From development to implementation of decision support for duty- and workstation rostering in hospitals

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Symposium

Timely and efficient planning of treatments through intelligent scheduling

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Outline

1. Motivation of the problem
2. Project descirption
   - Development of optimization models (research)
   - Implementation of a software tool (practice)
3. Conclusion and outlook

Rising importance of physician scheduling

Rising demand due to megatrends

- Technological progress and demographic change lead to rising demand for health services
- 293.8 billion Euro cost in 2011 for the health care sector (11.3% of the gross domestic product)
- 26% of health care cost are consumed by 2,045 hospitals (76.8 billion Euro in 2011)
- More than 50% of the hospitals in Germany generated a loss in 2013

Health care is service industry

- Main cost block in hospitals are HR expenses
- Classical motivation for physicians to choose a specific hospital are high income and further/advanced education
- New focus on work-life balance
- Rising importance of shift rosters that consider fairness and employee satisfaction

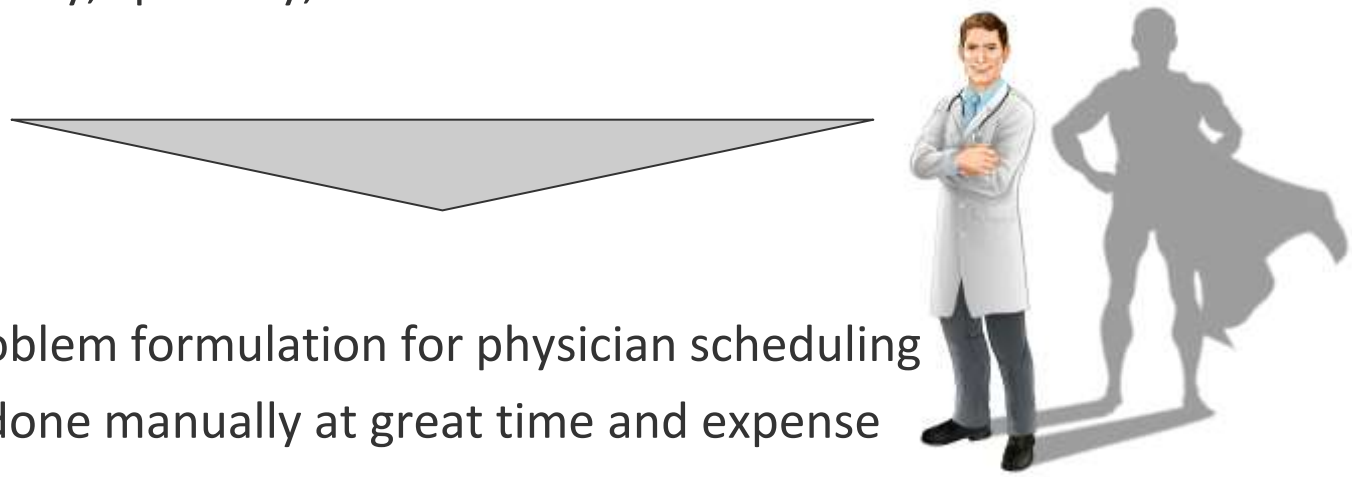
Complexity of physician scheduling

Strong requirements…

- Wide fluctuations in demand
- On-call service to handle emergencies in off-hours
- Detailed labor contracts that vary by region, governing authority, seniority, specialty, and training

…and "soft" constraints

- Preference considerations to promote job satisfaction
- Specialized skills and necessity for training
- Near-monopolistic environment



- No generic problem formulation for physician scheduling
- Scheduling is done manually at great time and expense

A decade of physician scheduling (milestones)

PhD-phase

Flexible Shift Scheduling in the Service Industry: The Case of Physicians in Hospitals

Student theses

Excel-tool for (manual) planning

Irregular meetings with cooperation partner

Postdoc-phase

Publication with physicians

Several talks at international conferences

First draft of software tool with IT-students

Irregular meetings with cooperation partner

Professorship

Foundation of UNIKA-T

Student theses

PhDs and postdoc involved

Publication with physicians

Several talks at international conferences

Cooperation with IT company

Regular weekly meetings with cooperation partner and IT company

Cooperative application for funding

Ongoing project in close cooperation

Ongoing project in close cooperation

Co-financing of personnel resources

Implementation and testing

2006 2009 2013 2014 today

Project with cooperating hospital

Cooperation with the anesthesia department of Klinikum rechts der Isar (MRI) – A German university hospital in Munich

- Staff unsatisfied with current schedules
- Senior physician invests several days a week on roster creation
- Current tool unstable and dependent on specific employee

Real implementation phase started in 2014 and covered many aspects

Two main outcomes

- Models to create rosters that consider various rules (**research**)
- Software to enable automatic planning at MRI (**practice**)

Problem description: duty and workstation rostering

Duty- and workstation-rosters

- A duty is defined by working irregular hours (regular working time 8.5 hours starting at 7 am)
- Allocation of 24-hour duties and late duties for normally 4-weeks
- Duties are not physical workstations
- Workstation assignments for each day based on duty assignments and absence plan
- Each duty or workstation requires some experience/qualification
- Each physician has an experience (qualification) level

Focus today: Duty rostering

Duty-roster model

Assigns physicians to duties over a predefined planning horizon

Set of 24-hour duties

- One physician of each seniority level
- One physician for emergencies, one physician for PACU

Set of late duties

- Late duties: Six 4-day duties (S1, S2, S3, S4, S5, S6)
- Pre-medication: Four 4-day duties (P1, P2, P3, P4)
- PACU: Two 5-day duties (AST, ANT)

Objective function

- Maximize assignment
- Penalize deviations of soft constraints (see next slides)

Hard constraints

Violations are <u>not</u> allowed

- The maximum requirement (duty/day/week) of physicians cannot be exceeded
- Every physician can be allocated to at most one duty on any day
- After a 24-hour duty, the physician has a day off
- The late duties are carried out four days a week by the same physician, i.e. fifth day is off
- If a physician is absent (s)he cannot be assigned to a duty
- In any two weeks one weekend has to be off duty
- At least one of the late duties S1, S2, or S6 has to be carried out by a sub-senior physician
- Late duty P1 (P2) needs experience level 1.-duty (2.-duty)

Soft constraints

Violations are allowed and deviations are penalized

- Each physician can request a specific duty or to be off duty on any day
- Limit the number of 24-hour duties in the planning period for each physician (i.e. fair distribution)
- Late duties S3 – S5 should be evenly distributed between experience levels 1.-, 2.-, and 3.-duty

Duty-roster model – example

24h duties

Dat	Oberarzt	FOA	1. Dienst	2. Dienst	3. Dienst	Notarzt
1	Wagner	Fink	Schüller	Krause	Vettl	Bach
2	Berger	Pfeifer	Wenzel	Lauth	Bachler	
3	Berger	Jelen	Kecht	Mayer	Meyer	
4	Berger	Podtschasl	Fageth	Huber	Bender	Binder
5	Schneider	Ottl	Kneitz	Wallner	Vettl	Krause
6	Rust	Bader	Fageth	Kern	Brom	Schüller
7	Wagner	Fink	Schlick	Hofinger	Kauf	Binder
8	Wagner	Jelen	Kecht	Mayer	Meyer	Ottl
9	Rust	Bader	Schüller	Wallner	Bachler	
10	Berger	Fink	Fageth	Hofinger	Bender	
11	Schneider	Pfeifer	Wenzel	Lauth	Brom	Tripp
12	Schneider	Podtschasl	Kneitz	Krause	Bachler	Jelen
13	Rust	Ottl	Schüller	Huber	Vettl	Binder
14	Wagner	Jelen	Kecht	Mayer	Kauf	Bach
15	Berger	Fink	Fageth	Hofinger	Bender	König
16	Wagner	Bader	Schüller	Krause	Vettl	

Late duties

Dat	S 1	S 2	S 3	S 4	S 5	S 6	P 10	P11	P 12
1	Hoffman	Söllner	Wenes	Posch	Lang	Hiederer	Hörter	Dum	Ziegler
2	Hoffman	Söllner	Wenes	Posch	Lang	Hiederer	Rosner	Kurz	Löffler
3									
4									
5	Dum	Rosner	Ziegler	Löffler	Kurz	Schmuck	Wenes	Hoffmann	Söllner
6	Dum	Rosner	Ziegler	Löffler	Kurz	Schmuck	Wenes	Hoffmann	Kurz
7	Dum	Rosner	Ziegler	Löffler	Kurz	Schmuck	Wenes	Hoffmann	Hiederer
8	Dum	Rosner	Ziegler	Löffler	Kurz	Schmuck	Wenes	Hoffmann	Surer
9	Dum	Rosner	Ziegler	Löffler	Kurz	Schmuck	Posch	Lang	Langer
10									
11									
12	Kraus	Kehl	Putz	Posch	Hoch	Hörterer	Ziegler	Löffler	Schmitt
13	Kraus	Kehl	Putz	Posch	Hoch	Hörterer	Ziegler	Löffler	Kunze
14	Kraus	Kehl	Putz	Posch	Hoch	Hörterer	Ziegler	Löffler	Surer
15	Kraus	Kehl	Putz	Posch	Hoch	Hörterer	Ziegler	Löffler	Langer
16	Kraus	Kehl	Putz	Posch	Hoch	Hörterer	Wenes	Kurz	Schmitt

Performance of model – standard solver sufficient

Model is tested with numerical study (5,800 instances)

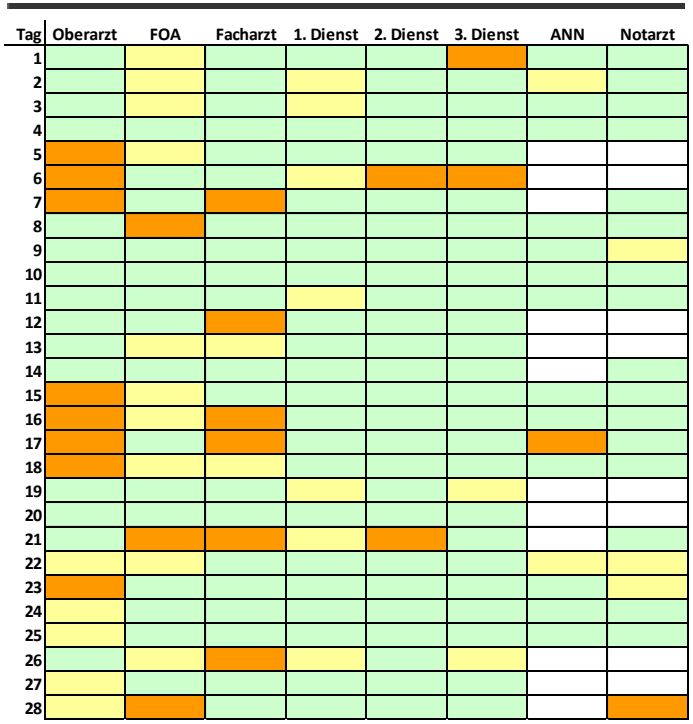
- Optimal solution could be found for all instances
- Computation times negligible (<5 sec for 300 physicians)
- Trade-off between soft constraints is observed

Model solutions significantly outperform current practice

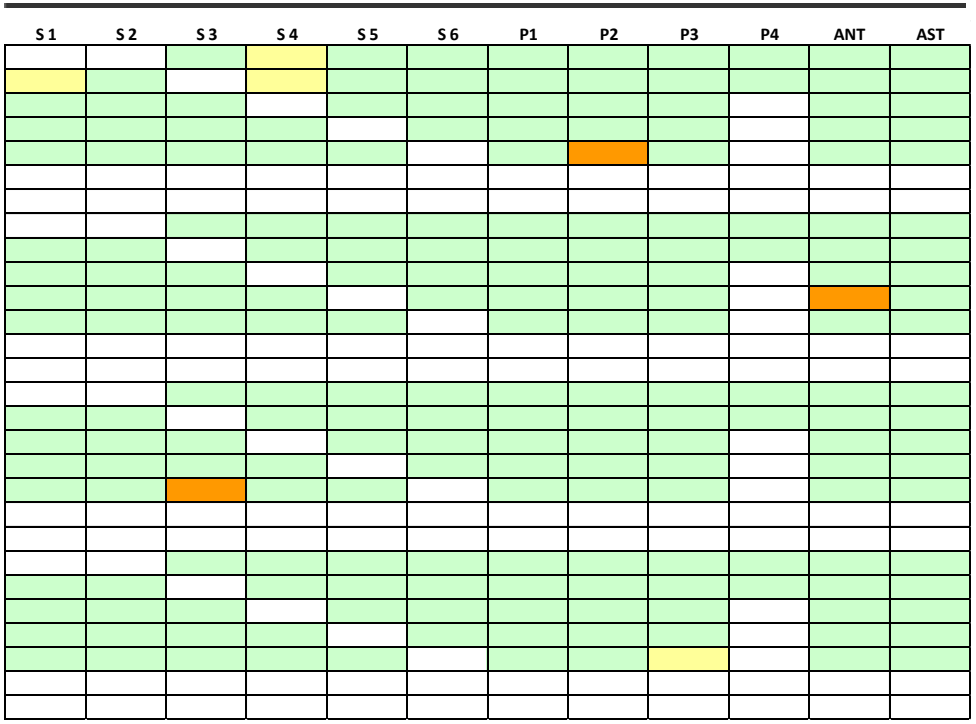
- No hard constraint violations
- More duty requests could be accepted
- Additional constraints (e.g. Thursday-Sat-Off rule, specific seniority requirements) can be applied

Duty roster – status quo

24h duties



Late duties



408 Scheduled duties

30 Schedules on day off, two consecutive weekends, not required qualification

49 Not granted shift/no shift requests, too many 24h shifts

Duty roster – model solution

24h duties

Tag	Oberarzt	FOA	Facharzt	1. Dienst	2. Dienst	3. Dienst	ANN	Notarzt
1								
2								
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Late duties

S 1	S 2	S 3	S 4	S 5	S 6	P1	P2	P3	P4	ANT	AST

408 Scheduled duties

0 Schedules on day off, two consecutive weekends, not required qualification

48 Not granted shift/no shift requests, too many 24h shifts

Implementation within software tool

Status quo at MRI

- Excel tool (Excel 2003) with VBA macros in use to create rosters
- Tool unstable due to problem size
- No rule-based scheduling possible → some scheduling rules could not be handled within tool

Software tool created to implement scheduling logic

- Intuitive web-based user-interface
- Automatic plan generation
- Manual adjustments possible
- Documentation of duty and workstation assignments

Lessons learned from project

Software development should follow process reengineering

- Discuss processes first, derive software specifics accordingly
- Late adaptions of software architecture are time- and cost-consuming

Keeping stakeholders in contact to maintain project timeframe

- Ensure early integration of key stakeholders for timely scope discussions
- Keep close interaction with software company
- Make sure that customers (physicians) and software developers speak the same language

- Software Presentation -

Conclusion and outlook

Development of new mixed integer programs for automated duty- and workstation rostering

Real-world application at German university hospital

- Software implementation that assists the scheduler (i.e. saves time)
- Model guarantees feasibility w.r.t. working regulations and considers physician preferences significantly better than current solution
- Scheduler may overrule any decision by the models (autonomy)

Next steps

- Regular application of software
- Monthly “Pulse Check” to observe employee satisfaction
- Re-schedule in case of availability or demand changes (e.g. illness)

Questions and comments!

Fügener A, Brunner JO, Podtschaske A (2015): **Duty and workstation rostering considering preferences and fairness: A case study at a department of anesthesiology**, *International Journal of Production Research (IJPR)*, DOI:10.1080/00207543.2015.1082667.