UBC Exam Timetabling

Chris Fawcett

Presented for EARG

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Outline - background

- The general timetabling problem
- Post-enrollment course and exam timetabling
- History of timetabling in our group
- Our problem model
- Our solver structure

Outline - collaboration with UBC

- UBC's current timetabling process
- Elicitation of constraints
- Necessary data cleaning and pre- and post-processing
- Ideal winter 2010 process schedule
- What actually happened
- Necessary changes and next steps

The general timetabling problem

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- Produce a schedule (or timetable) S assigning each $a \in A$ to a timeslot $t \in T$, such that:
  - All constraints $c \in C$ are satisfied.
- Easily extended to finding S such that an objective function f is optimized.

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- Each activity is attended by a subset of the students.
- Each activity must be assigned to both a timeslot $t \in T$ and a room $r \in R$.
- An objective function f based around the idea of soft constraints.

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- Groups of activities may need to be scheduled into the same timeslot or room.
- Each activity may need to be scheduled into only a subset of the timeslots.
- Each activity may need to be scheduled into a subset of the rooms, satisfying any additional features the activity requires (building, tables, projector, etc.).

Example soft constraints

- Students should not have two activities in the same day.

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- Students should not have three (or more) activities in four consecutive timeslots.
- Some activities should not be placed into certain timeslots (e.g., first-year courses in the last two days for December schedules at UBC).

Solver history

- In development beginning in late 2007.
- Third place in the post-enrollment track of the Second International Timetabling Competition (January 2008).
- Subsequently improved, achieving substantially better performance than the competition winner.
- Currently the state-of-the-art solver for this problem.

UBC collaboration history

- Collaboration with UBC classroom services beginning in winter 2009.
- Problem size is 100x larger than seen in the competition.
- Solver extension and improvements to support solving the UBC problem.
- Dry run in winter 2010, parts of resulting schedule were used.
- Hopefully full schedule used in Spring 2010.

Our problem model

- Six primitive objects:
  - Course
  - Room
  - Student
  - Timeslot
  - Feature
  - CourseGroup

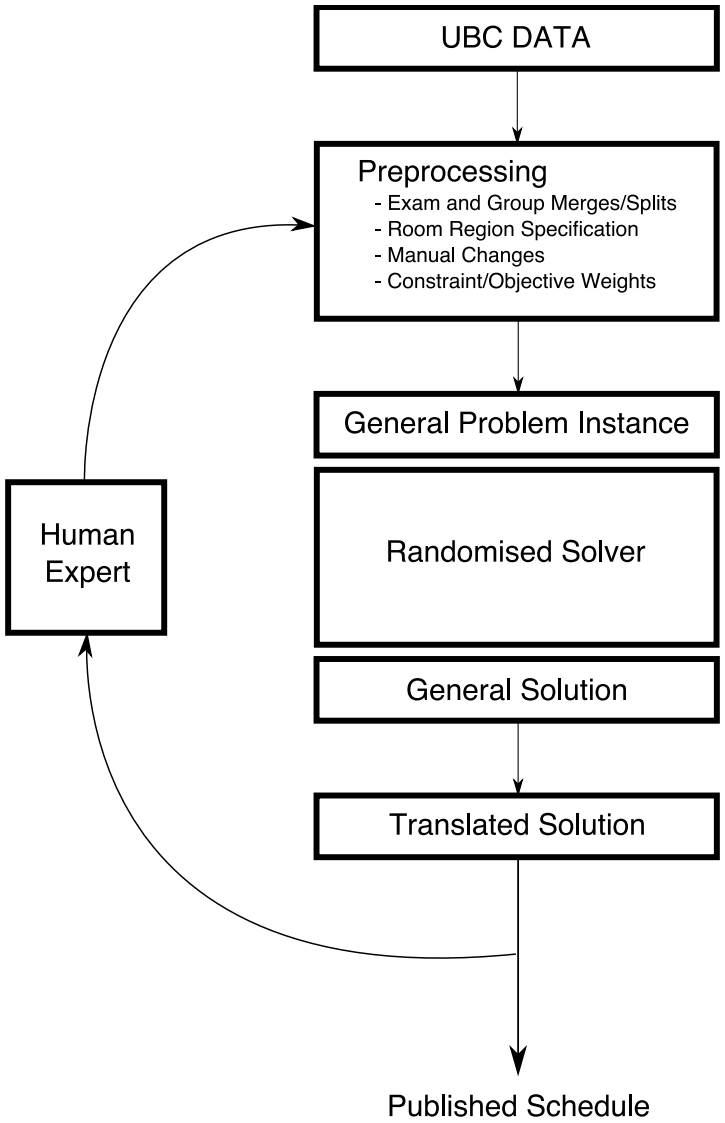
Our problem model

- Courses have students, feature requirements, timeslot restrictions and a single group id.
- Rooms have capacities and features.
- Students have courses.
- Timeslots are ordered.
- CourseGroups have courses.
- Solver deals strictly with assigning groups to timeslots and rooms.

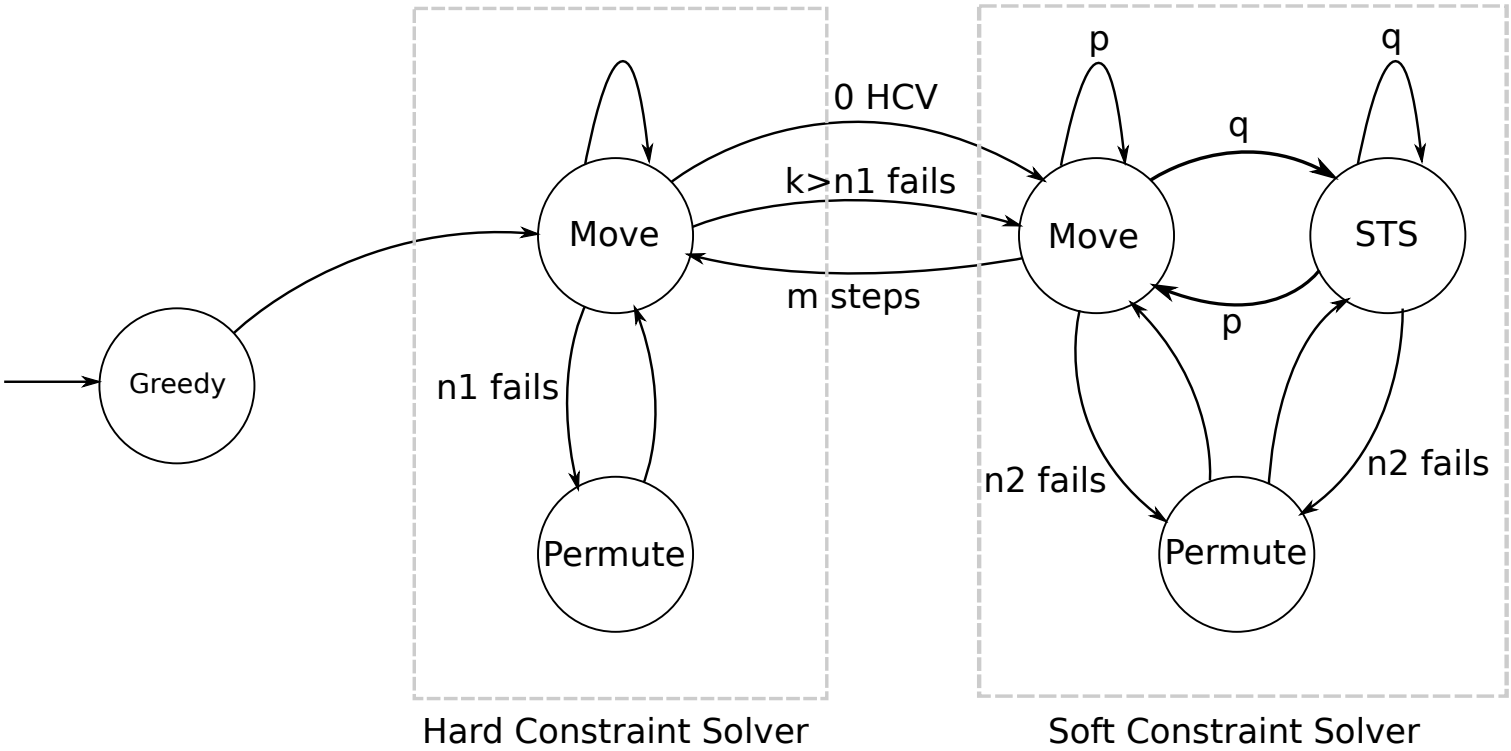
Our solver

- Randomised solver, designed to find good (but not necessarily optimal) solutions quickly.
- Extremely modular, with a general and flexible problem specification format.
- Leverages automated design and configuration techniques to tailor performance specifically to a given problem, in this case UBC's exam scheduling.
- Partially automated pre-processing stage to convert UBC data into our format, including merging or splitting course sections as necessary.

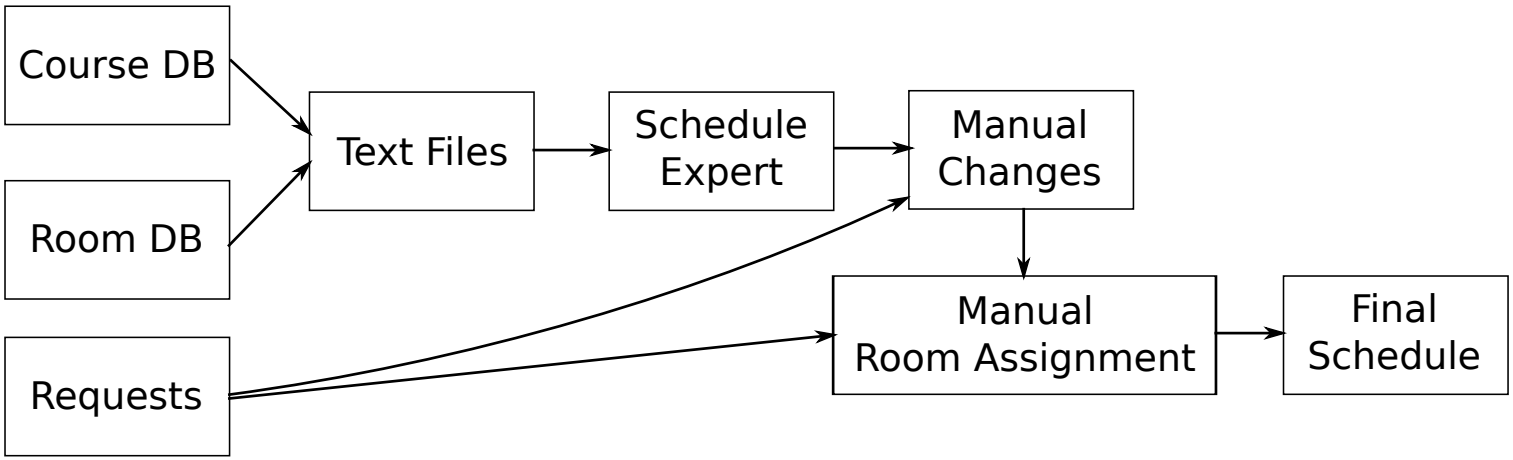
Our solver


UBC DATA
Preprocessing
- Exam and Group Merges/Splits
- Room Region Specification
- Manual Changes
- Constraint/Objective Weights
General Problem Instance
Randomised Solver
General Solution
Translated Solution
Human Expert
Published Schedule

Solver algorithm specifics



The current UBC process



Elicitation of constraints

- Users have great difficulty expressing the constraints they care about.
- They often give misleading or incorrect information.
- Best progress achieved from asking hypothetical questions about groups of exams.
- UBC problem is inherently multi-objective, with opposing objective components.
- Some constraints will likely never exist explicitly in our solver.

Discovered constraints

- "Student conflicts": Two exams in the same timeslot.
- "Student hardships":
  - Two exams in the same day.
  - Three or more exams in the same period.
  - Two exams within 8 consecutive timeslots.
- Is this exhaustive? Definitely not, as we found out.

Data cleaning and preprocessing

- Convert UBC database reports to standard csv format.
- Each course has a "type", with a timeslot restriction template defined for each type.
  - Template can be overridden for each exam section.
- Construct room region(s) and features for each room, and initial feature requirements for each exam section based on course code.
- Merge exam sections in the same exam group into a single exam.
- Split sections as required or requested in order to have valid room assignments.
- Formalize special requests as feature requirements, timeslot restrictions, or merges and splits.

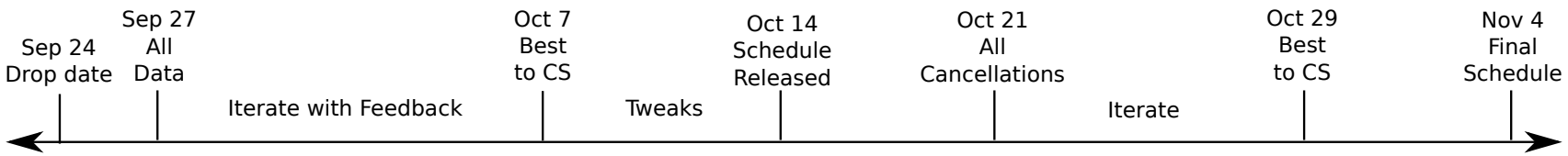
Room regions

- Impossible to determine allowable rooms for each course based on rules.
- Retrieved 20 previous schedules. For each exam section, stored the buildings used.
- The reverse mapping of course code to building corresponds to a first draft of "room regions".

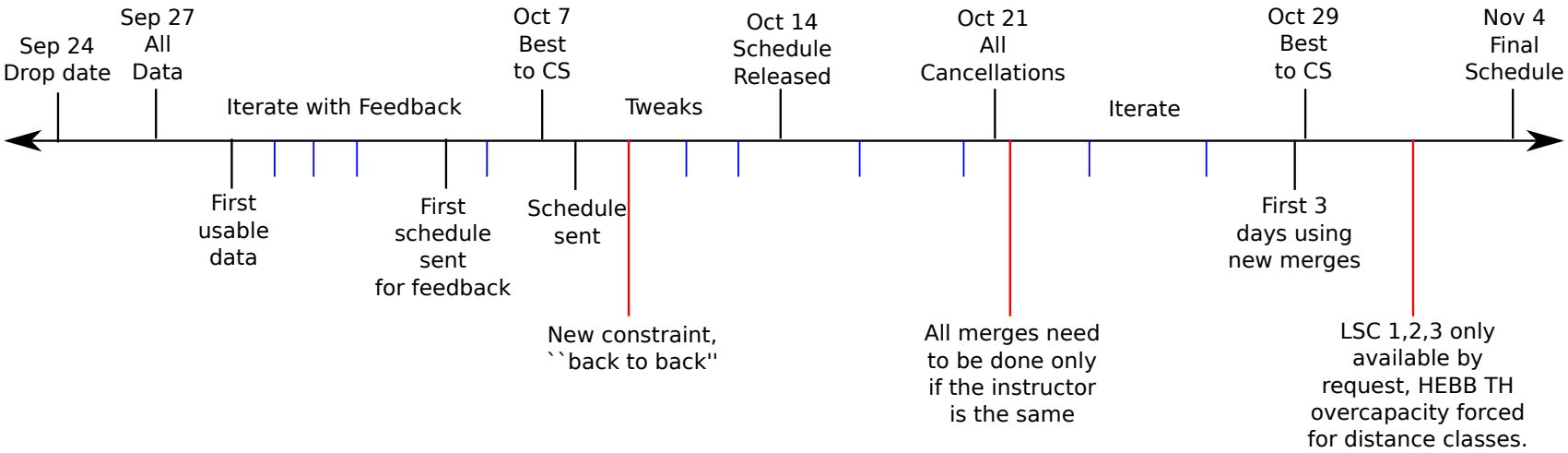
Reporting

- A generalised reporting tool has been implemented.
- Currently outputs text files, but could be quite easily modified to support other formats.
- Six report types are currently available:
  - Seat report - A high level summary of the number of students and sections in each exam period.
  - Summary report - A brief summary of objective values for a given schedule.
  - Student report - For each student, their classes and constraint/preference violations are shown.
  - Period report - For each exam period, the scheduled exams, their exam groups, and their scheduled rooms are shown.
  - Room report - For each exam period, the rooms used are shown along with the exams scheduled in them and the enrollment/capacity.

Ideal winter 2010 process



What actually happened



Results

Constraint	UBC	A
Student Conflicts	27	6
Three Exams in Four Periods	139	202
Two Exams in the Same Day	4437	3615
Less than 8 Periods Between Exams	77970	93544

Results

- Competitive schedules produced in 2-3 hours, based on our previous model of the constraints.
- No timeslot assignments used.
  - Could not produce a new schedule quickly enough after "back-to-back" concern was raised on October 7.
- Approximately half of generated room assignments were used.

Necessary changes and next steps

- A clear, objective measure of schedule quality agreed upon in advance.
- Small modifications to room regions based on feedback.
- Implement the "back-to-back" constraint based on feedback.
- Ability to support room disjunctions.
- Dynamic section splitting, inside the solver.

Discussion