examination scheduling

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outline

Problem

Formulation of Constraints

Objective Function

Improvements and Next Steps

problem

problem

Find a good examination schedule for the exam period of the TUM

most important criteria for an examination schedule

- Each exam is planed in exactly one period

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- In each room there is only one exam at a time

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- No student has to write two exams at the same time

most important criteria for an examination schedule

- Each exam is planed in exactly one period
- In each room there is only one exam at a time
- There are enough seats for each exam
- No student has to write two exams at the same time
- Rooms for an exam are minimized

most important criteria for an examination schedule

- Each exam is planed in exactly one period
- In each room there is only one exam at a time
- There are enough seats for each exam
- No student has to write two exams at the same time
- Rooms for an exam are minimized
- Time between exams is maximized

outline

formulation of constraints

model - variables

$$x_{i,k,l} := \begin{cases} 1, & \text{if exam } i \text{ is written in period } l \text{ in room } k \\ 0, & \text{otherwise} \end{cases}$$

$$y_{i,l} := \begin{cases} 1, & \text{if exam } i \text{ is written in period } l \\ 0, & \text{otherwise} \end{cases}$$

connecting variables

Connecting variables x and y

$$(1) \qquad \sum_{\forall \text{ rooms } k} x_{i,k,l} \leq y_{i,l} \cdot M \qquad \forall \text{ exams } i, \forall \text{ periods } l$$

connecting variables

Connecting variables x and y

$$(1) \qquad \sum_{\forall \text{ rooms } k} x_{i,k,l} \leq y_{i,l} \cdot M \qquad \forall \text{ exams } i, \forall \text{ periods } l$$

$$(2) \qquad \sum_{\forall \text{ rooms } k} x_{i,k,l} \geq y_{i,l} \qquad \forall \text{ exams } i, \forall \text{ periods } l$$

each exam is planned

Each exam is planned in exactly one period

$$(3) \qquad \sum_{\forall \text{ periods } l} y_{i,l} = 1 \qquad \forall \text{ exams } i$$

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$$\text{c.f. } (2) \qquad \sum_{\forall \text{ rooms } k} x_{i,k,l} \geq y_{i,l} \qquad \forall \text{ exams } i, \forall \text{ periods } l$$

there are enough seats

There must be enough seats for the students in the chosen rooms

$$(4) \qquad \sum_{\substack{\forall \text{ periods } l, \\ \forall \text{ rooms } k}} c_k \cdot x_{i,k,l} \geq s_i \qquad \forall \text{ exams } i$$

$$s_i := \# \text{ students taking exam } i.$$

$$c_k := \# \text{ seats in room } k.$$

one exam at a time

In each room there is only one exam at a time

$$(5) \qquad \sum_{\forall \text{ exams } i} x_{i,k,l} \leq 1 \qquad \forall \text{ rooms } k, \forall \text{ periods } l$$

no conflicts

No student has to write two exams at the same time

$$(6) \qquad \sum_{\substack{\forall \text{ exams } j: \\ i,j \text{ have a conflict}}} y_{j,l} \leq (1 - y_{i,l}) \cdot M \qquad \forall \text{ exams } i, \forall \text{ period}$$

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Minimize the total number of rooms

$$\text{minimize} \quad \sum_{\text{exams } i} \sum_{\text{rooms } k} \sum_{\text{periods } l} x_{i,k,l}$$

maximize time between exams

Maximize the time between two exams

$$\max \sum_{j>i:q_{i,j}>0} d_{i,j}$$

$d_{i,j}$:= Distance between exams i and j

maximize time between exams

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objective functions combined

Combine objective functions using weighting factor $\gamma > 0$

$$\min \sum_{i=1}^{n} \sum_{k=1}^{r} \sum_{l=1}^{p} x_{i,k,l} - \gamma \sum_{j>i:q_{i,j}>0} d_{i,j}$$

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improvements and next steps

finding a feasible starting point

- Use graph-coloring to schedule exams without conflicts
- Plan difficult exams first
- Calculate difficulty by:
  - number of students taking exam
  - Identifying cliques in conflict graph

model improvements

Clique Constraints

$$(7) \qquad \sum_{\text{j in clique}} y_{i,l} \leq 1 \quad \forall \text{cliques calculated from conflict graph}$$

data