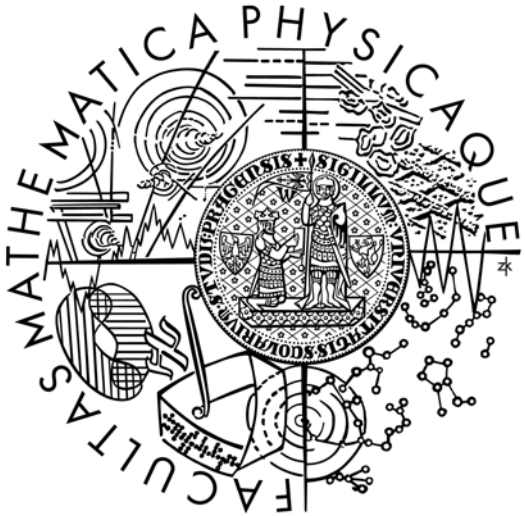
Some Novel Approaches to Lecture Timetabling



CPDC 2002

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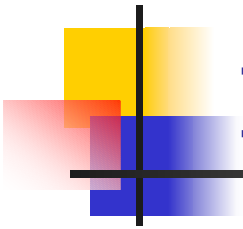
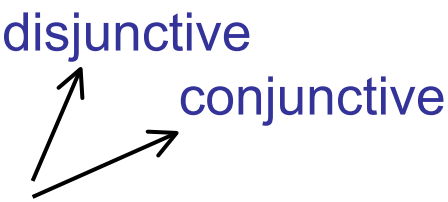


Introduction

- Allocation of activities
- Resources
- Various soft & hard constraints
  - preferences, capacities, dependences, ...
- Interactivity
  - combination of automated timetabling with user interaction
  - presentation of sub-results during execution
    - solution is built step by step
    - work with feasible (sub-) solutions
    - minimal differences between following (sub-) solutions
  - restartable from any sub-solution
    - user can stop/continue it during the search and modify the (sub-) solution

The Model

- Time Slots
- Time Preferences
  - soft and hard constraints
- Activities *~ Lectures, Seminars*
  - name, duration, time preferences
  - sets of needed resources - resource groups



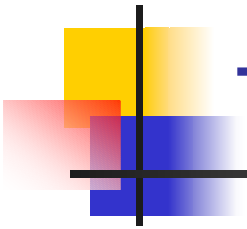
- Resources *~ Teachers, Classes, Classrooms, ...*
  - name, time preferences
- Dependencies
  - binary, between two activities
  - before, closely before, concurrently, ...

The (Partial) Feasible 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.

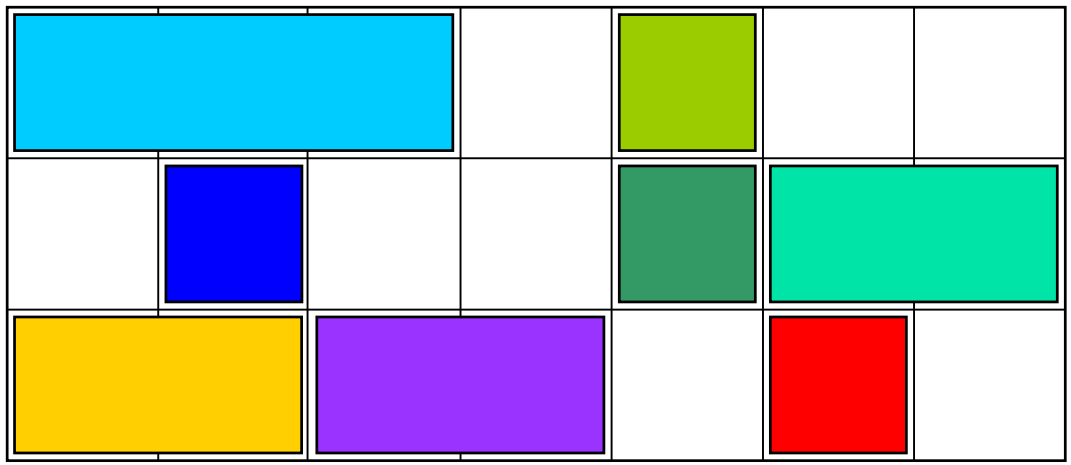


The (Interactive) Solver

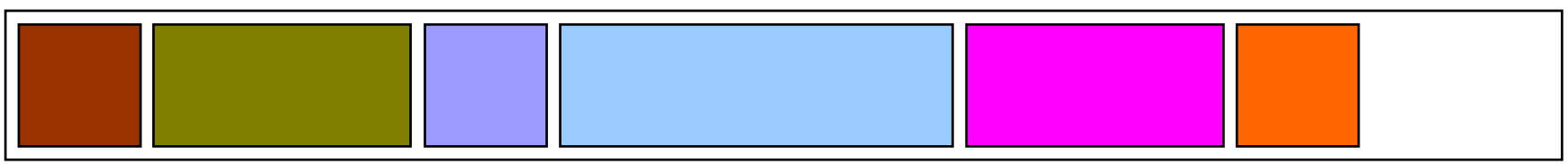
- Basic Approaches
  - local search
  - backtracking based search
- Interactive Solving Algorithm
  - forward based search
  - works in iterations
  - extending feasible partial solution
  - can provide a sub-result even in over-constrained problem

The Solver

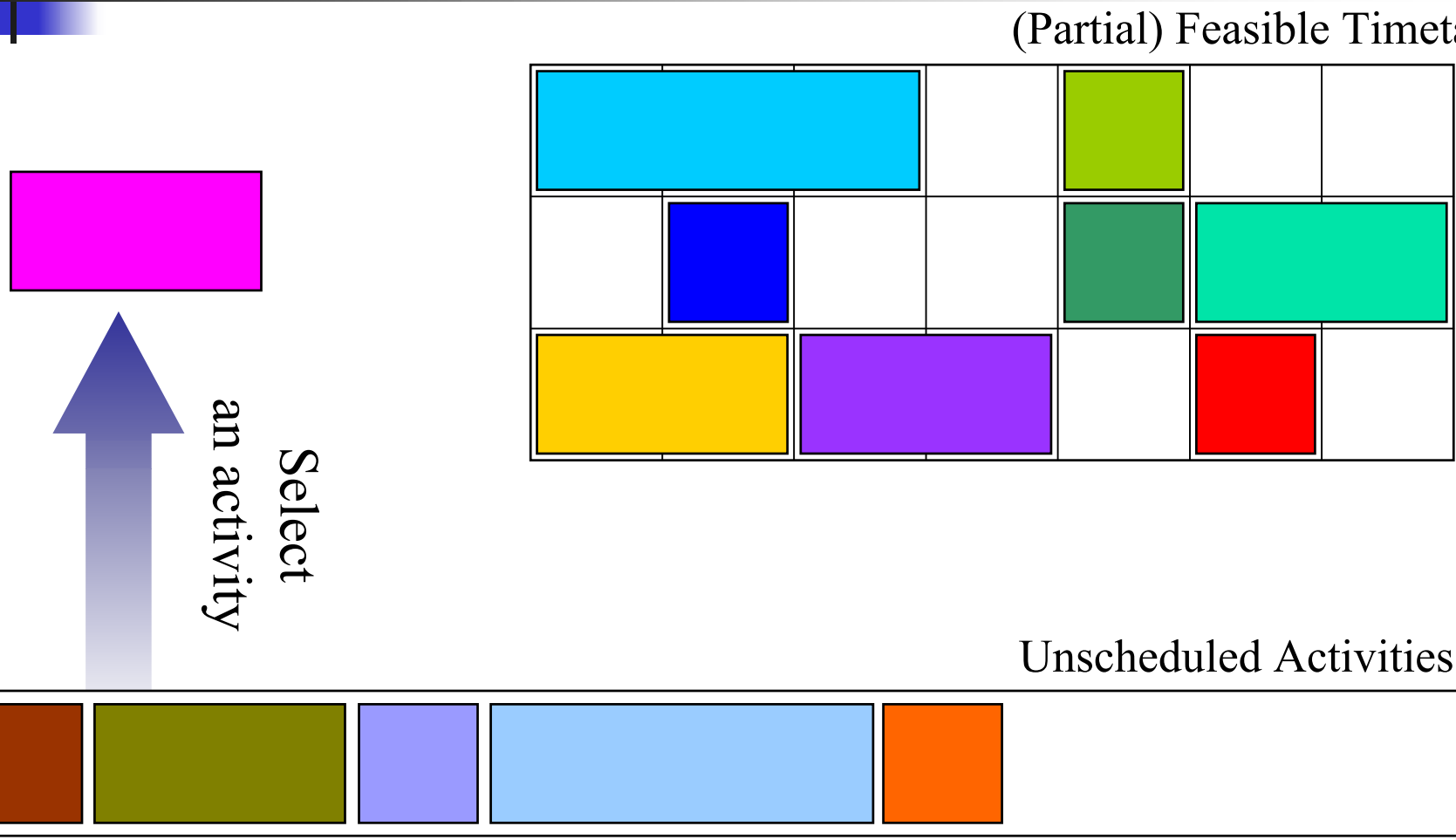
(Partial) Feasible Timetable



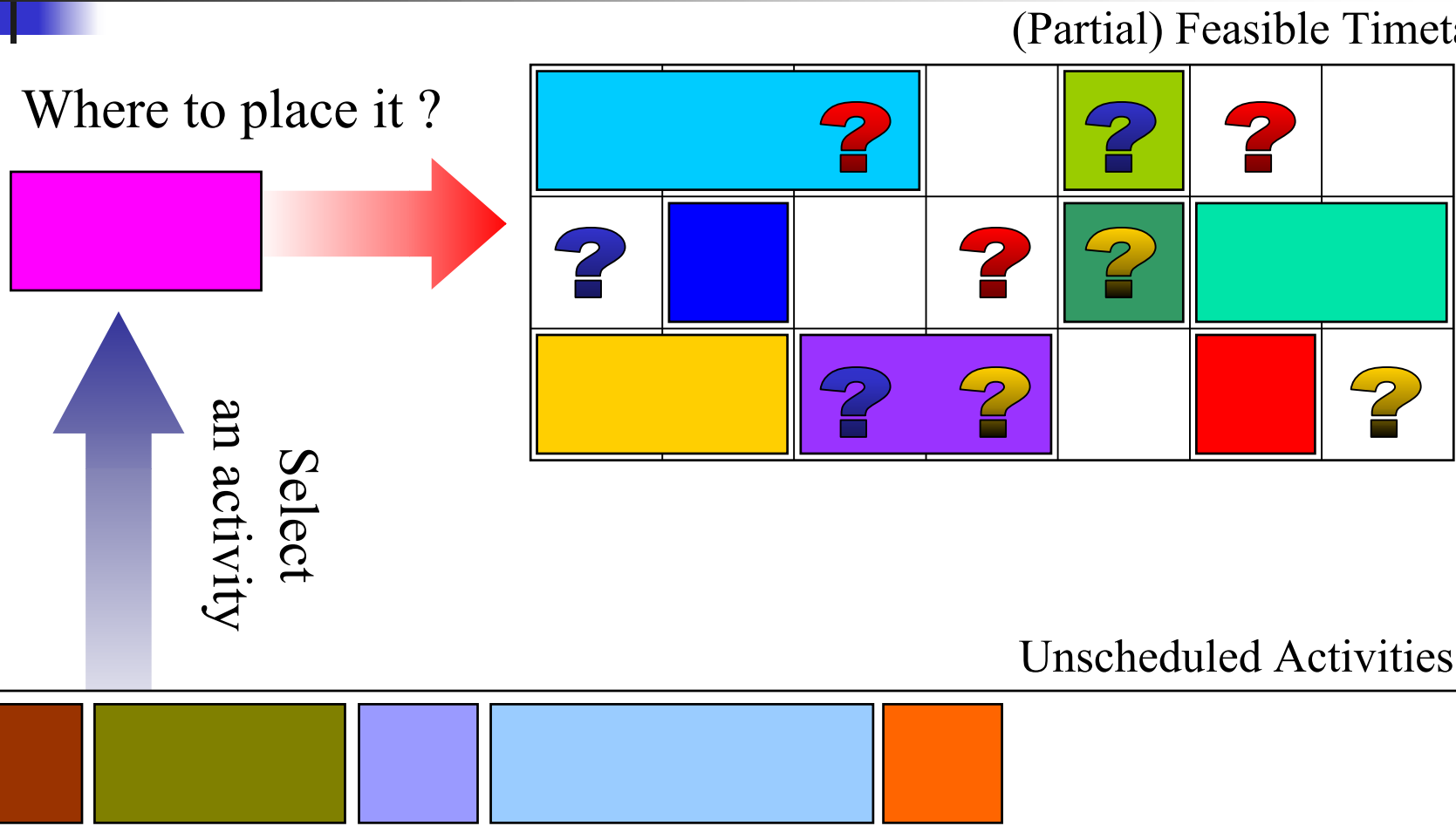
Unscheduled Activities



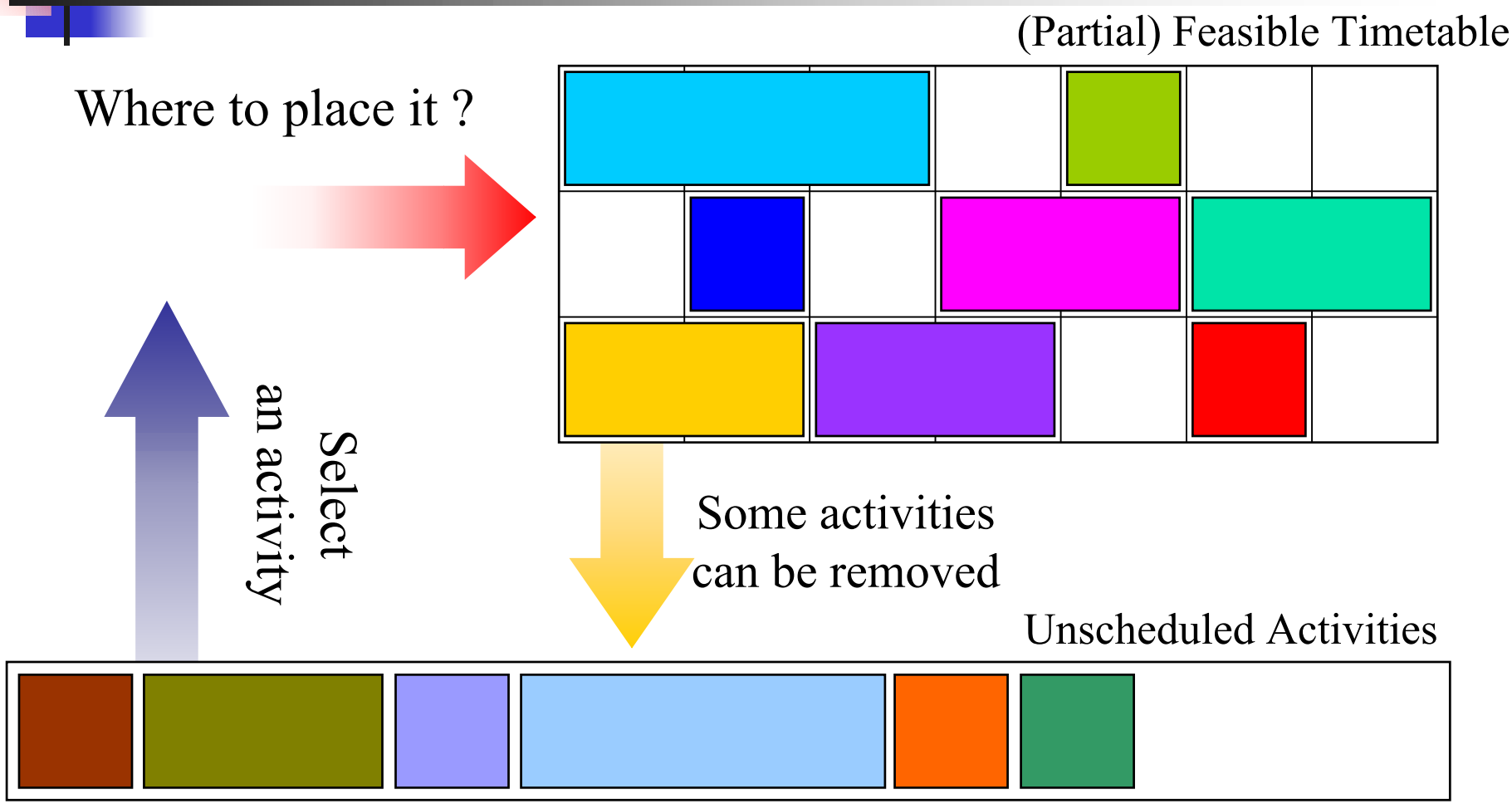
The Solver


(Partial) Feasible Timetable
Select
an activity
Unscheduled Activities

The Solver

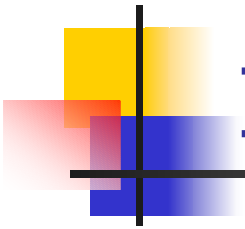

(Partial) Feasible Timetable
Where to place it ?
Select
an activity
Unscheduled Activities

The Solver


(Partial) Feasible Timetable
Where to place it ?
Select an activity
Some activities can be removed
Unscheduled Activities

Activity & Location Selection

- Activity Selection Criterion
  - first-fail principle
  - weighted sum of several criteria *(for each unscheduled activity)*
    - in how many dependencies does the activity participate
    - in how many locations can the activity be placed
    - …
  - an activity with minimal value is selected
- Location Selection Criterion
  - best-fit place
  - weighted sum of several criteria *(for each possible location)*
    - number of violated soft constraints
    - number of conflict activities
    - …
  - a location with minimal value is selected

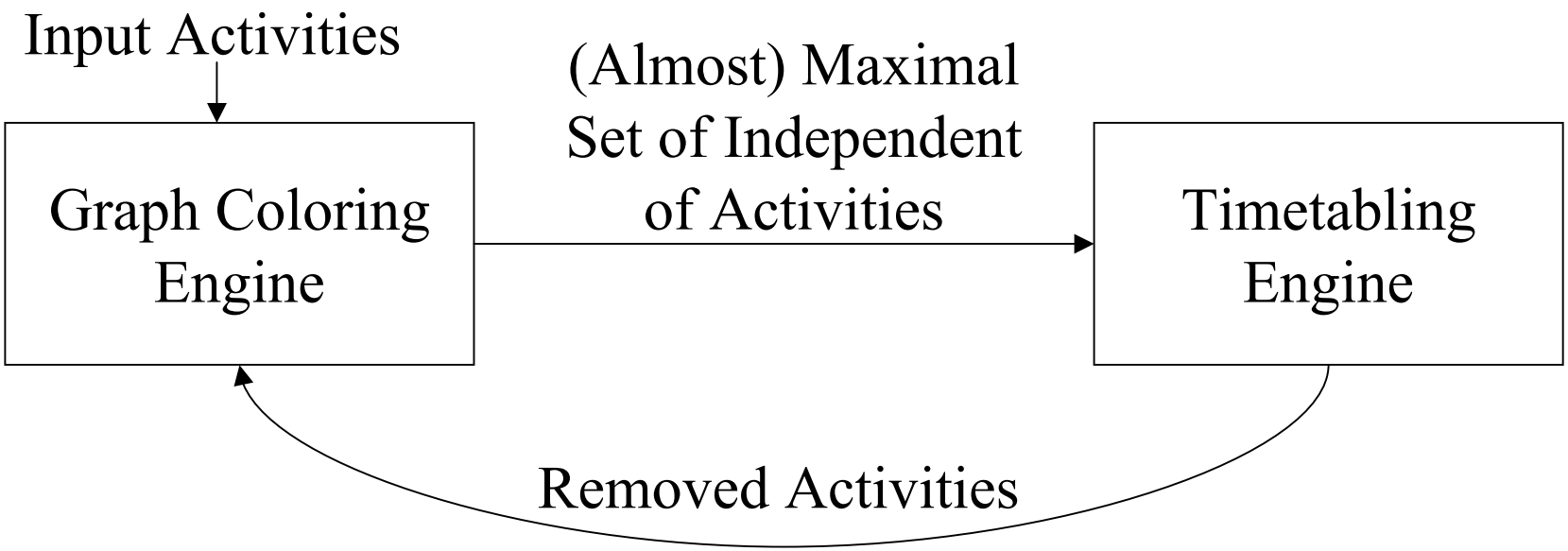


Improvements

- Current Improvements
  - activity selection
    - select randomly 20% of unscheduled activities first
  - location selection
    - random selection from the top *N* places
  - tabu list
- Ongoing & Further Improvements
  - graph colouring approach
  - evolutionary approach

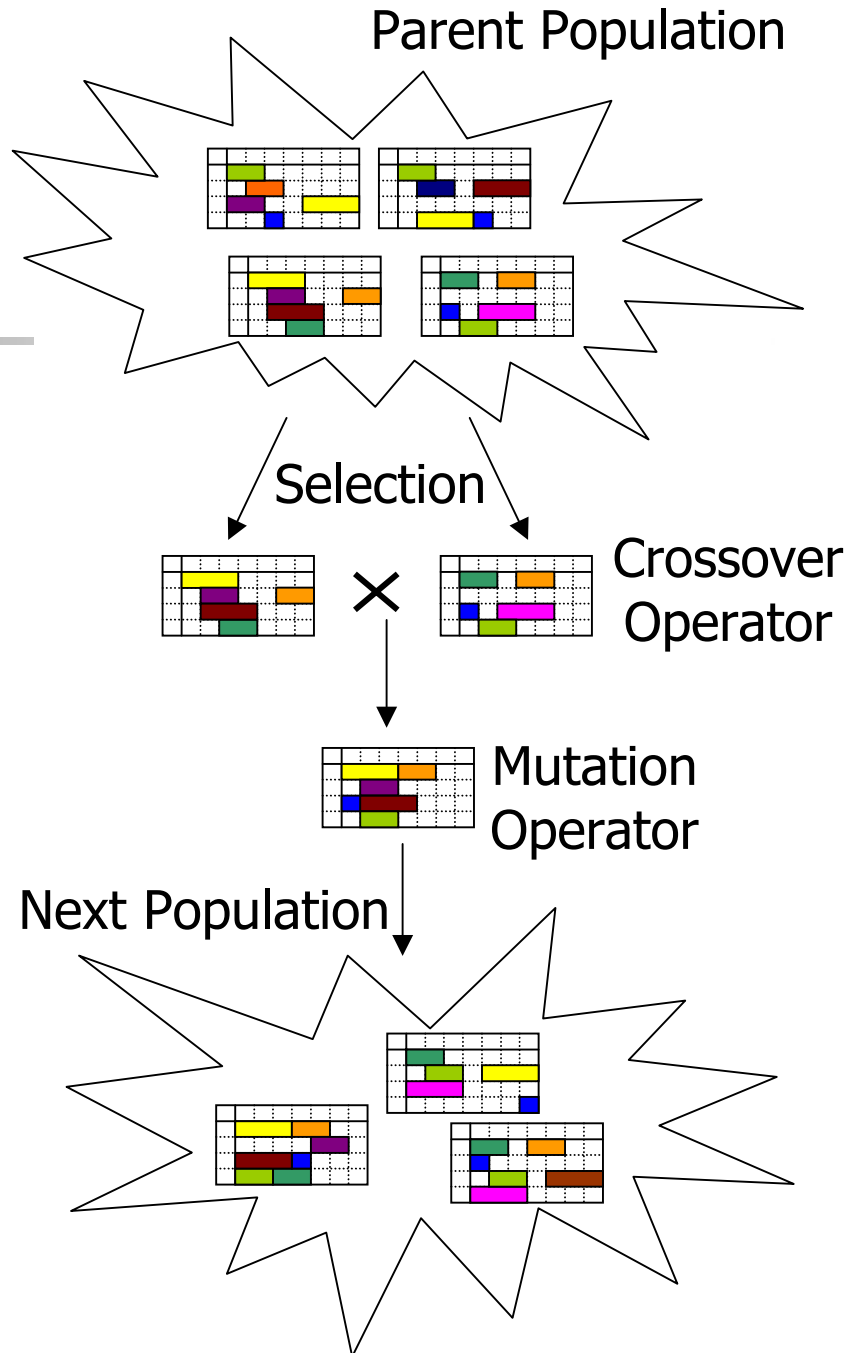
Graph Colouring Approach

- Graph Colouring Problem
  - vertex ~ activity
  - edge ~ dependence between activities, same resource required
- (Almost) Maximal Set of Independent Activities



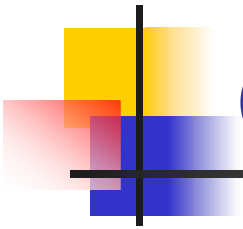
Evolutionary Approach

- Genetic Algorithm
- Population
  - set of feasible timetables
- Next Population
  - selection
  - crossover
  - mutation



Evolutionary Approach

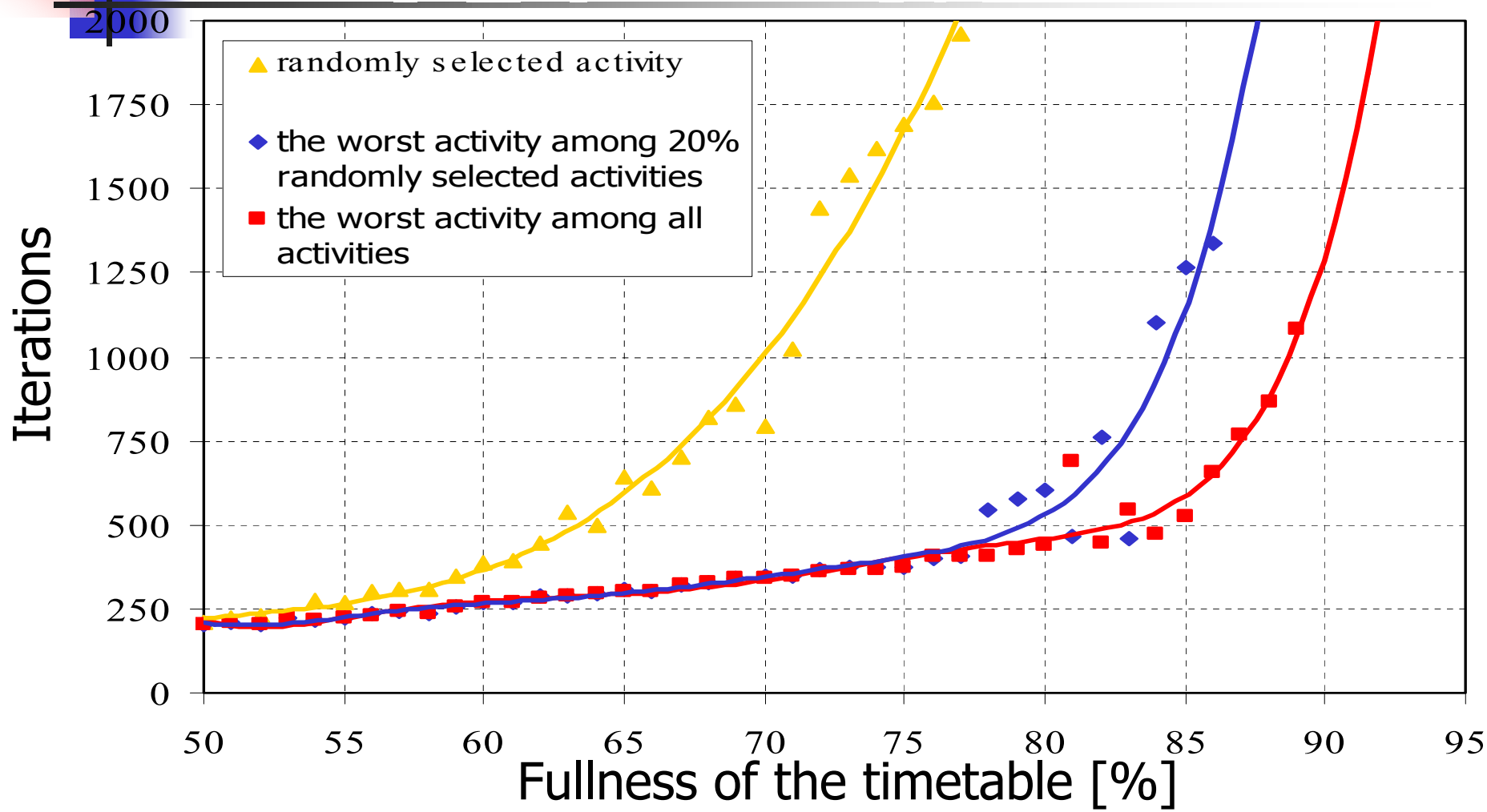
- Initial Population
  - randomly generated (+ remove conflict activities)
  - free timetables + at most *N* iterations
- Selection
  - evaluation *(e.g. number of unscheduled activities)*
- Crossover Operator
  - merge scheduled activities
    - same location as in one of the parent timetables
  - remove conflict activities
- Mutation Operator
  - at most *N* iterations of the presented algorithm



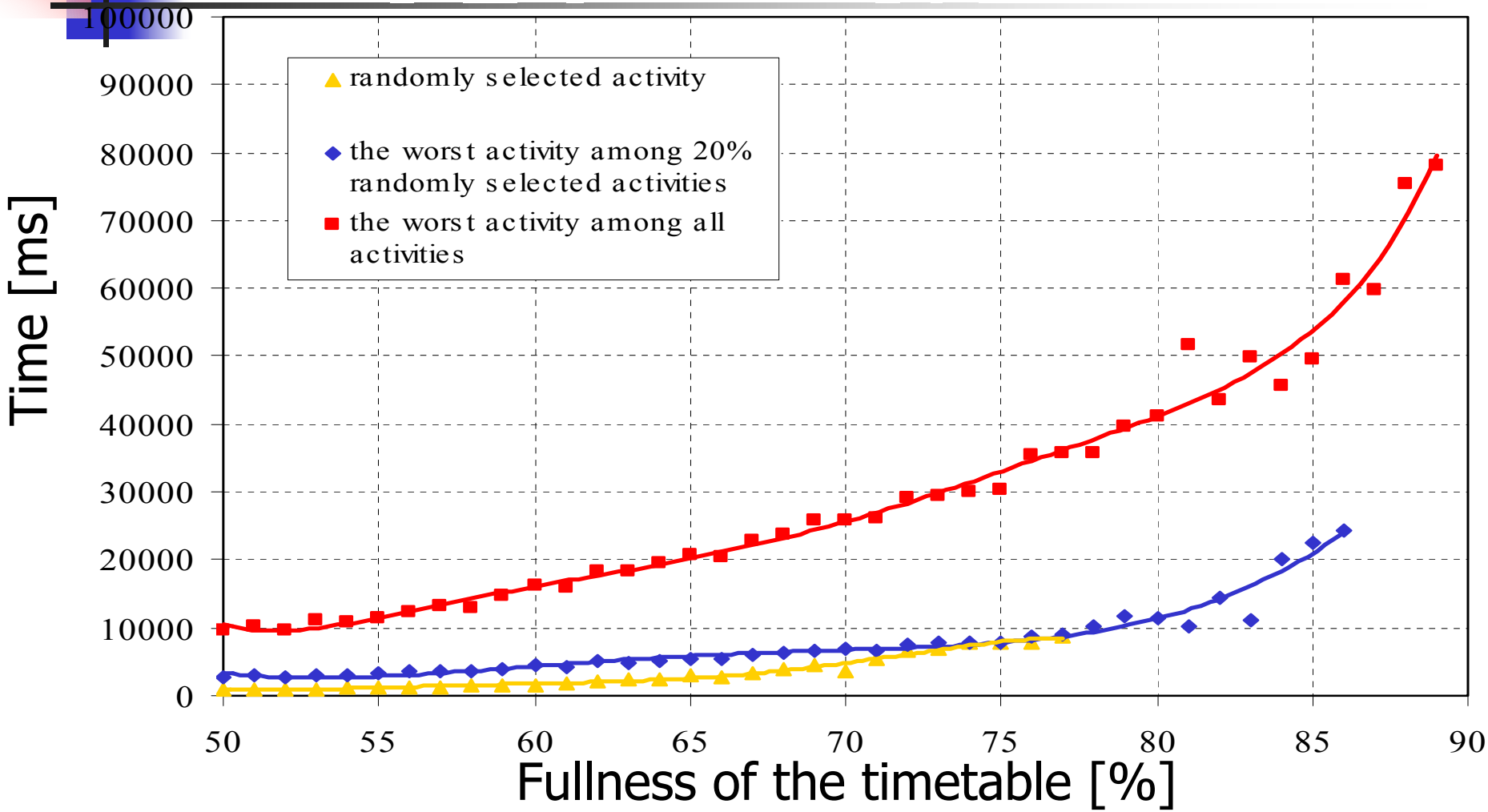
Conclusions and Future Work

- Current Algorithm
  - JAVA, several independent modules
    - general timetabling engine, activity & location selection criteria, GUI for lecture (university) timetable
  - very promising results
    - large randomly generated problems *~ 2000 activities*
    - timetable at Faculty of Mathematics and Physics
  - easily extensible
    - new constraints, dependencies between activities, …
  - generalizable to other constraint satisfaction problems
- Further Work
  - presented improvements
  - more results (on another real-world problems)
  - interactivity

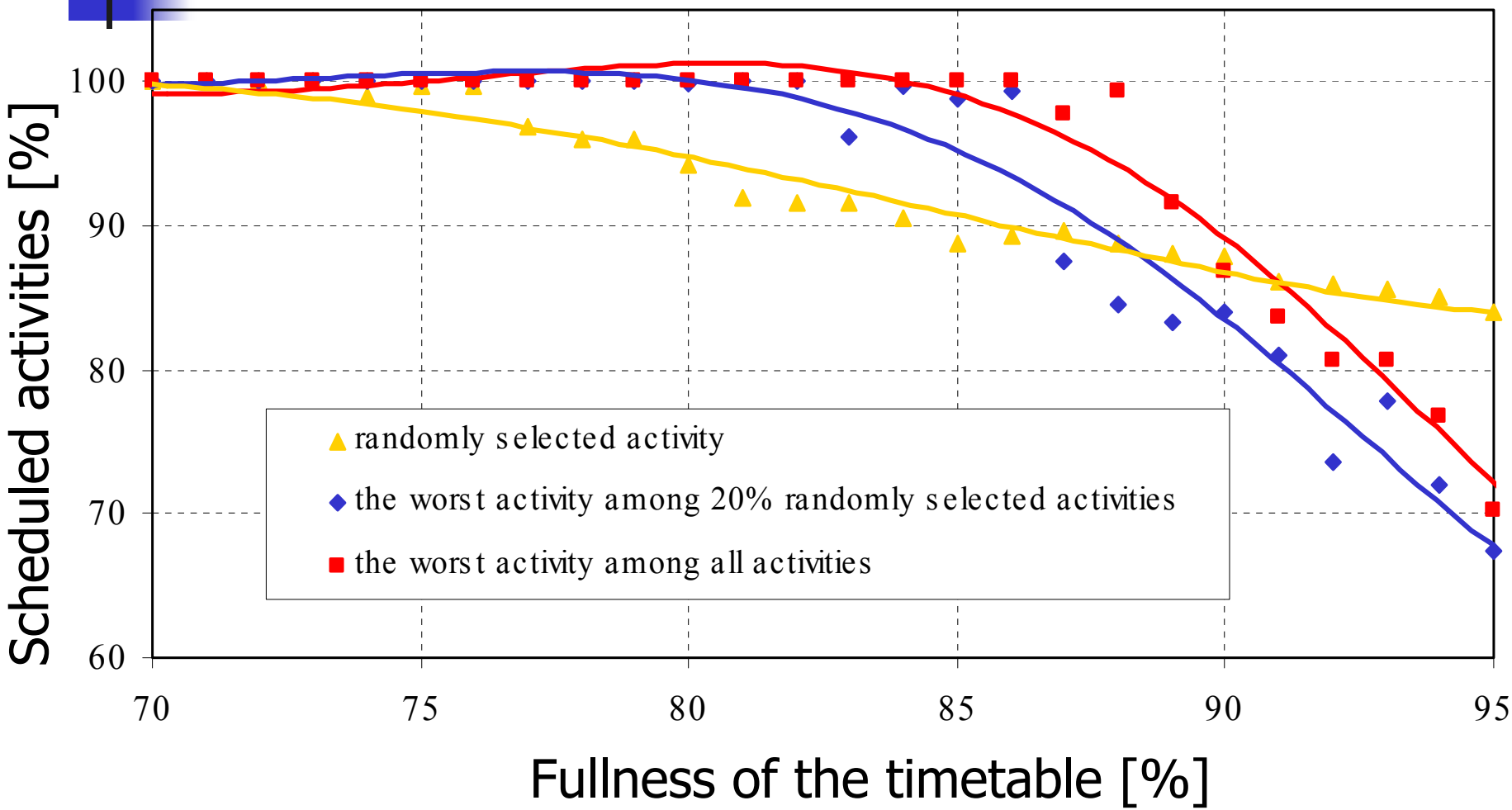
Comparison of the number of iterations for three basic activity selection criteria



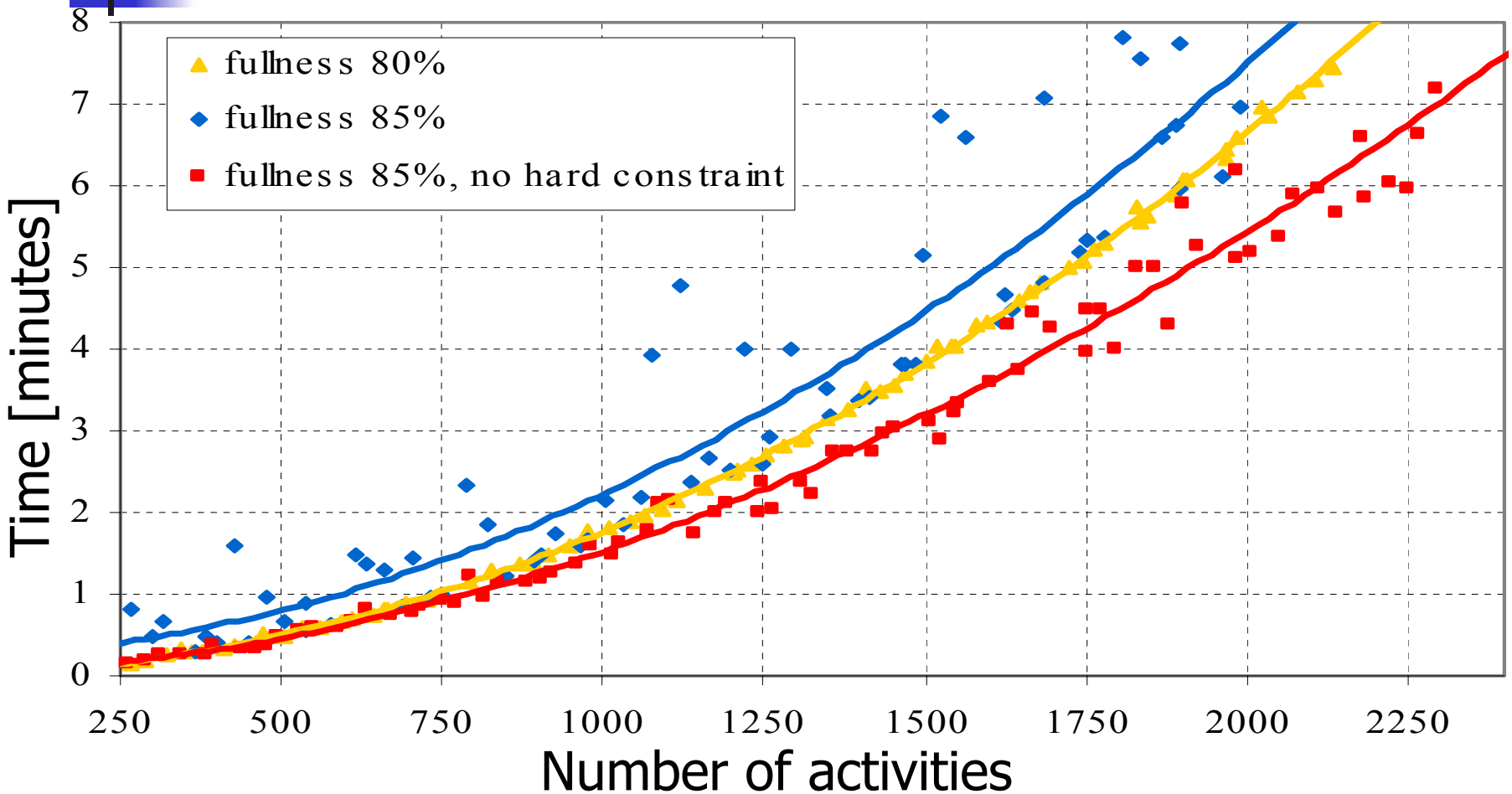
Comparison of the time for three basic activity selection criteria

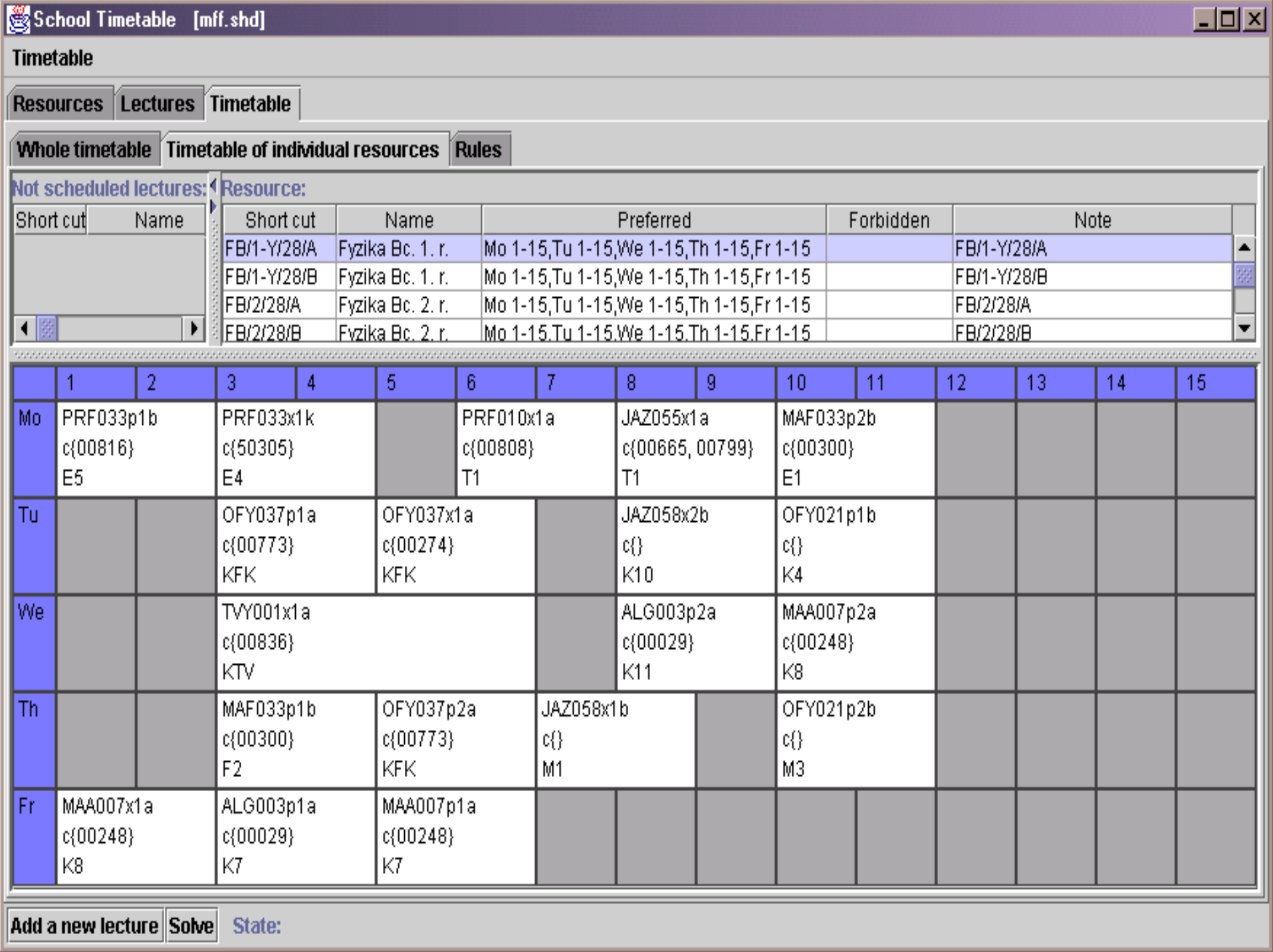


Comparison of the number of scheduled activities for three basic activity selection criteria



Comparison of the time spent on solving the problem and the size of the problem




School Timetable [mff.shd]
Timetable
Resources
Lectures
Timetable
Whole timetable
Timetable of individual resources
Rules
Not scheduled lectures:
Short cut
Name
Resource:
Short cut
Name
Preferred
Forbidden
Note
FB/1-Y/28/A
Fyzika Bc. 1. r.
Mo 1-15,Tu 1-15,We 1-15,Th 1-15,Fr 1-15
FB/1-Y/28/A
FB/1-Y/28/B
Fyzika Bc. 1. r.
Mo 1-15,Tu 1-15,We 1-15,Th 1-15,Fr 1-15
FB/1-Y/28/B
FB/2/28/A
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Mo 1-15,Tu 1-15,We 1-15,Th 1-15,Fr 1-15
FB/2/28/A
FB/2/28/B
Fyzika Bc. 2. r.
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PRF033x1k c{50305} E4
PRF010x1a c{00808} T1
JAZ055x1a c{00665, 00799} T1
MAF033p2b c{00300} E1
Tu
OFY037p1a c{00773} KFK
OFY037x1a c{00274} KFK
JAZ058x2b c{} K10
OFY021p1b c{} K4
We
TVY001x1a c{00836} KTV
ALG003p2a c{00029} K11
MAA007p2a c{00248} K8
Th
MAF033p1b c{00300} F2
OFY037p2a c{00773} KFK
JAZ058x1b c{} M1
OFY021p2b c{} M3
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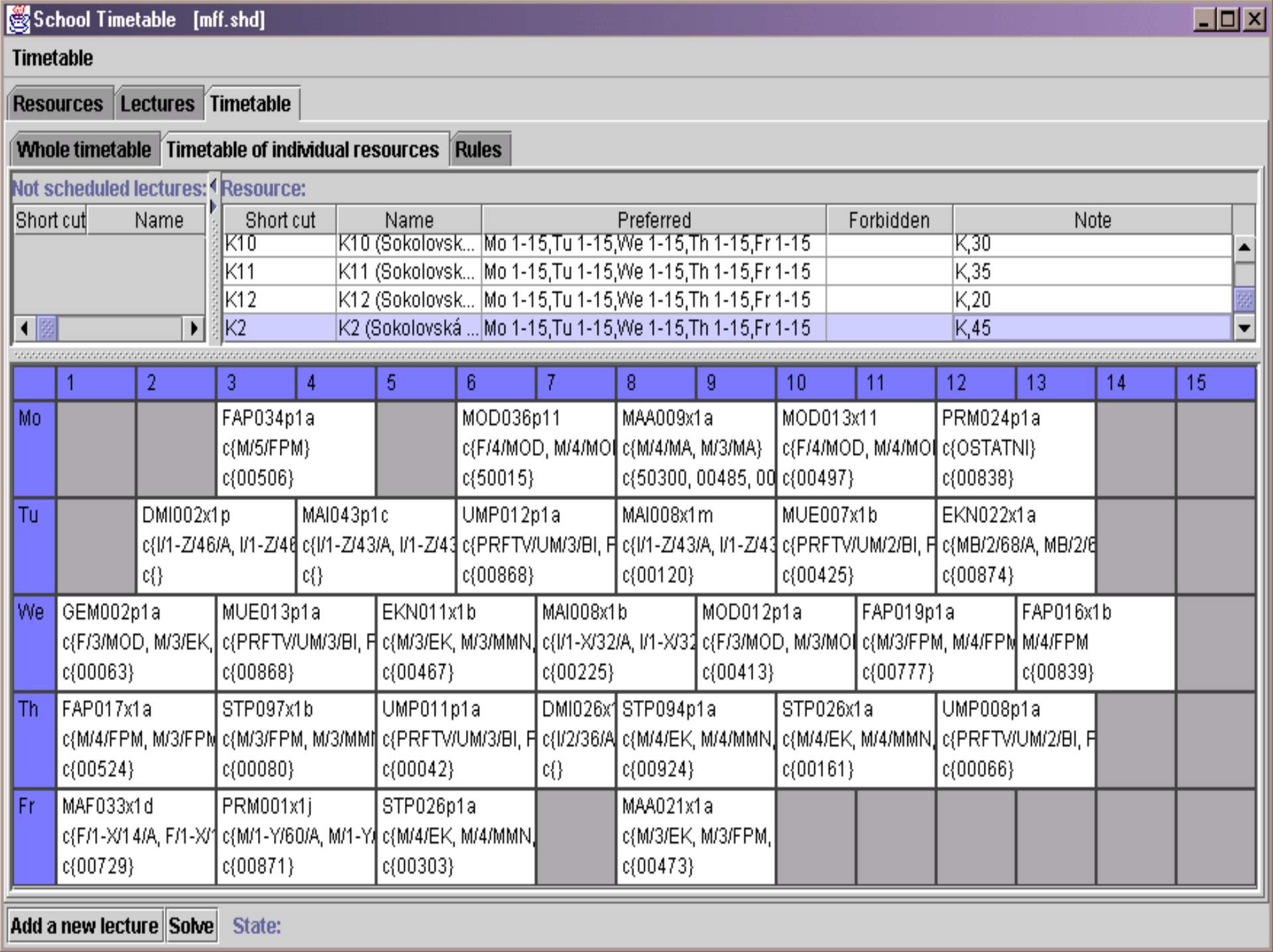
MAA007x1a c{00248} K8
ALG003p1a c{00029} K7
MAA007p1a c{00248} K7
Add a new lecture
Solve
State: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Name
Preferred
Forbidden
Note
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K12 (Sokolovsk...
Mo 1-15,Tu 1-15,We 1-15,Th 1-15,Fr 1-15
K,20
K2
K2 (Sokolovská ...
Mo 1-15,Tu 1-15,We 1-15,Th 1-15,Fr 1-15
K,45
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Tu
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EKN022x1a c{MB/2/68/A, MB/2/6 c{00874}
We
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Fr
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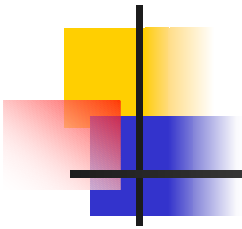
PRM001x1j c{M/1-Y/60/A, M/1-Y/ c{00871}
STP026p1a c{M/4/EK, M/4/MMN, c{00303}
MAA021x1a c{M/3/EK, M/3/FPM, c{00473}
Add a new lecture
Solve
State:



References

- [1] T. Müller. *Interactive Timetabling*. Diploma Thesis, MFF UK, Prague, 2001
- [2] T. Müller and R. Barták. *Interactive Timetabling.* In Proceedings of the ERCIM workshop on constraints, Prague, 2001
- [3] T. Müller and R. Barták. *Interactive Timetabling: Concepts, Techniques, and Practical Results.* In Proceedins of the PATAT conference, Gent, 2002
- [4] T. Müller. *Interactive Heuristic Search Algorithm.* Submitted to CP 2002 Doctoral Programme, Ithaca, 2002
- [5] T. Müller. Some Novel Appraches to Lecture Timetabling. In Proceedings of the CPDC workshop, Gliwice, 2002