🗸
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5.	Course 💌	MA 💌 152 💌		MA 💌 159 💌	
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11.	Course 💌	A&AE 💌 203 💌		× ×	💌 💌 🔒 🕯
42.	Course 💌	A&D 💙 114 💙		A&D 💌 117 💌	

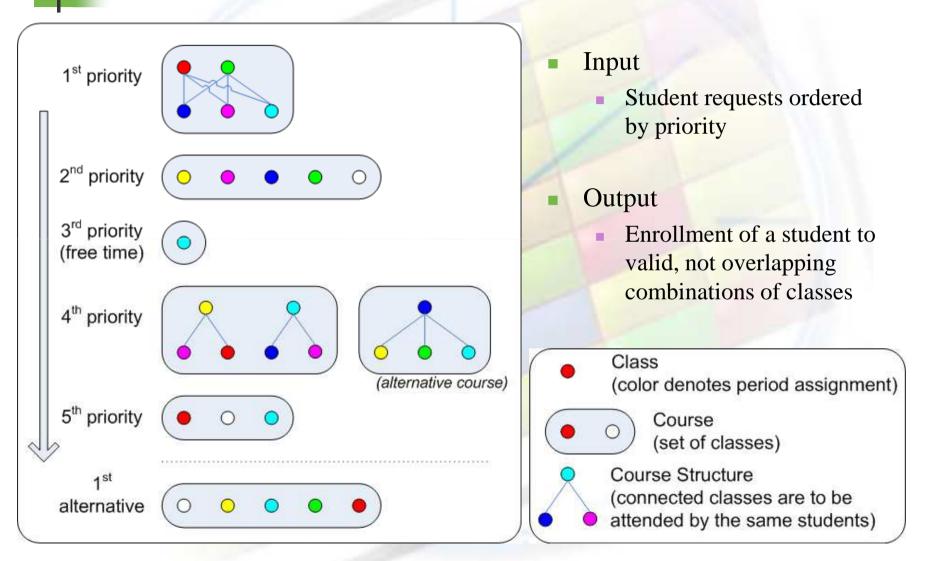
Student Sectioning Problem Model

- Variables
 - Individual student course requests
 - including priorities, free times, alternates
- Values
 - A valid set of classes of the requested course (or its alternative), requested free time
- Constraints
 - Course structure, class timetable
 - Course & class limits
 - Course & class reservations
- Solution
 - A set of (most complete) student schedules
 - Maximizing overall request priorities, minimizing use of alternatives, etc.

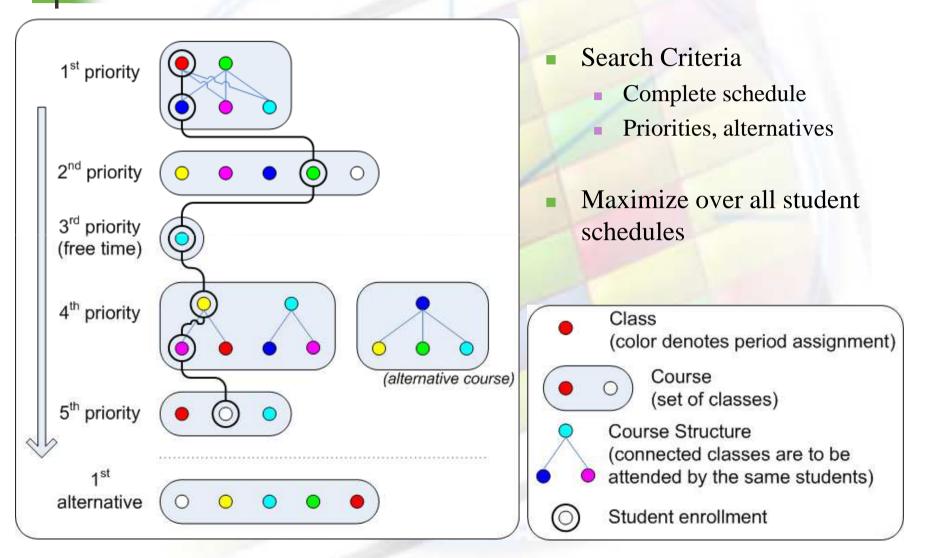
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		W 8	:30a - 9:20	a Full Tern	n	
2.	BIOL 110					
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Student Sectioning Example

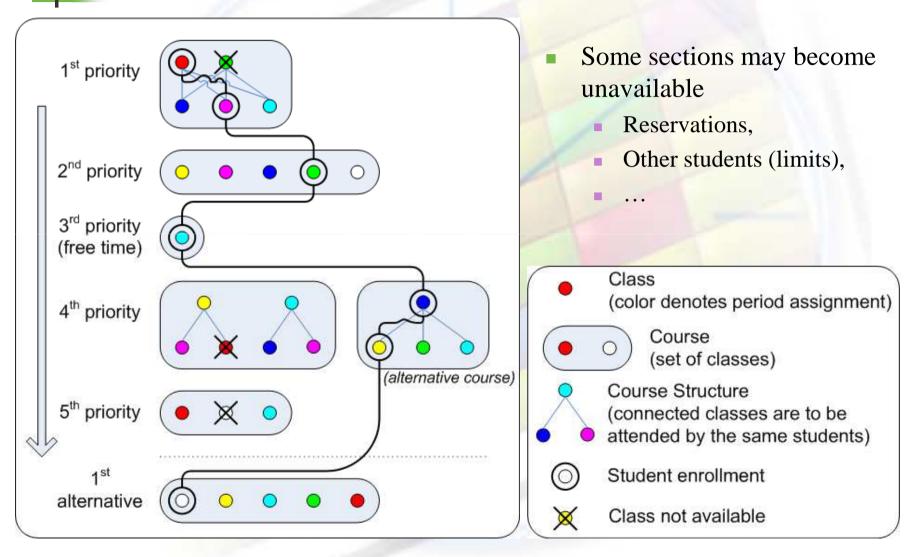


Student Sectioning Example



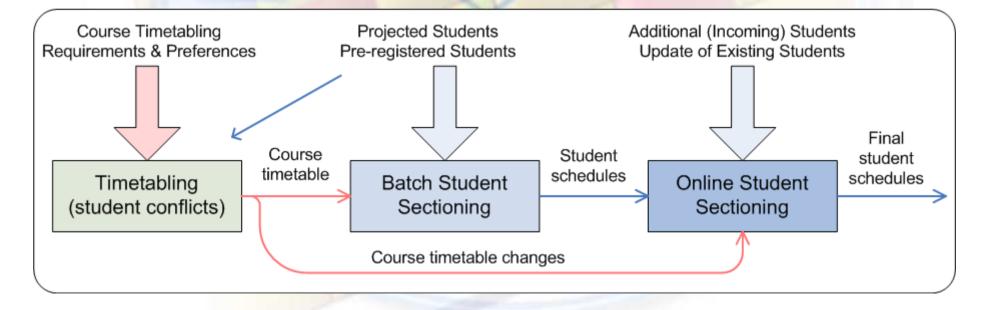


Student Sectioning Example



Student Sectioning Phases

- Initial Sectioning (during timetabling)
 - Timetabling solver minimizes potential student conflicts
- Batch Sectioning
 - Registration of classes for students, reservations, wait lists
- Online Sectioning
 - Registration of first year students, changes in existing enrollments

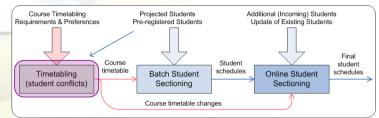




Initial Sectioning

- Student Course Requests
 - Last-like semester student course demands
 - Current course requests from pre-registered students
 - with priorities, alternatives, free times, ...
 - Course enrollment projections
 - Reservations
 - \rightarrow minimization of student conflicts
 - Two classes overlapping in time (or being back-to-back in distant locations) with common students
 - Weighted by request priorities
- Solver

- Additional criterion in the timetabling solver
- Initial sectioning (before timetabling starts), re-sectioning of students between alternative classes during or after the search



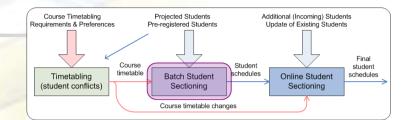
Reservations limit what classes/courses

are available to which students.

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Batch Sectioning

- All students are sectioned altogether
 - Projected student information is used
 - However, first priority is to give pre-registered students full schedule
- \rightarrow maximization of assigned student requests
 - Pre-registered students are enrolled to classes and/or to wait-lists
 - Reservations for expected (not yet registered) students are created
- Solver
 - CPSolver library is used
 - Open source, local-search based, also used in course timetabling
 - Works with incomplete feasible solutions (no constraint is violated)
 - Various neighborhoods including
 - Branch&bound over all requests of a student
 - Limited-depth backtracking search (over a request and its conflicts)
 - Student swap (swapping of student enrollments between sections)



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Final

student

schedules

Additional (Incoming) Students

Undate of Existing Students

Online Student

Sectioning

Studen

schedules

Online Sectioning

- One student is processed at a time
 - Returning a most-complete schedule
 - Considering priorities, alternatives, free-time requests
- \rightarrow same model (as for batch sectioning), different algorithm

Course Timetabling

Timetabling

(student conflicts)

Requirements & Preferences

Projected Students

Pre-registered Students

Batch Student

Sectioning

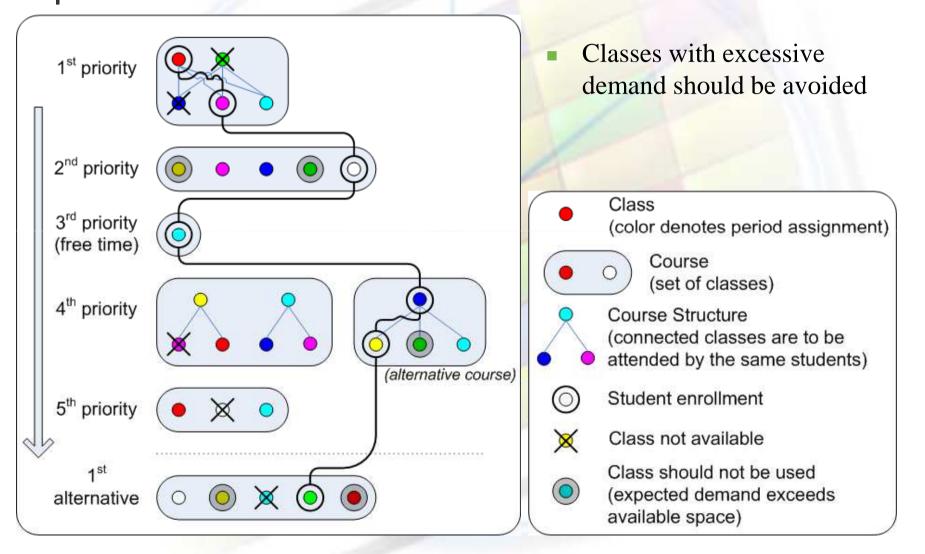
Course timetable change

Course

timetable

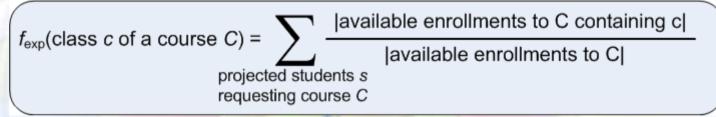
- Branch&bound returning most complete schedule,
- optimizing the given preferences (free times, alternatives),
- avoiding sections reserved for expected students
- Can be an iterative process
 - Student can change requests / choices based on the provided results, assignments are committed at the end
- Reservation of space for expected students
 - Based on projected student enrollments from batch sectioning
 - In each class, a given number of spaces is reserved for new students
 - These reservations are updated as the students are enrolled into classes

Online Student Sectioning Example



Online Sectioning: Expected / Held Space

- Computation (after batch sectioning)
 - Counter for each class using enrollments of projected (last-like) students
 - Express availability of the class to projected students



New Student

- Difference between expected and currently available space
 - Directing students from classes most likely to be needed to other future students
- Counters are updated after each new student is sectioned
- Existing Student (students already enrolled in the course)
 - Held space in a class (unavailable to existing students)
 - Computed as the number of projected students after batch sectioning

Practical Results

- Fall 2007 course timetable from Purdue University
 - 9 000 classes, 570 rooms, 39 000 students with 190 000 course requests
- Student data
 - Last-like (Fall 2006) student course requests
 - 185 494 course requests from 38 740 students
 - Real (Fall 2007, data as of July 11, 2007) student course requests
 - 187 847 course requests from 36 117 students
 - No alternatives, free time requests, or reservations ⊖
 - Invalid course requests were eliminated (~2000 requests)
- Test cases
 - Batch sectioning of last-like student course requests
 - \rightarrow results used for expected / held spaces for online sectioning
 - Batch sectioning of real student course requests
 - Online sectioning of last-like and real student course requests
 - Students are sectioned one by one in a random (or given) order
 - Sectioning by student preferences (uniform, mid-day, early/late)
 - Number of choices provided to the students

Practical Results: Batch versus Online

- Fall 2007 course timetable, Fall 2006/2007 student course requests
- Average and RMS values from 20 independent runs
- Percentage (and actual number) of <u>unassigned course requests</u>
- For online sectioning runs, expected space computed from the best last-like sectioning batch run (316 unassigned course requests)

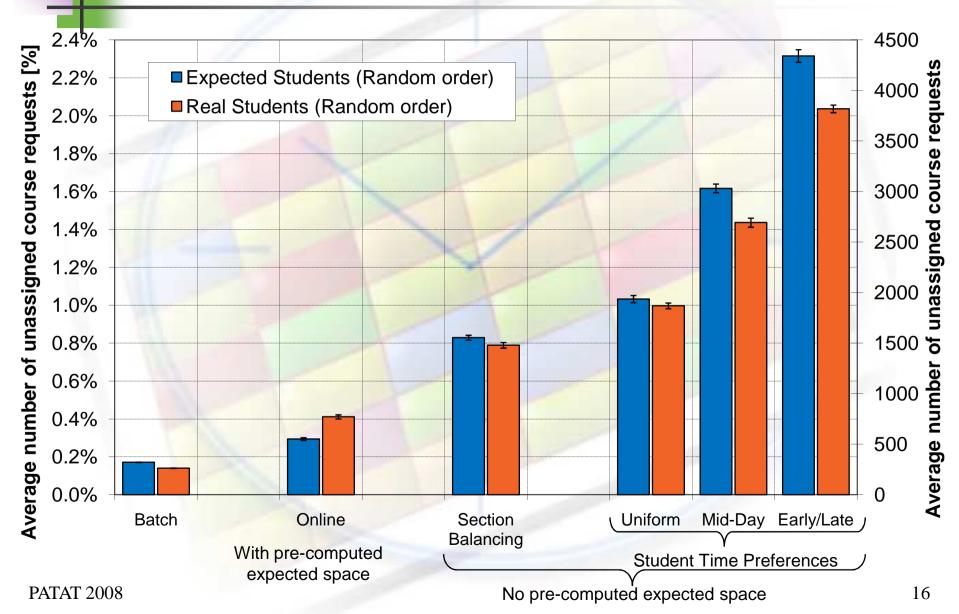
X	Projected Students	Real Students
Batch Sectioning	$0.171\% \pm 0.001\%$	$0.140\% \pm 0.001\%$
(Average $\pm RMS$ of 20 runs)	(317.4 ± 1.6)	(264.6 ± 1.9)
Online Sectioning	$0.294\% \pm 0.007\%$	$0.411\% \pm 0.011\%$
(Random order)	(545.2 ± 13.5)	(772.5 ± 20.3)
Online Sectioning	$0.401\% \pm 0.007\%$	$0.556\% \pm 0.008\%$
(Students with more choices first)	(744.0 ± 12.5)	(1043.7 ± 15.0)
Online Sectioning	$0.249\% \pm 0.002\%$	$0.318\% \pm 0.002\%$
(Students with less choices first)	(461.6 ± 3.6)	(597.0 ± 4.3)
Online Section Balancing	$0.828\% \pm 0.013\%$	$0.789\% \pm 0.015\%$
(Random order, no expected space)	(1696.4 ± 16.3)	(1481.9 ± 27.4)

Practical Results: Batch versus Online

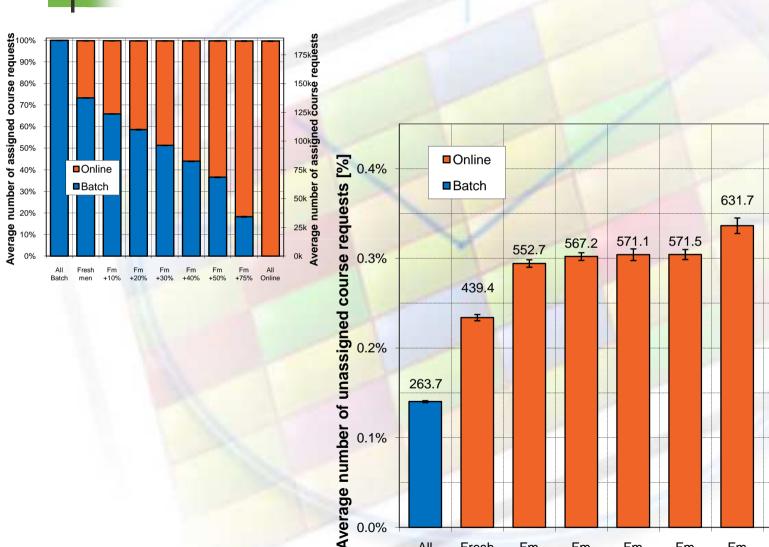
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Practical Results: Batch, Online, Time Preferences



Practical Results: Combining Batch & Online



0.0%

All

Batch

Fresh

men

Fm

+10%

Fm

+20%

Fm

+30%

Fm

+40%

Fm

+50%

Fm

+75%



0

All

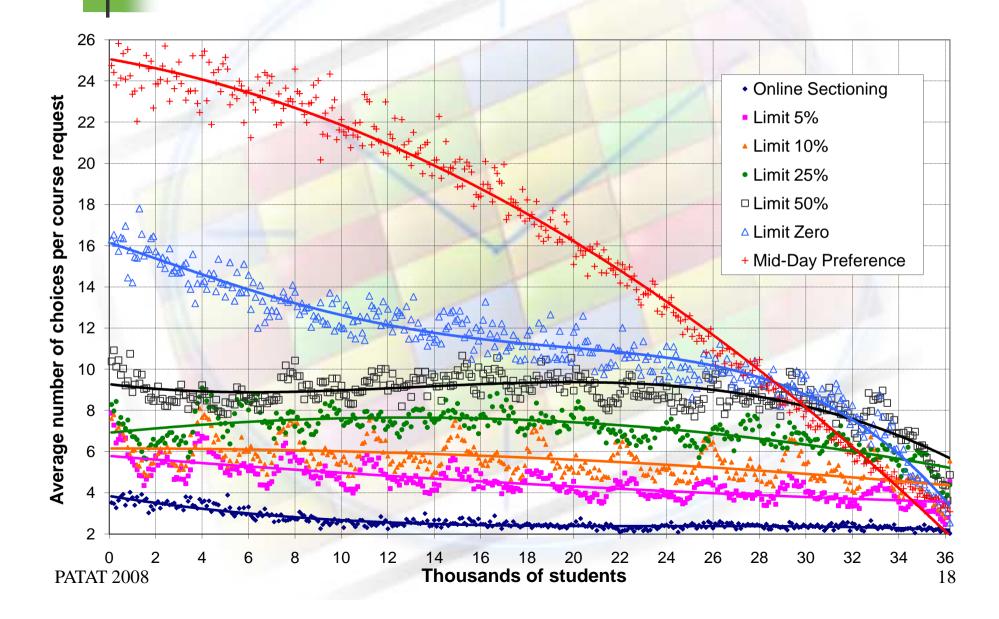
Online

800

772.5

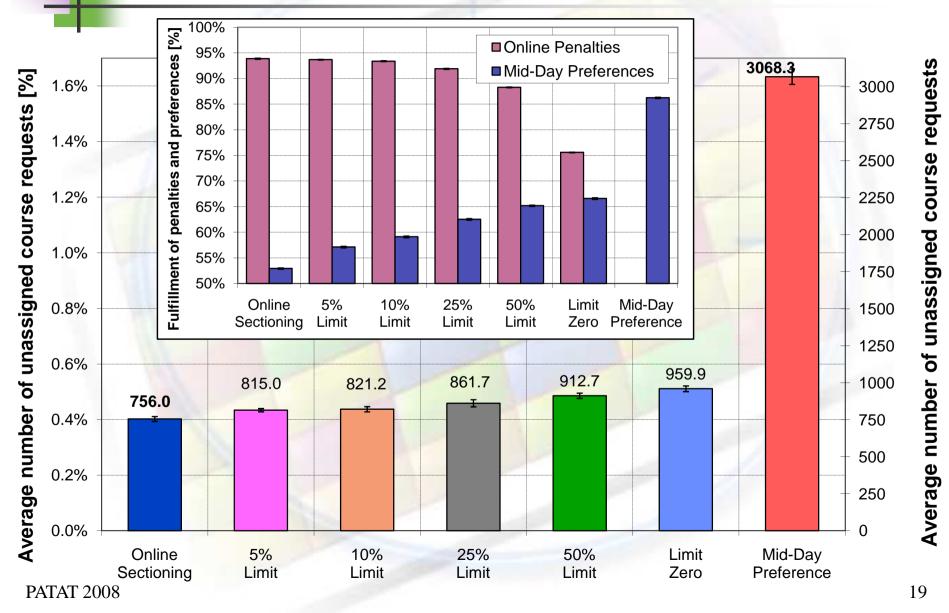
715.5

Practical Results: Student Choice



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Practical Results: Student Choice





Future Work

- Reservations
 - On courses or classes
 - Academic area, major / minor, learning-communities, individual
- Wait-listing on Courses
- Re-Sectioning
 - Wait-list processing, course timetable changes, mass cancellations, etc.
- Student Choices
 - (Limited) ability to choose time and instructor
 - Choice between available classes
 - Wait-listing for classes that are not available

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Conclusions & Further References

Conclusions

- Demand based timetabling and sectioning provides the best results
- However, master timetabling with online sectioning can be significantly improved using past information on student course demands
- \rightarrow The presented hybrid approach is highly applicable in practice
 - Allows for earlier planning, but improves on the efficiency of current sectioning approaches
- Further References
 - http://www.unitime.org
 - Software available for download
 - Documentation
 - Ongoing research
 - Real-life benchmark data sets

