Interactive Timetabling: Concepts, Techniques, and Practical Results

PATAT '02 T. Müller, R. Barták 21-Aug-2002

Introduction - Timetabling

- Allocation of activities
- Resources
- Various constraints
- Interactivity
 - combination of automated timetabling with user interaction
 - solution is built step by step
 - presentation of sub-results during execution

The Model

- Time Slots
- Time Preferences
 - soft and hard constraints
- Activities ~ Lectures, Seminars
 - name, duration, time preferences
 - sets of needed resources resource groups
- Resources ~ Rooms, Classes, Classrooms, ...

disjunctive

conjunctive

- name, time preferences
- Dependencies
 - binary, between two activities
 - before, closely before, concurrently

The (Partial) Solution

- Every (scheduled) activity has all required resources reserved.
 - all from conjunctive, one from disjunctive group
- Two (scheduled) activities cannot use the same resource at the same time.
- No hard constraint of time preference is violated.
- All dependencies are satisfied.

Furthermore:

We want to minimize the number of violated soft constraints.

The Interactive Solver

- Basic Approaches
 - local search
 - backtracking based search
- Interactive Solving Algorithm
 - forward based search
 - works in iterations
 - extending feasible partial solution
 - interactivity

The Interactive Solver



Unscheduled Activities





The Interactive Solver





Activity Selection

- First-fail Principle
- Weighted Sum
 - for each unscheduled activity
 - several criteria
 - in how many dependencies does the activity participate
 - in how many locations can the activity be placed
 - ...
 - an activity with minimal value selected

Improvement:

Select randomly 20% of unscheduled activities first.

Location Selection

- Select The Best-fit Place
- Weighted Sum
 - for each possible location
 - several criteria
 - a number of violated soft constraints
 - a number of conflict activities
 - ...
 - a location with minimal value is selected

Improvement:

Random selection of the top N places.

Practical Results:

Faculty of Mathematics and Physics

- Model Extension
 - alternative activities
 - at least one possibility
 - maximize possibilities for each assigned resource (class)
 - three different buildings
 - one free slot for crossing
 - minimize the number of crossings
 - time preferences
 - class: max 10 hours a day, 6 hours without a break
 - teacher: max 8 hours a day, 6 hours without a break
 - minimize the number of free hours during the day

Leads to:

Extension of activity & location selection criteria.

Practical Results: Faculty of Mathematics and Physics

- Problem size:
 - 5 days a week, 15 time slots (hours) a day
 - one time slot ~ 45 minutes
 - 746 lectures (1512 time slots)
 - 349 classes and sub-classes
 - 479 teachers
 - 30 classrooms
 - 3 different locations (buildings)
- Solution:
 - approx. 8-10 minutes
 - no user intervention needed

Practical Results: Faculty of Mathematics and Physics

Solution:

- all activities scheduled all hard constraints satisfied
- 76 crossovers for classes, 7 for teachers
- 21 classes with more than 10 hours a day, one class with more than 6 hours without a brake
- alternative lectures: a class could attend on average 84% of all alternatives
- 74 % of lectures scheduled from 9:00 to 16:25 (3rd-11th slot)
- 87% of lectures scheduled form 8:10 to 17:15 (2nd-12th slot)
- only 3% of lectures scheduled after 18:10 (14th slot) or after 14:50 (10th slot) on Fridays

Randomly generated timetable problems: Comparison of the time spent on solving the problem and the size of the problem



Conclusions

- Current Implementation
 - JAVA, several independent modules
 - general scheduling engine
 - activity & location selection criteria
 - GUI school timetable
 - very promising results
 - easily extensible
 - new constraints, dependencies between activities, ...
 - generalizable to other constraint satisfaction problems

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Comparison of the number of iterations for three basic variable selection criteria



Comparison of the time for three basic variable selection criteria



