

Real-life Examination Timetabling

MISTA 2013

- **Objectives**
 - Examination timetabling at Purdue University
 - Large problem (~1,800 exams), with some interesting differences
- **Solver**
 - Local-search based hybrid approach, used at ITC2007
- **Data sets**
 - Nine large instances from Purdue University
 - Made publicly available as part of this work
- **Experiments**
 - Why do we allow for student direct conflicts?
 - An alternative approach to avoiding direct conflicts
- **Conclusion**

- The Usual

- Examinations with students enrolled in them
- Examination periods (*not overlapping, can have various lengths*)
- Rooms (*with capacities, availabilities, and period preferences*)
- Individual examination requirements and preferences (*on periods and on rooms*)
- Distribution constraints (*same/different room, same/different period, precedence*)

- The Unusual

- Seating type (*normal / examination seating*)
- Direct student conflicts are allowed
- An examination can be split among multiple rooms
- Sharing a room between multiple exams is not allowed

- **Hard Constraints**

- No two exams in the same period and room
- Examination must fit the period and room
- Room must be available
- An exam cannot be placed in a period or a room that is prohibited for the exam
- Required (*hard*) distribution constraints must be satisfied

- **Soft Constraints / Objectives**

- Direct student conflicts
- More than two exams on a day
- Back-to-backs
- Period, room, and distribution penalties
- ... and a few others
 - Minimize room splits (*and the distance between these rooms, if an exam is split*)
 - Distance to original room (*for class exams, original room is where the class took place*)
 - Large exams first
 - Rotation (*average period*)

- **Phases**
 - Construction (IFS with conflict-based statistics)
 - Hill Climbing (*accept a neighbor that does not worsen the objective*)
 - Great Deluge (*accept a worsening neighbor if the objective is still below the bound*)
- **Neighborhoods**
 - Assign one unassigned exam, conflicting exams are unassigned (if any)
 - Period / room change, examination swap, random move
- **Highlights**
 - Operates over feasible timetables
 - Construction always returns a complete timetable
 - Great deluge includes reheating
- **Very much like the one used in ITC 2007 (PATAT 2008)**
 - ITC2007 solver description: a hybrid approach
 - Tomáš Müller, *Annals of OR*, November 2009, Volume 127, Issue 1, pp 429-446

- Nine data sets from Purdue University
 - Starting with Fall 2008, four latest are discussed in the paper in more detail

<i>Problem</i>	Fall 2012	Spring 2012	Fall 2011	Spring 2011
Exams	1,864	1,798	1,914	1,866
Periods	29	29	29	29
Students	33,279	31,593	33,856	31,688
Enrollments	117,271	111,355	122,386	113,224
Distribution constraints	20	13	6	1
Exams fixed in time	57	63	58	99
Exams fixed in room	24	6	70	170
Large exams (600+)	22	20	18	17
Exams needing room split	10	9	20	13
Exams with original room	1,533	1,485	1,524	1,485
Available periods	28.2 ± 0.4	28.0 ± 0.5	28.2 ± 0.4	27.5 ± 0.7
Available rooms	262.9 ± 6.1	265.8 ± 3.2	256.3 ± 9.8	234.7 ± 11.8
that are big enough	143.3 ± 38.5	143.3 ± 37.1	135.1 ± 40.1	126.6 ± 37.5

- **Nine data sets from Purdue University**
 - 29 periods, ~ 1,800 exams, ~ 32,000 students, ~ 350 rooms
 - Hard in size, density and utilization of large rooms

<i>Fall 2012</i>	All	≥ 100 seats	≥ 200 seats	≥ 400 seats	≥ 600 seats
Rooms	347	30 (16)	12 (8)	7 (3)	2 (2)
Exams	1,864 (819)	248 (179)	87 (69)	37 (32)	22 (21)
Density	3.3%	29.6%	60.0%	81.2%	83.6%

- Chromatic number of at least 27
- Available online in XML format (http://www.unitime.org/exam_datasets.php)

- **Configurations**

- Production
- Base (*more weight on student conflicts*)
- Color (*graph coloring in construction phase, direct conflicts not allowed*)
- Split (*added ability to split an exam in two and move students in between*)

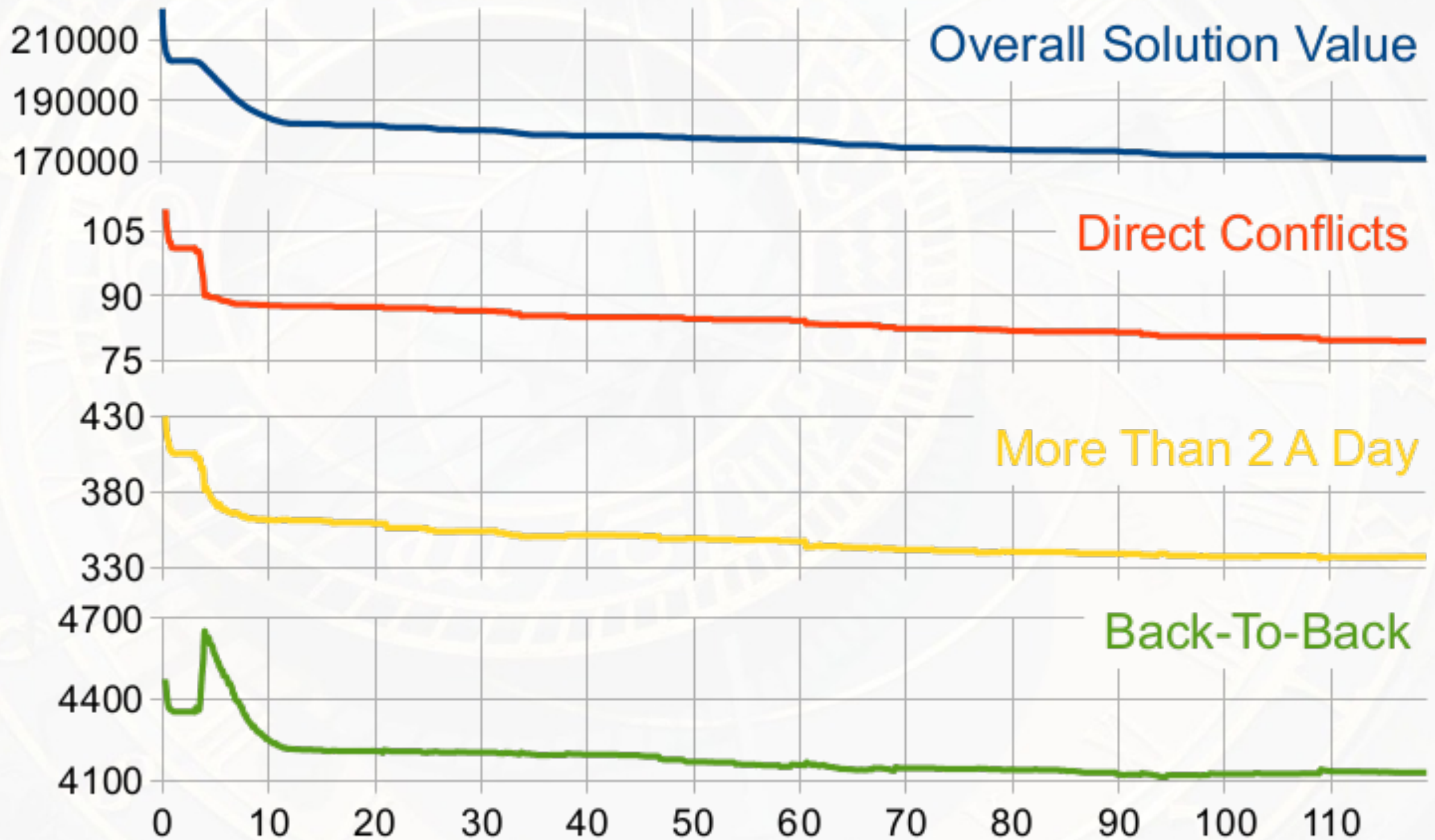
Weight	Production	Base	Color	Split
Direct Conflict	1,000	1,000,000	-	1,000,000
More Than 2 A Day	100	10,000	10,000	10,000
Back-To-Back	10	100	100	100
Period Penalty	1	1	1	1
Room Penalty	1	1	1	1
Room Split	10	10	10	10
Hard Constraint Violation	-	-	1,000	-
Exam Period Split	-	-	-	5,000

Experimental Results

Fall 2012	Production	Base	Color	Split
Direct Conflicts	79.7 ± 3.4	32.7 ± 3.9	0.0 ± 0.0	0.0 ± 0.0
More Than 2 A Day	345.2 ± 10.0	344.8 ± 26.6	650.7 ± 38.0	71.3 ± 11.6
Back-To-Back	4107.2 ± 74.5	4792.1 ± 151.2	6342.0 ± 133.5	1802.7 ± 112.0
Period Preferences [%]	91.5 ± 0.3	88.2 ± 0.4	85.8 ± 0.3	88.6 ± 0.4
Room Preferences [%]	74.3 ± 0.5	72.4 ± 0.3	72.5 ± 0.4	72.3 ± 0.7
Room Splits	43.0 ± 2.3	48.5 ± 8.9	19.8 ± 9.7	46.8 ± 3.6
Unavailable Period	-	-	12.7 ± 1.3	-
Unavailable Room	-	-	10.8 ± 0.9	-
Violated Distribution	-	-	2.8 ± 0.8	-
Period Splits	-	-	-	64.10 ± 3.54

- Average of 10 runs, 2 hour time limit
- More details are in the paper and online

Experimental Results





Conclusion

- **Conclusion**
 - Real world instances with solutions applied in practice at Purdue
 - Available in UniTime (open-source university timetabling system)
- **Future work**
 - Include instances from other schools as well
 - Allow for room sharing
- **For more details**
 - See our paper
 - Visit http://www.unitime.org/exam_datasets.php