Automated System for University Timetabling

Space Management & Academic Scheduling
Purdue University

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Purdue University Timetabling

- University-wide problem size
  - 9 000 classes, 570 rooms
  - 39 000 students with 259 000 class requests
- Problem Decomposition
  - Central timetable for large lecture classes
    - Approximately 900 classes, 54 rooms
    - Utilization over 78% (~ 97% for four largest rooms)
  - Timetables for individual departments
    - 70 timetables with sizes from 10 to 750 classes
    - Built on top of large lecture timetable
    - Departmental schedule managers are responsible for their own solutions
  - Central computer laboratory timetable

Purdue University Timetabling

- For each class
  - Student requirements
  - Time requirements & preferences
    - Meeting patterns (e.g., 3 x 50 min, 2 x 75 min)
  - Room requirements & preferences
    - Capacity
    - Required equipment
    - Room / building preference
    - Building distances
  - Instructor
  - Additional (distribution) constraints
    - Between several classes (e.g. back-to-back, precedence)
  - Other
    - Departmental balancing, efficient utilization of time and rooms, …

Each student states which courses he or she wants to attend (soft constraint)

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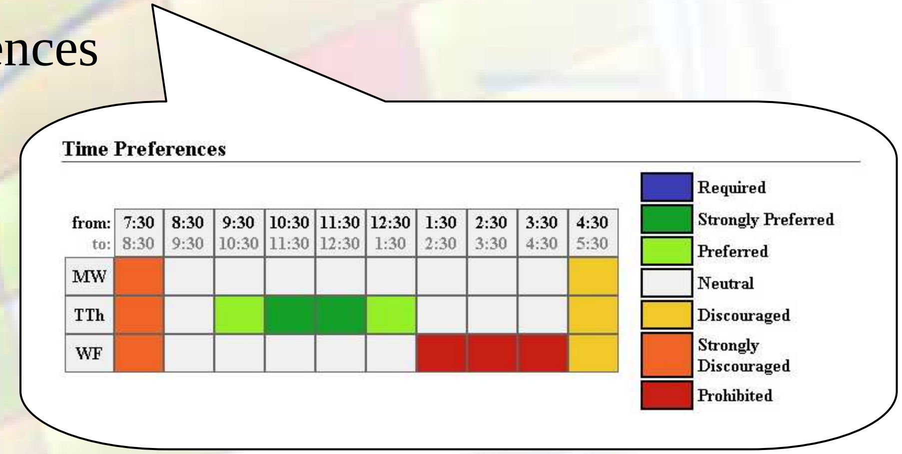

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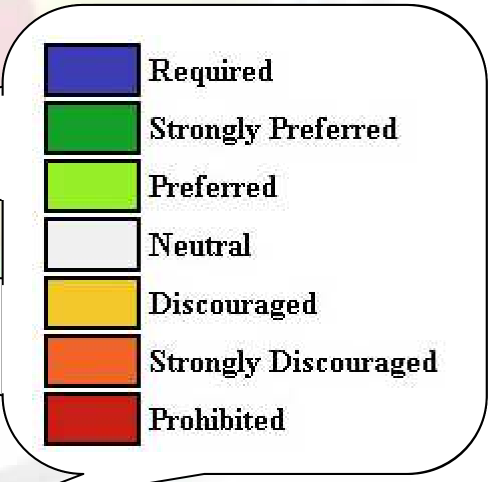

Purdue University Timetabling

- User Interface
  - Server-client application with web-based interface
  - Written in Java, using J2EE, Hibernate, and Oracle Database
  - Supports coordinated work on timetabling in a multi-user environment
- Solver
  - Iterative Forward Search (IFS) algorithm
    - A mixture of local search and backtracking
    - Works in iterations
    - Gradually extends (partial) feasible assignment
    - Applicable to various problems and scenarios
  - Problem model and constraints consider complexity of all university courses

Critical Aspects of Application

- Interaction between problems
  - Only committed solutions are visible and considered by other problems
    - Consistency is ensured between committed solutions
    - Room sharing
      - At any time, a room is either unavailable, available for use on a first come (commit) first served bases, or allocated to a particular department
    - Mutual constraints (e.g., student enrollments) are considered only between the current problem and solutions to committed problems
  - If there are many relations between two (or more) departments
      - E.g., many students are taking classes from both departments
    - These departments can be solved together
      - A timetable containing all classes of these departments is created
    - Or agree on a solution order
      - E.g., the more difficult problem can be solved and committed, the second timetable is built on top of the first.

Critical Aspects of Application

- Data Management (instructional offering structure)
  - Classes are organized in a visual representation of the course structure
    - GUI allows intuitive entry and display of class and constraint data
    - Preferences and requirements can be set at multiple levels
    - Some constraints are automatically deduced from the structure

					----Preferences----			
	Demand	Mins Per Week	Limit	Time Pattern	Time	Room	Distribution	Instructor
MA 170 STAT 170	62		40					
Lecture		50	40	1 x 50		Classroom		
Laboratory		150	40	3 x 50		ENAD Dell 2.8 machines	BTB	
Lec 1		50	40	1 x 50		Classroom		S. Bell
Lab 1		150	20	3 x 50		ENAD Dell 2.8 machines	BTB	J. Beckley
Lab 2		150	20	3 x 50		ENAD Dell 2.8 machines	BTB	J. Beckley

Critical Aspects of Application

- Competitive Behavior (fairness of the solution)
  - Preferred times and rooms
    - Minimization of the overall cost (objective function) typically favors those who provide the most preferences
  - Normalization of time preferences
    - Increasing the number of preferneces lowers individual preference weights

from: / to:	7:30a 8:20a	8:30a 9:20a	9:30a 10:20a	10:30a 11:20a	11:30a 12:20p	12:30p 1:20p	1:30p 2:20p	2:30p 3:20p	3:30p 4:20p	4:30p 5:20p
MWF	0	0	0	-40	0	0	0	0	0	0

from: / to:	7:30a 8:20a	8:30a 9:20a	9:30a 10:20a	10:30a 11:20a	11:30a 12:20p	12:30p 1:20p	1:30p 2:20p	2:30p 3:20p	3:30p 4:20p	4:30p 5:20p
MWF	0	-5	-5	-20	-5	0	0	0	0	0

from: / to:	7:30a 8:20a	8:30a 9:20a	9:30a 10:20a	10:30a 11:20a	11:30a 12:20p	12:30p 1:20p	1:30p 2:20p	2:30p 3:20p	3:30p 4:20p	4:30p 5:20p
MWF	4	-1	-1	-4	-1	1	1	1	1	1

  - Departmental balancing constraint
    - Classes from a department are evenly spread across available times

Critical Aspects of Application

- Data Consistency Checking
  - Ability to find a solution
    - Input data often contain inconsistencies preventing a complete solution from being found
    - Therefore, the first stage of the timetabling process is to verify data and identify the weaknesses
  - Providing feedback to the user
    - Solver must be able to provide information in an easily readable form
    - Conflict-based statistics identify problem areas

Critical Aspects of Application

- Interactive Changes (ability to alter a solution)
  - Solutions can be manipulated manually or by fully automated solver
  - Ability to incorporate changes into an existing solution is critical in real-life problems
    - 1) Minimal Perturbation Problem
      - Solution to a modified problem is as close as possible to the initial solution
    - 2) Interactive Mode
      - Solver is guided by the user, providing an evaluated list of choices
      - Backtracking with limited depth is used

Score	Class	Date	Time	Room
0	PHIL 330 Lec 1	08/21-12/17	MWF 4:30p	CL50 224 → WTHR 200
	PSY 120 Lec 4	08/21-12/17	MWF 4:30p	WTHR 200 → CL50 224
+0.8	PHIL 330 Lec 1	08/21-12/17	MWF 4:30p	CL50 224 → EE 129
	AGEC 217 Lec 2	08/21-12/17	MWF 4:30p	EE 129 → CL50 224
+5.75	PHIL 330 Lec 1	08/21-12/17	MWF 4:30p	CL50 224 → LILY 1105

Critical Aspects of Application

- Student Sectioning
    - Student requests courses, system determines classes (sections)
  - Student Enrollments (for timetabling)
    - Pre-registration, last like data for first year students, projected changes
    - Solution is created based on these data
- Work in progress
  - Final Student Sectioning
    - Registration of classes for students, reservations, wait lists
  - Online Student Sectioning
    - Precompute expected conflicts based on final sectioning
    - Registration of first year students and other late registrants
    - Changes in existing enrollments

Demonstration