GUROBI SUMMIT - Oct 28, 2025 - Vienna – Reinhard Bürgy

BECAUSE TIME MATTERS

Empowering Smart Health-Care Scheduling through Participation and Optimization

Overview

polypoint
because time matters.

Company

polypoint
because time matters.

> 1'000

customers

Switzerland
Liechtenstein
Germany
Belgium
Luxembourg

> 450'000

users (> 40’000 planers)

1986

company foundation

Health-Care Industry

hospitals, clinics, rehabilitation centers, psychiatric facilities, long-term care homes

90

employees

Switzerland
Bern
Lausanne
Germany
Berlin

Workforce Management

Swiss-made software

Solutions

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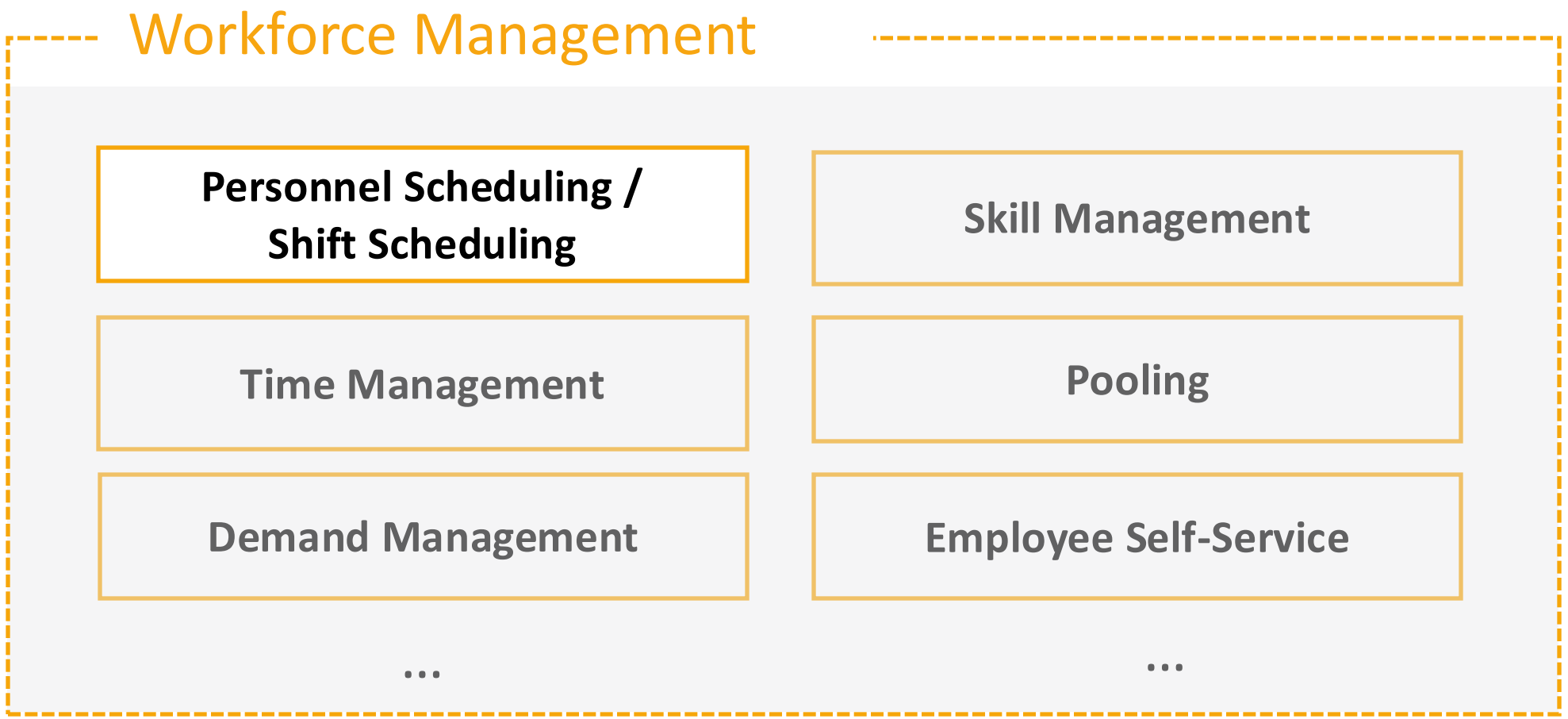
because time matters.



Overview

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01 POLYPOINT

02 SHIFT SCHEDULING

03 PARTICIPATION

04 OPTIMIZATION

Shift Scheduling

Shift palette

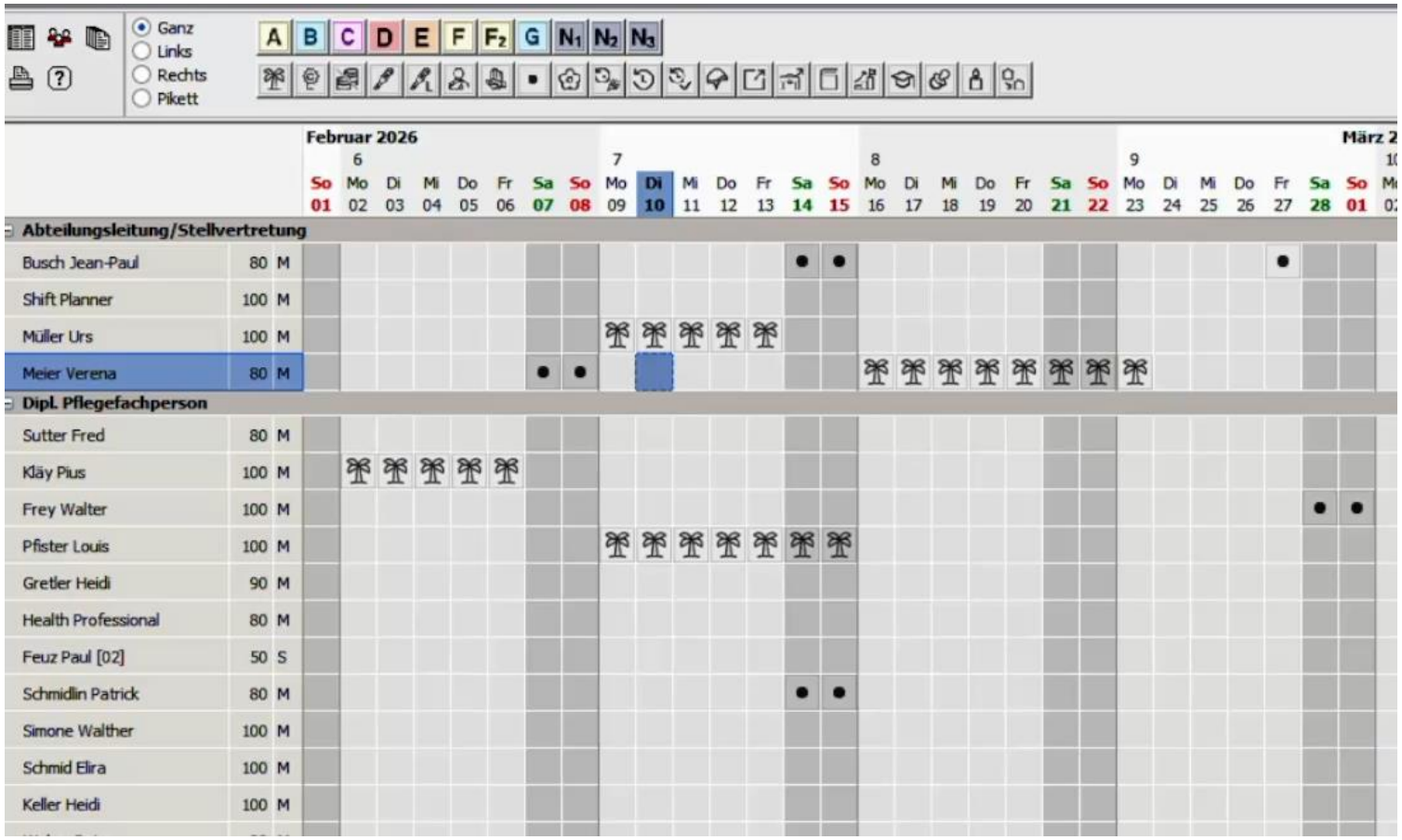
presences

absences

Shift Scheduling
Assign shifts to employees

Shift

- When (day + times)
- Where (unit / subunit)
- (responsibilities)



Shift Scheduling Characteristics

24/7 coverage

⇒ Shift work, including nights and weekends

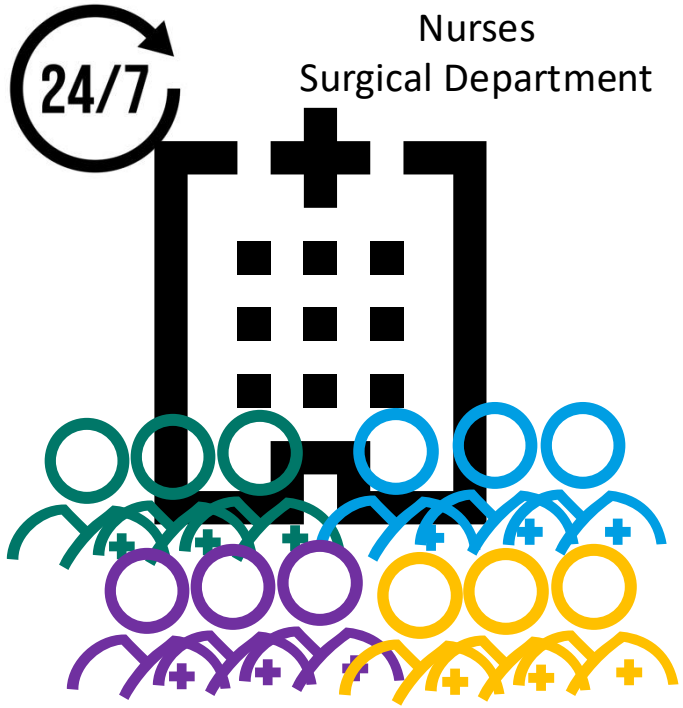
⇒ Legal and regulatory compliance

High variety of tasks and large work volume

⇒ Variety of qualifications, skills and experience

⇒ Large number of employees to schedule simultaneously (typically 40 – 100)

Example:
Nurses
Surgical Department



Shift Scheduling Characteristics

Volatile and stochastic demand

Supply: unplanned and short-notice events

⇒ “Robust” schedule

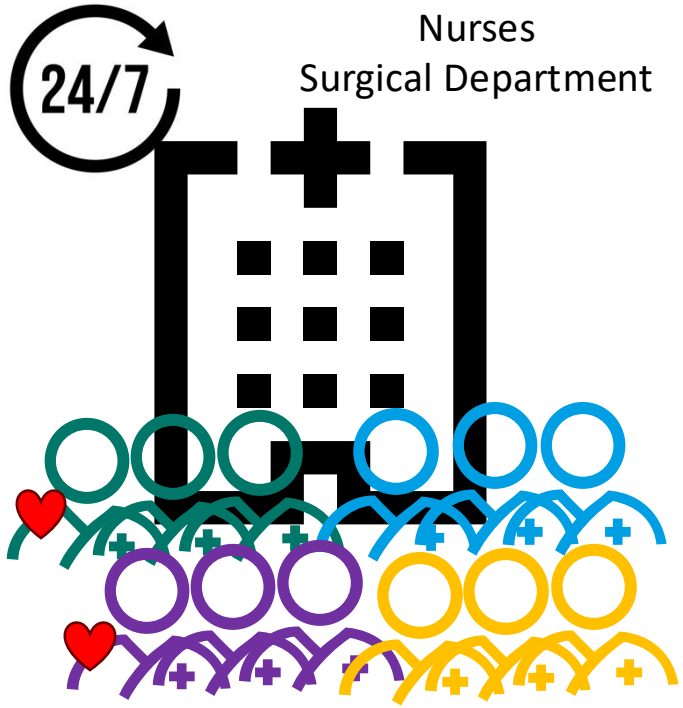
Scarce resources

⇒ High personnel autonomy in work agreements

In summary

Complex personalized scheduling setting

Example:
Nurses
Surgical Department



Shift Scheduling Process

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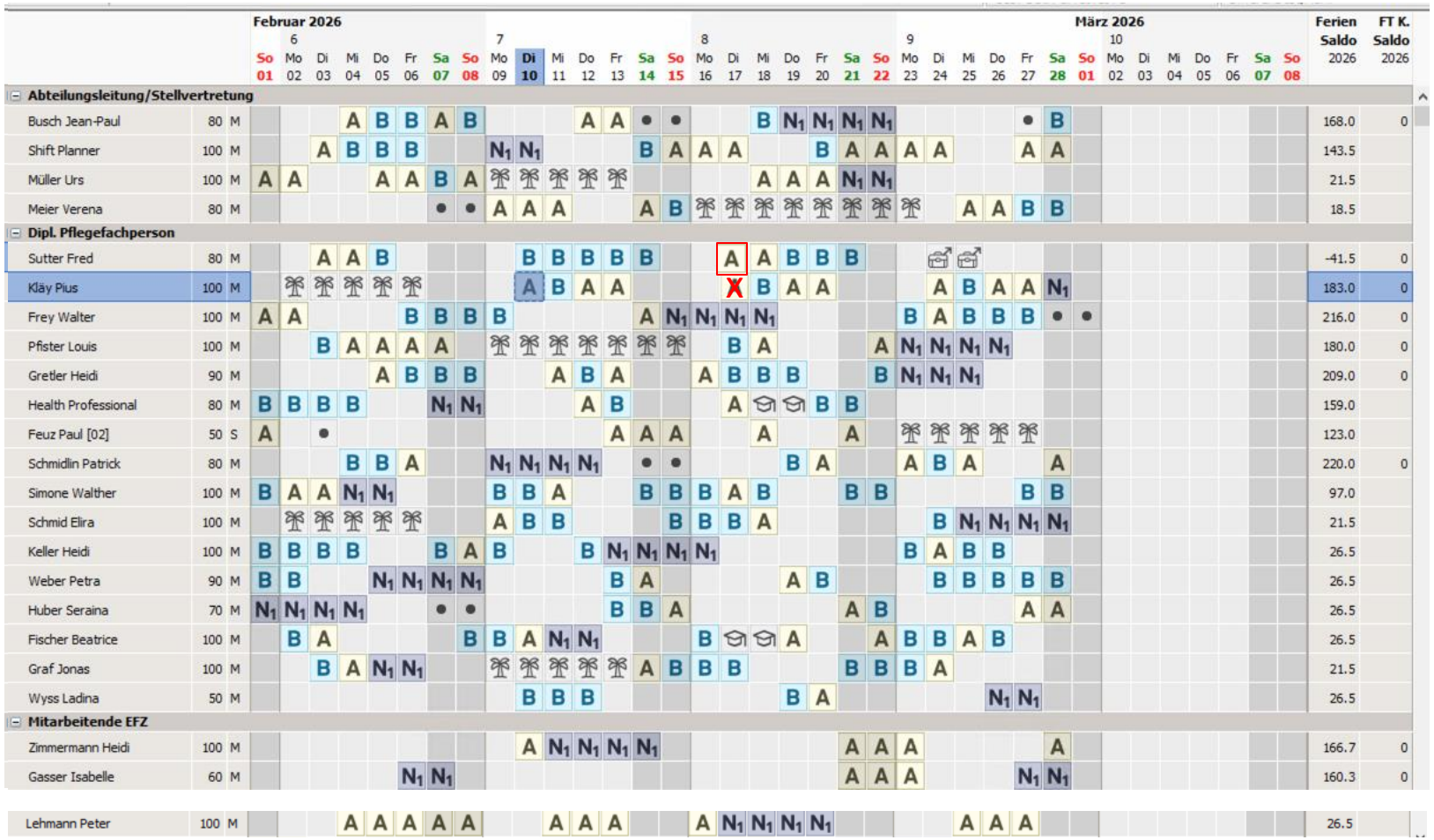

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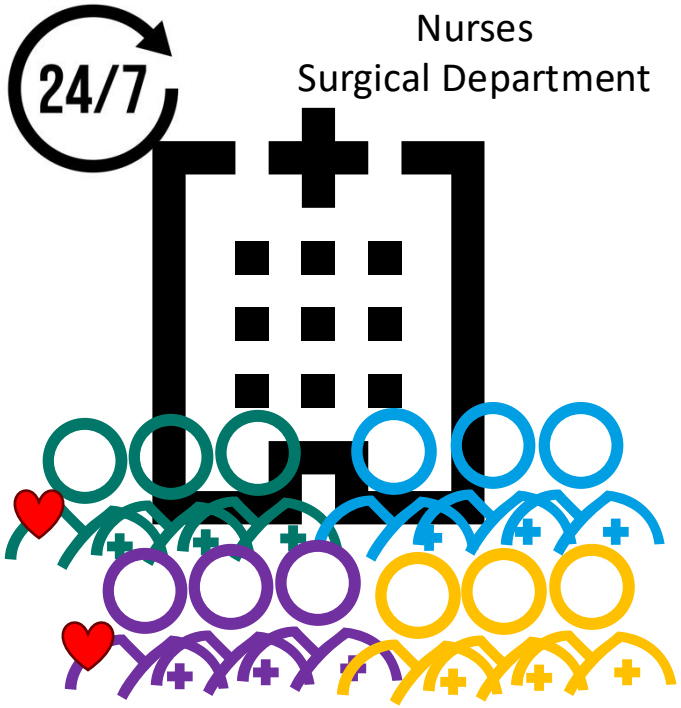

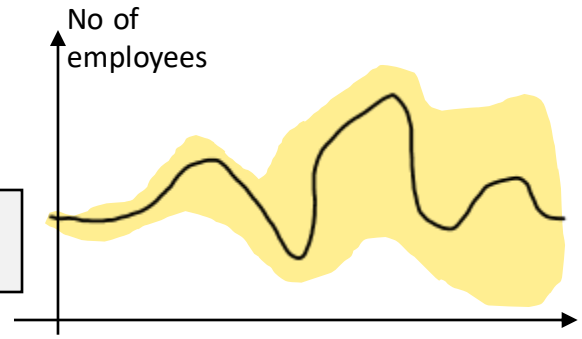

Absence planning (leaves, vacations)	Monthly scheduling	Resource replacement	Incident management
Lead time: 12 – 6 months	1.5 - 2 months	weeks to some days	days to “real-time“

Monthly Scheduling

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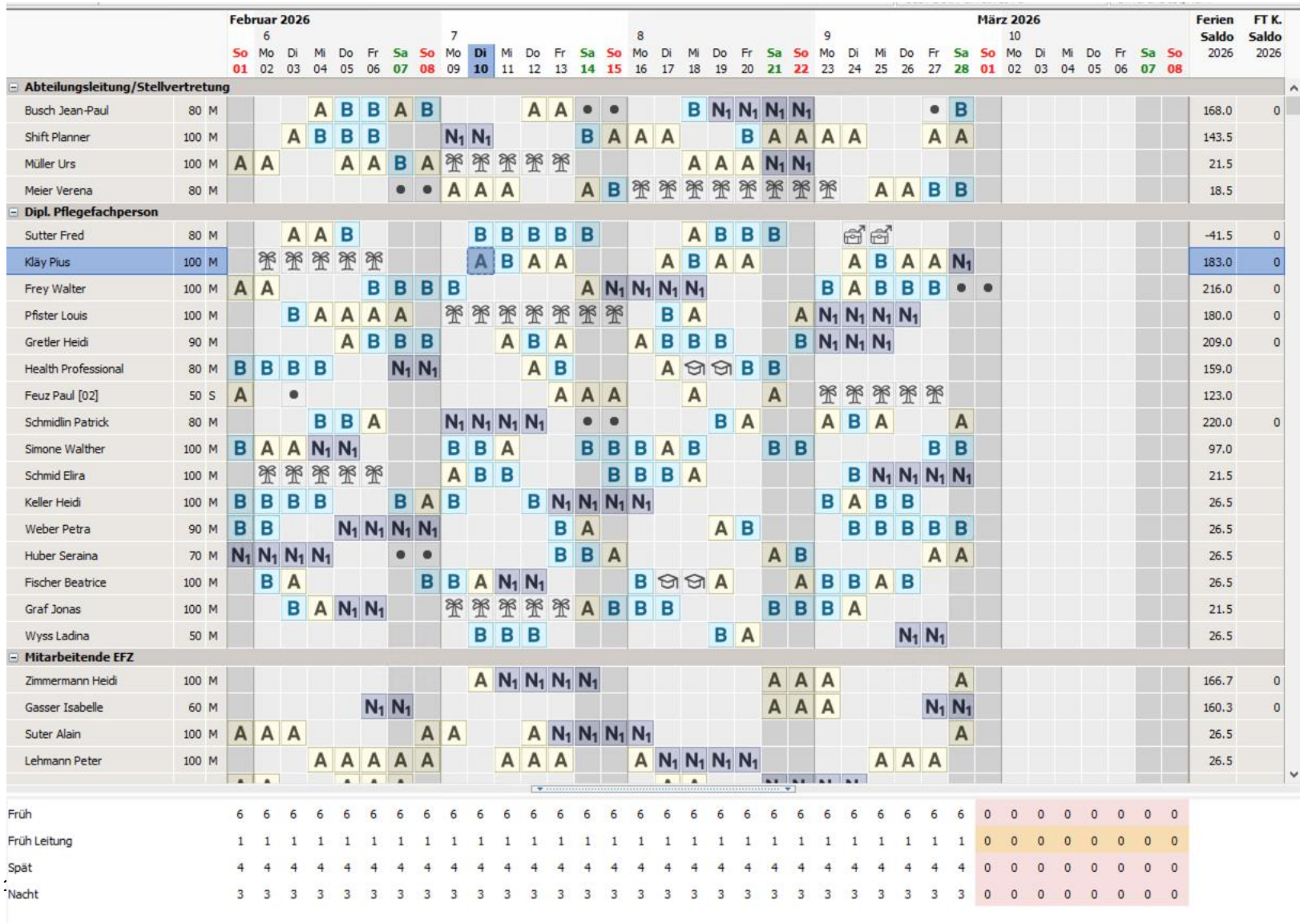


Process in the past

- Manual planning
- Different sub-steps (nights, weekends,…)
- Heterogenous data sources

Major challenges

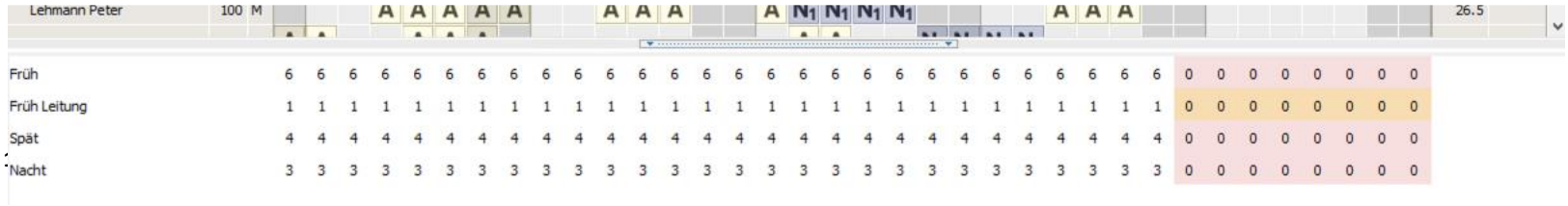
- Complex and time intensive
- Quality + fairness: difficult to assess and guarantee

Monthly Scheduling

IPSP: Intelligent and Participative Shift Planning (**smartPEP**)

Main goals

- Standardize process
- Improve transparency and fairness
- Substantially reduce planning effort and complexity



smartPEP

polypoint
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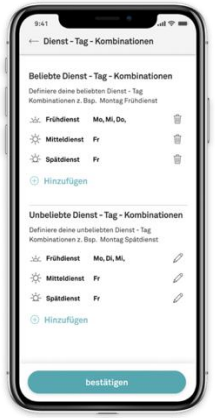
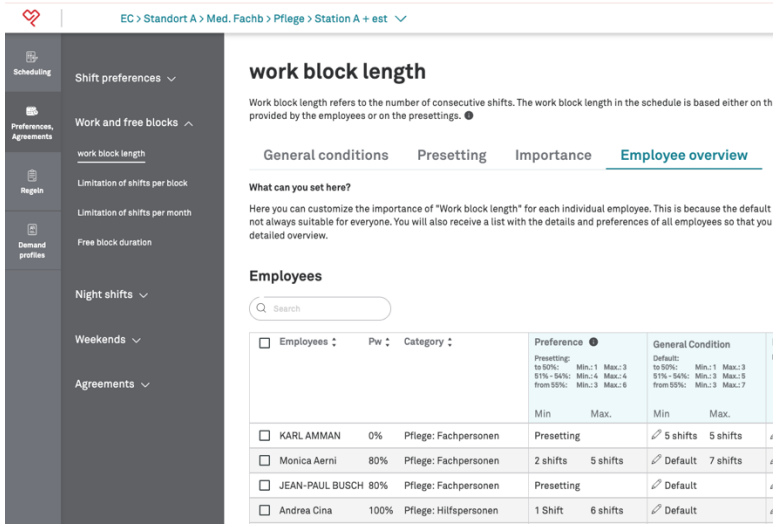
Participation

Employee (nurses, physicians, ….)

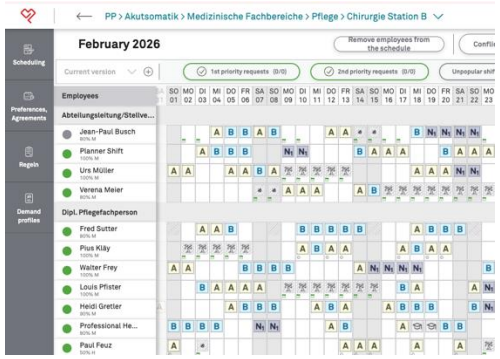


Shift planner

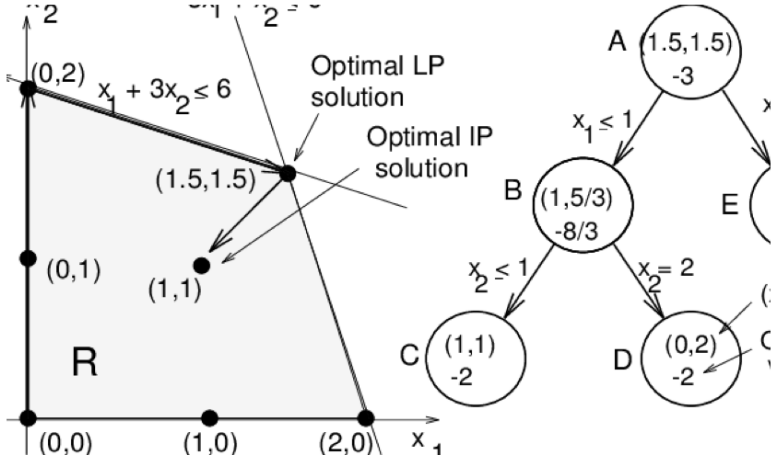


Optimization

Interactive scheduling board



Mathematical Optimization



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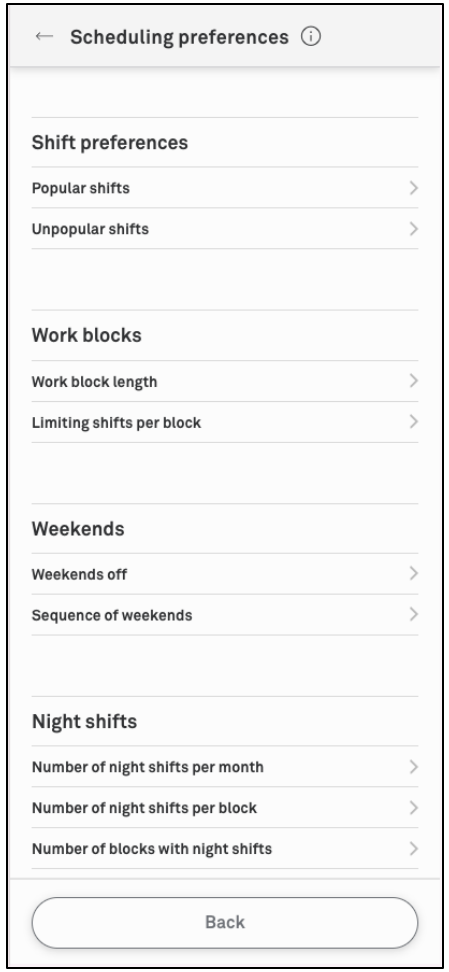
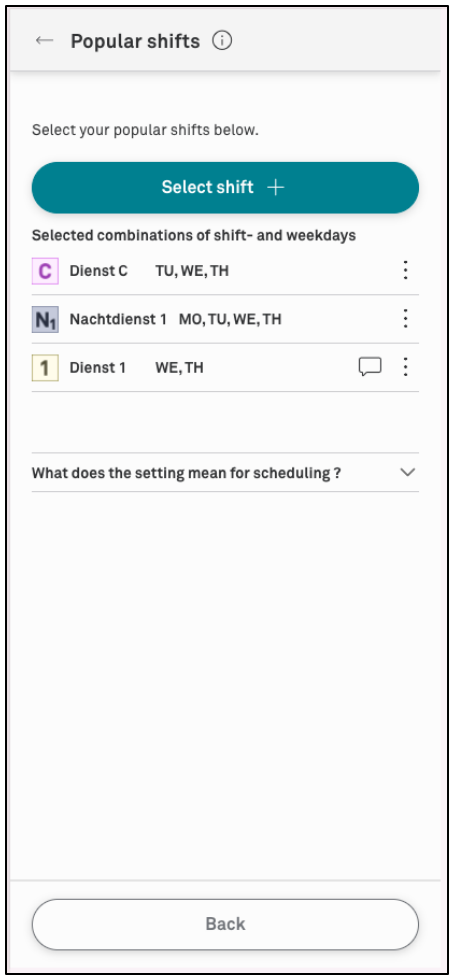
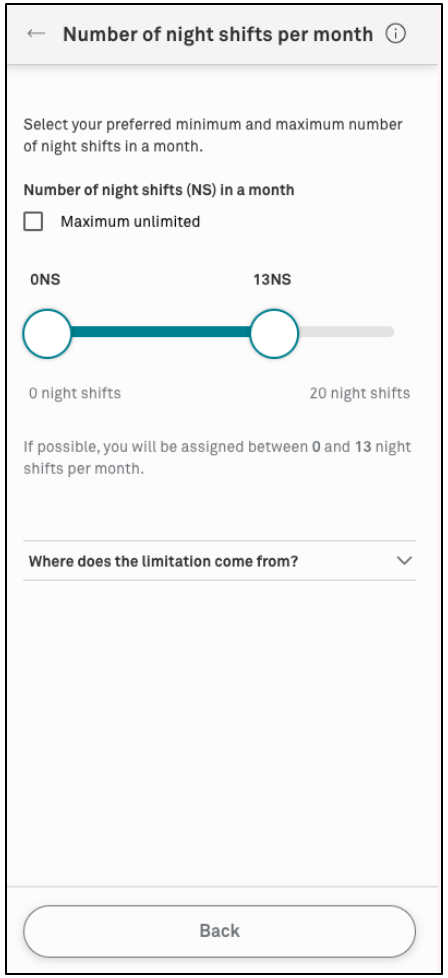
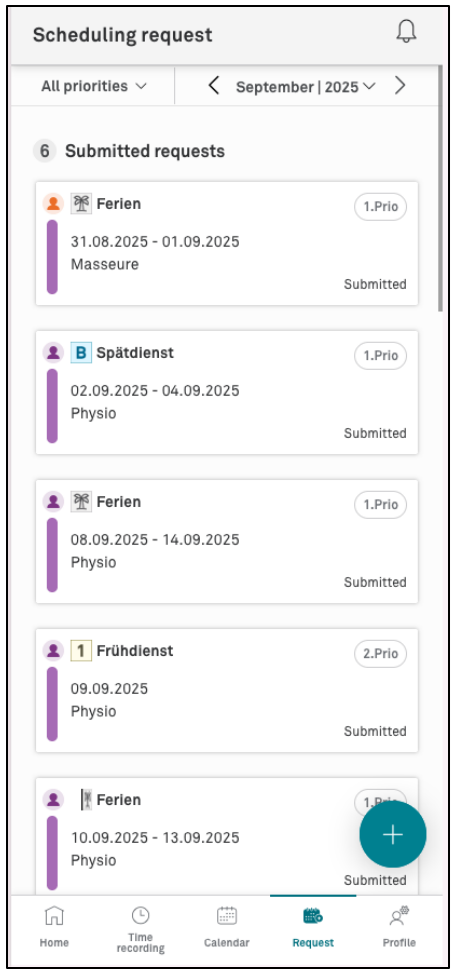
Employee Participation



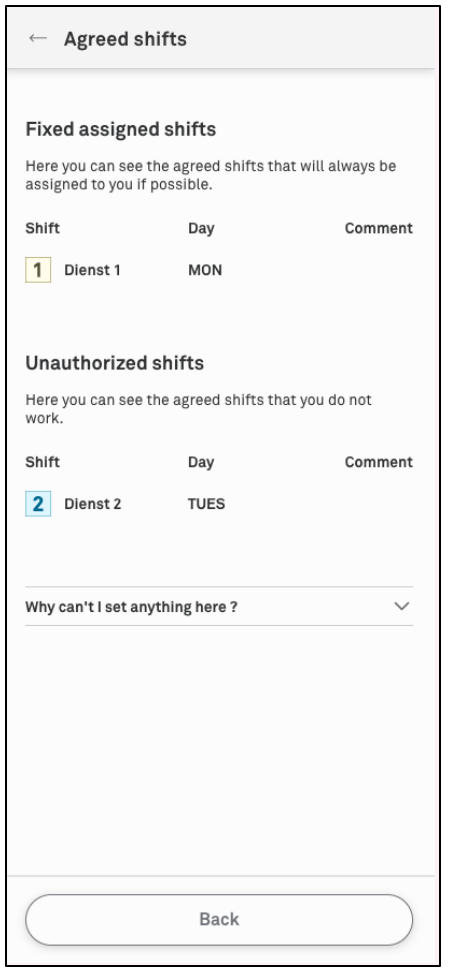




Preferences

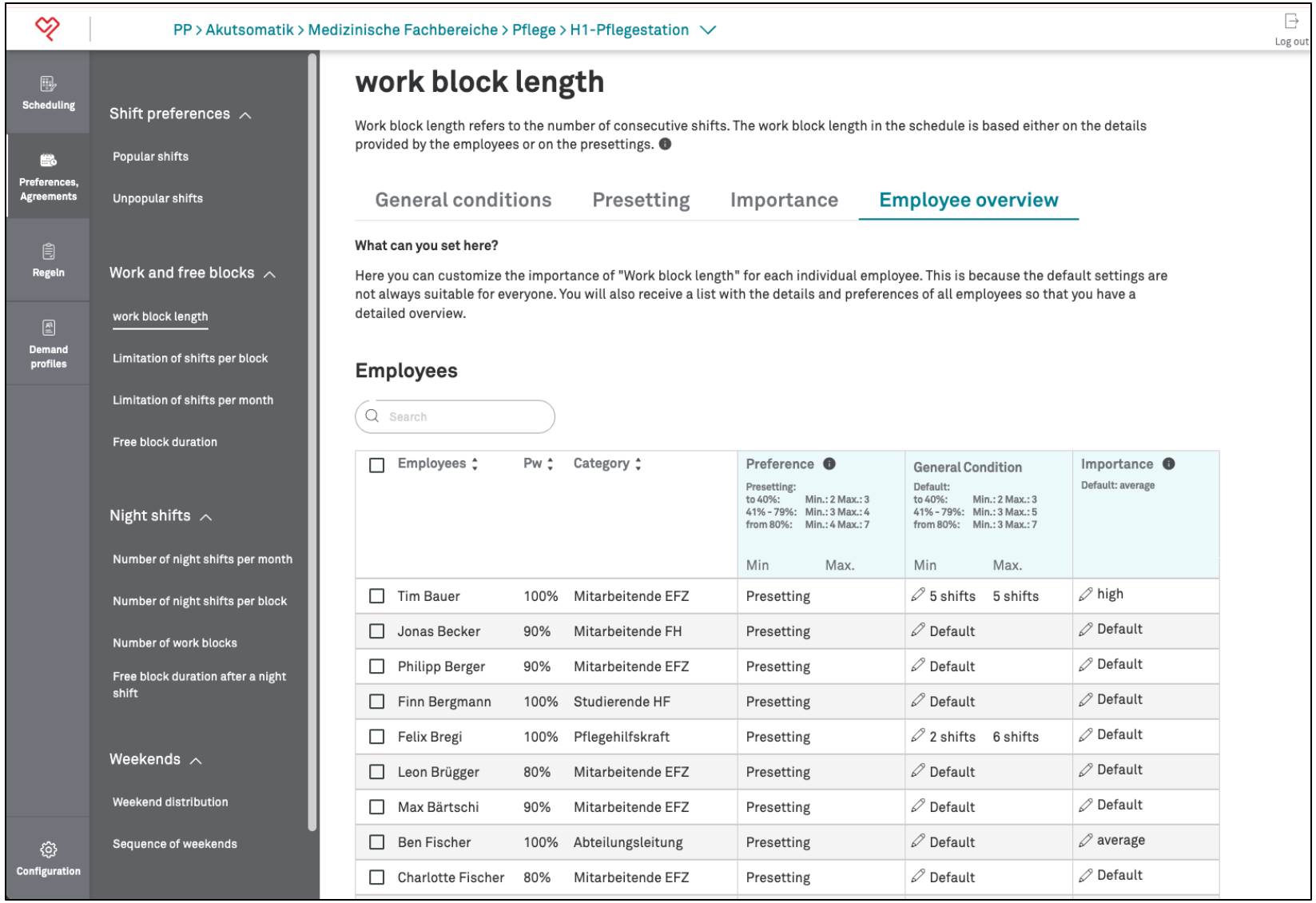


Monthly wishes



Agreements
(view-only)

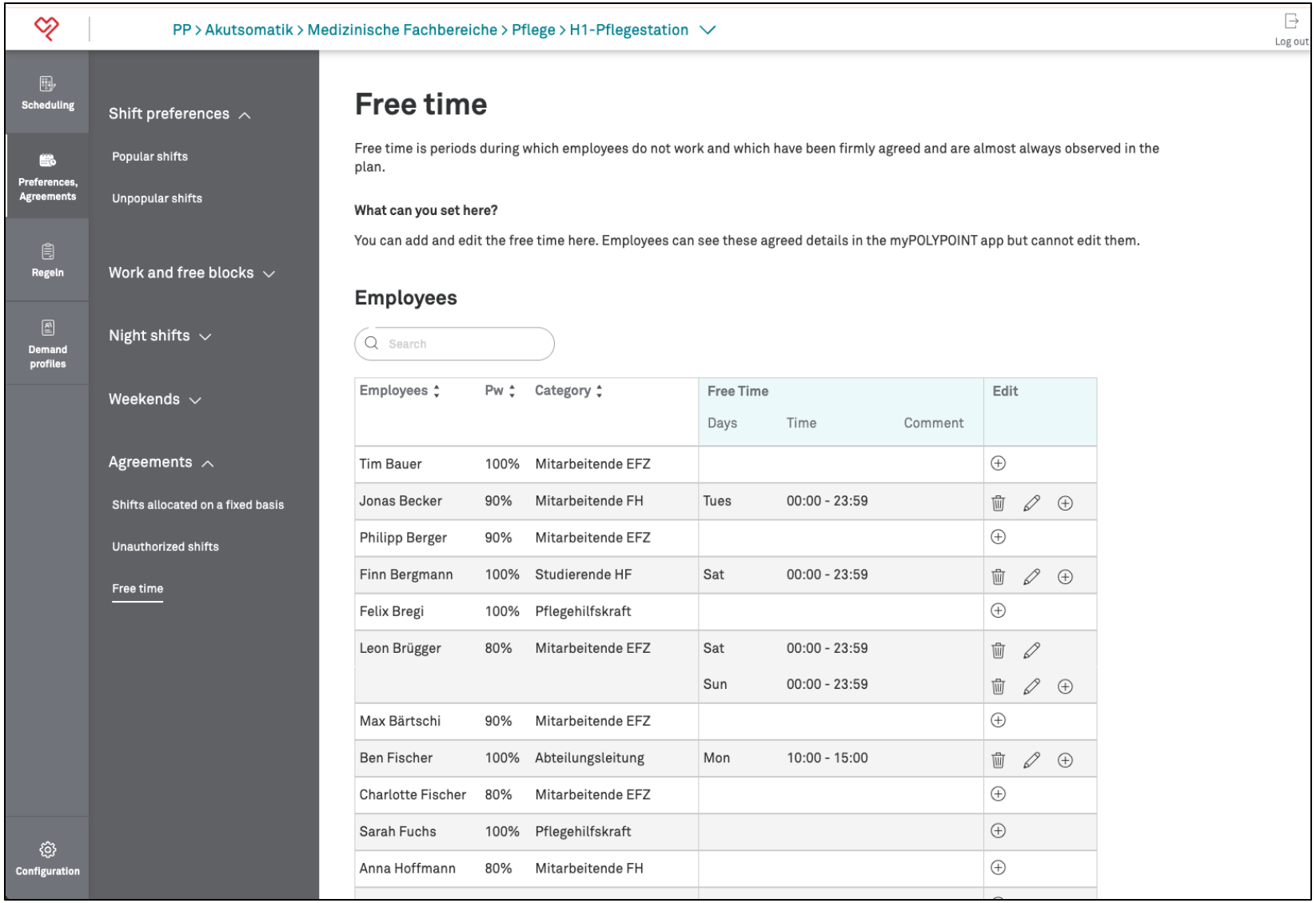
Shift Planner Participation



Refined employee preferences

(general conditions, default values, importance)

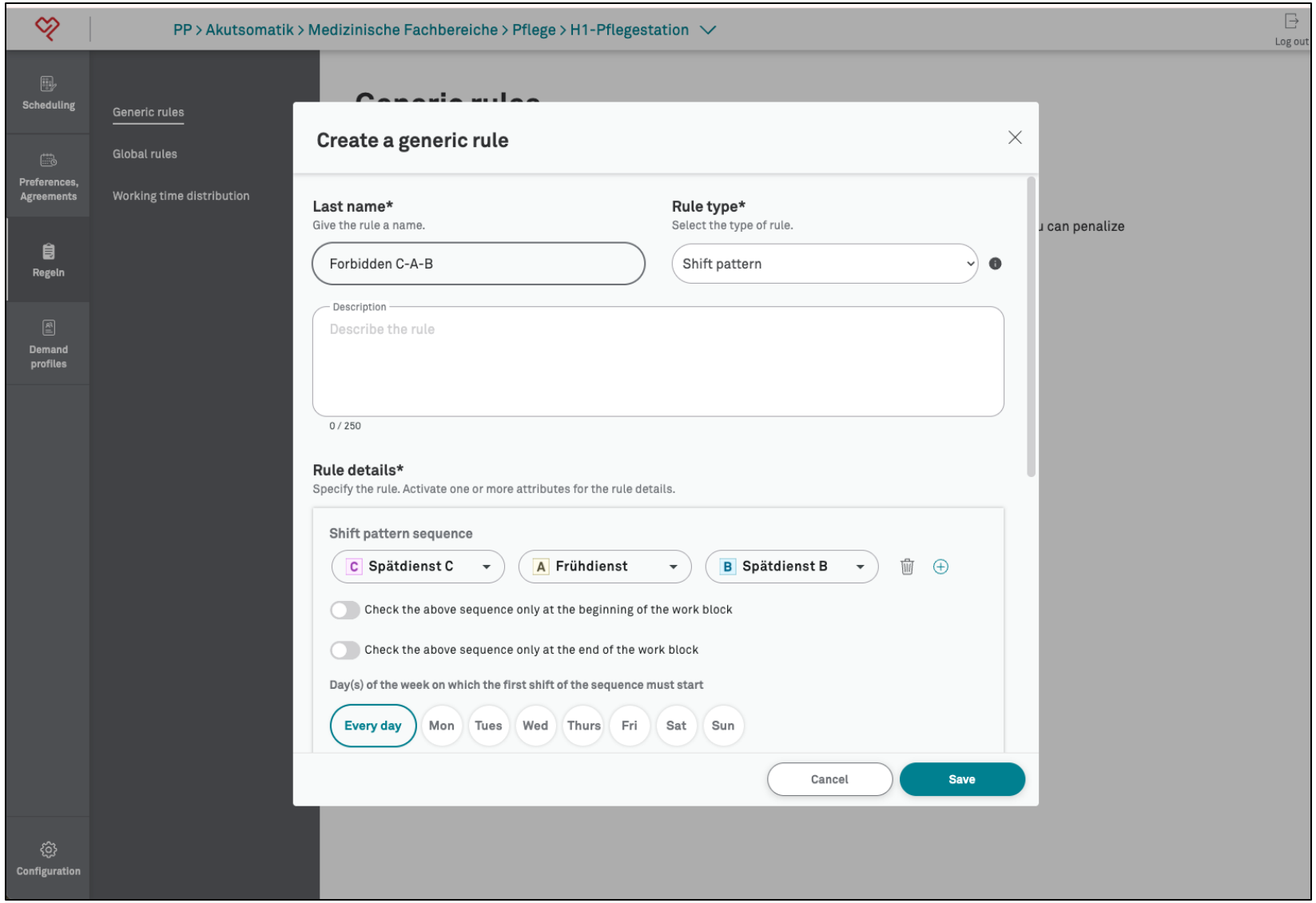
Shift Planner Participation



Shift agreements

(days-off, forbidden shifts, fixed shifts)

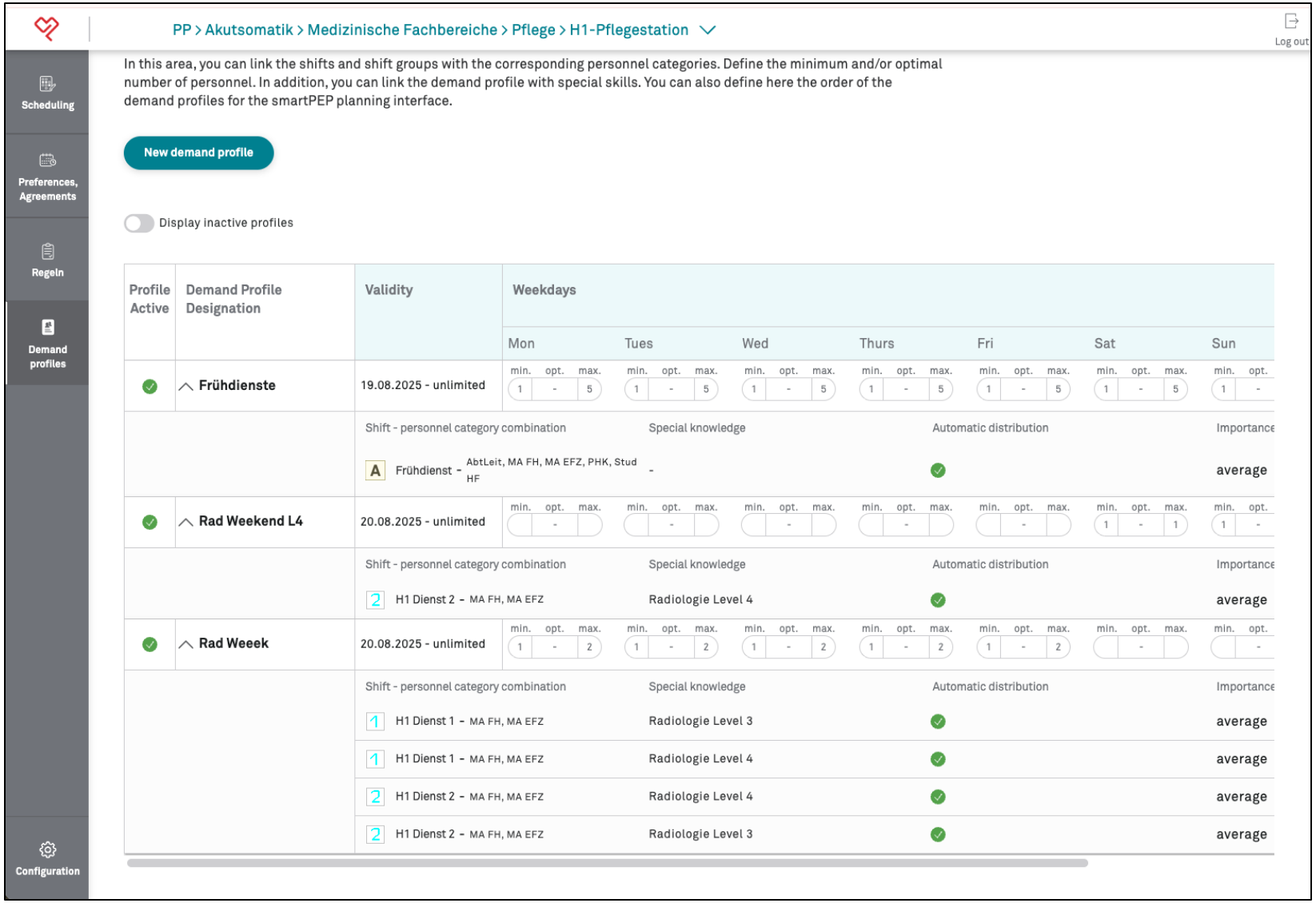
Shift Planner Participation



Additional preferences and constraints

(weekends, nights, monthly shift limits, more complex rules)

Shift Planner Participation



Employee demands

(combination of shifts, qualifications, skills)

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Interactive Planning Board

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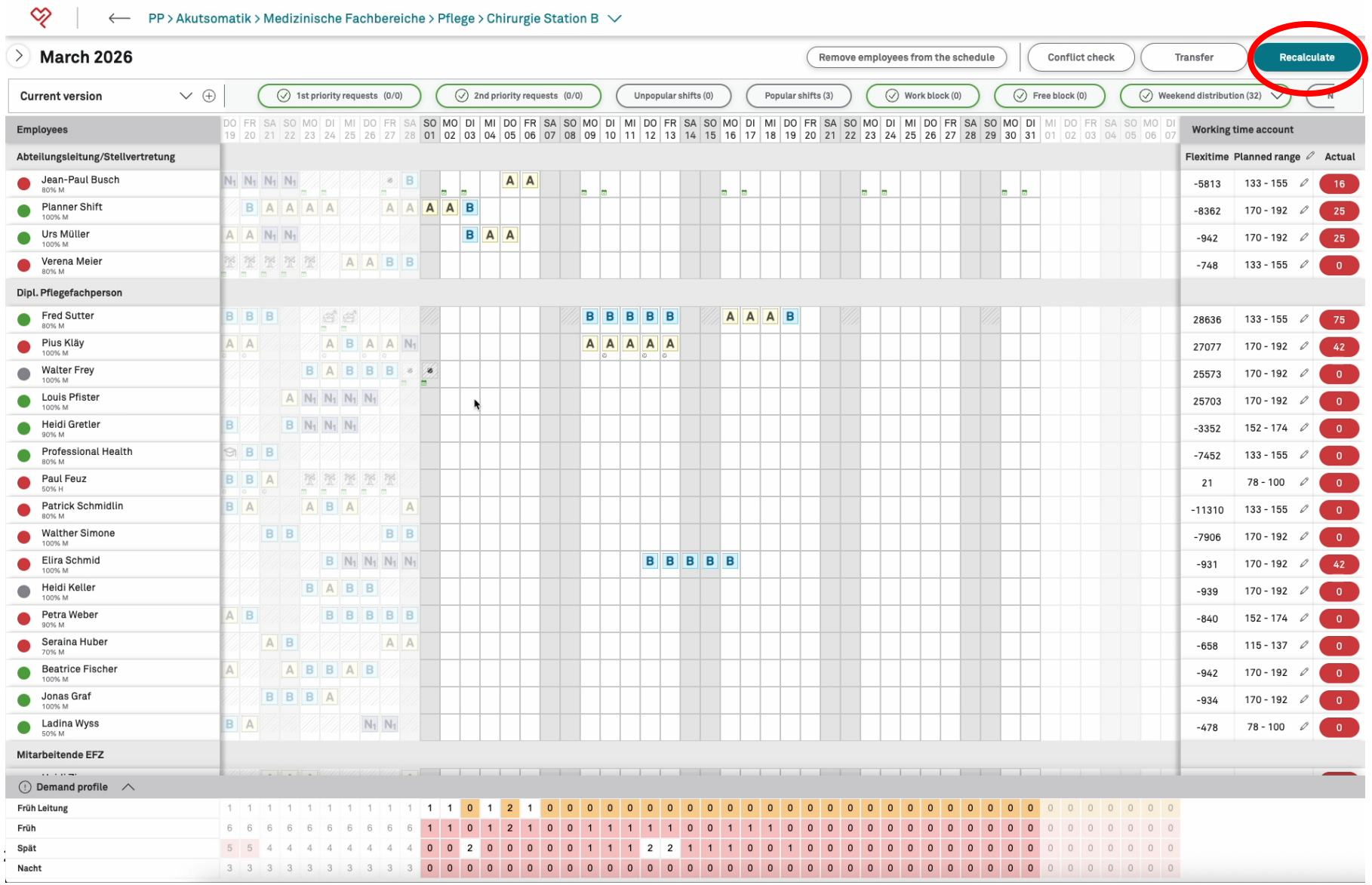

„What-if“ model for manual planning

Mathematical Optimization

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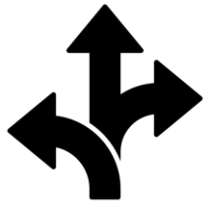
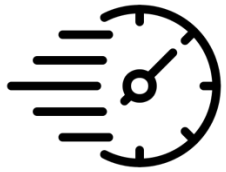
Some requirements



Flexibility: Easy to integrate new requirements



Speed: Fast but not instantly - max. one hour comp. time

Consistency: always high-quality solutions

Optimization Methods

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State-of-the-art (closely related problems)

- Constraint programming
- Multi-stage, problem-tailored combinatorial heuristics
- Extended formulations (exact / heuristic column generation)
- No “simple” compact mathematical program

Our method

- Observation: most complex rules within work block
- *Phase 1*: Work block generation
- *Phase 2*: Integer programming
- Like decomposition proposed by Brucker et al. in 2010

Two-Phase Heuristic

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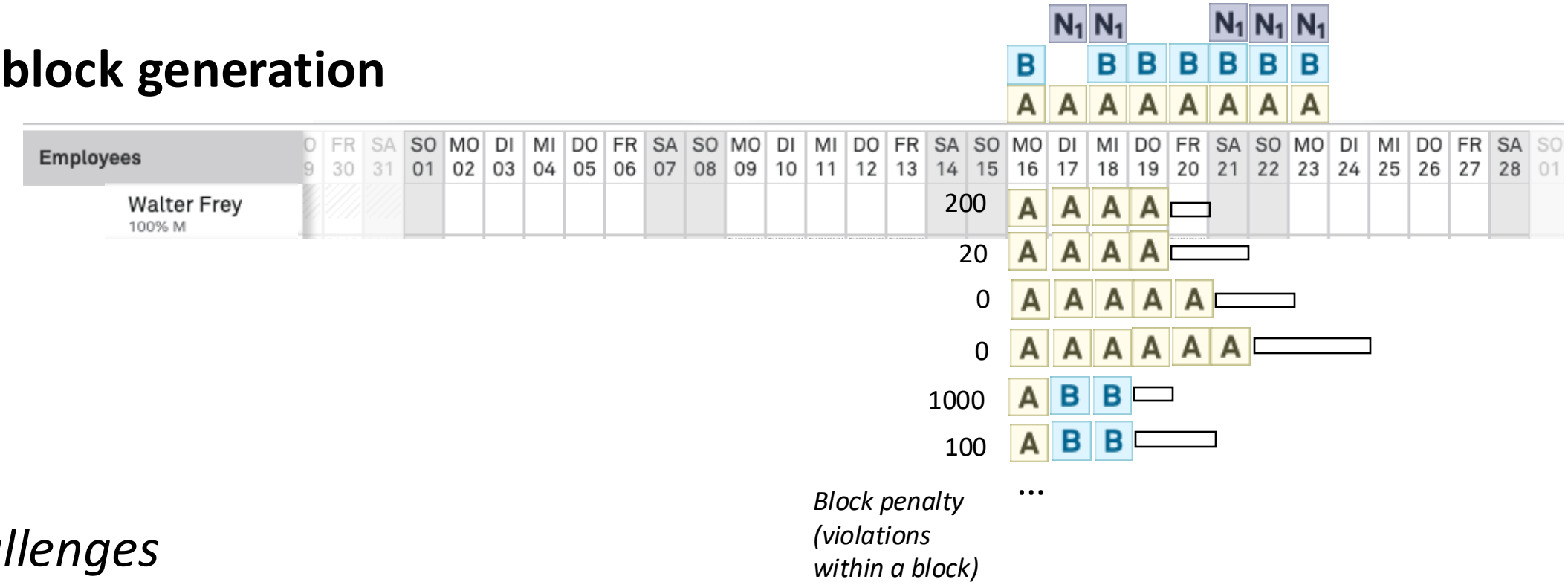
1 - Work block generation



Block penalty (violations within a block)

Main challenges

- Speed (must be fast)
- Filtering (typically, too many work blocks for the solver)

Two-Phase Heuristic

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2 – Integer programming

- Integer program based on work block variables:
  - Many variables (up to 800‘000) but „few“ constraints (~ 5‘000)
  - No single work block-related constraints
- Hard constraint: non-overlapping work blocks
- Soft constraints for (almost all) violations
- Convex (pwl) cost structures for some violations (e.g. demand)

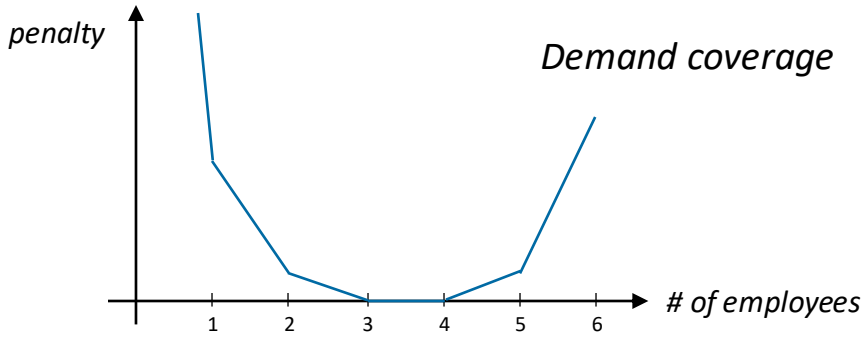
$$\text{Minimize} \quad \sum_{A \in \mathcal{F}} c_A x_A + \sum_{d \in D} f_d^{\text{cov}}(y_d)$$

subject to

$$\sum_{A \in \mathcal{F}} h_{A,d} x_A = y_d \qquad \text{for all } d \in D,$$

$$\sum_{A \in \mathcal{F}_e} x_A = 1 \qquad \text{for all } e \in E,$$

$$x_A \in \{0,1\} \qquad \text{for all } A \in \mathcal{F},$$



Some Challenges

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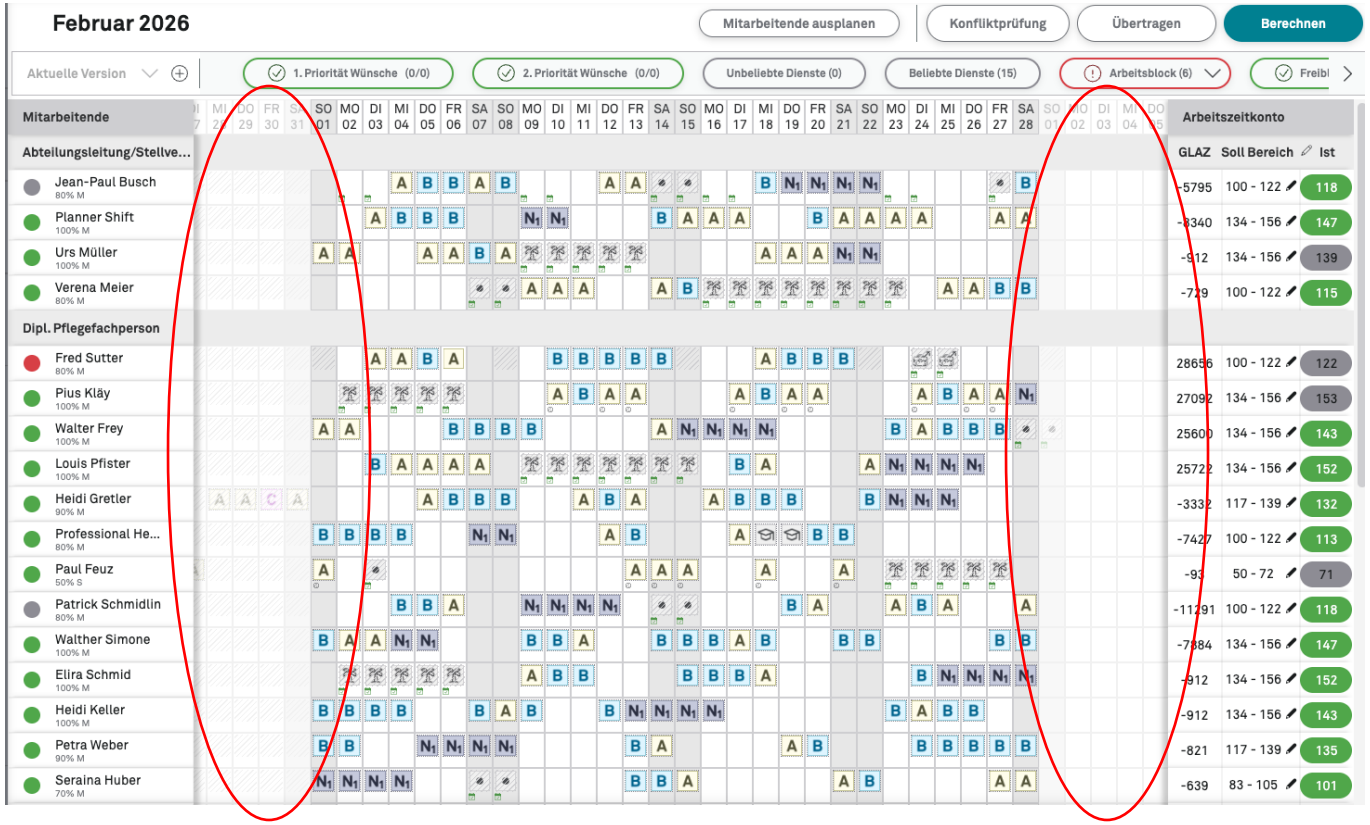
Dynamic planning horizon

- Past and present link
- Impact on future
- Strategic look-ahead



Solution quality

- Weakly-coupled phases, no global optimality
- Local optimality of solutions not guaranteed (due to early stop + filtering)

Some Challenges

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Fairness

- Generally difficult with multiple facets, such as:
  - Procedural: voice requests and preferences
  - Distributive: Balance needs and preferences among employees
  - Informational: provide explanations
  - Interpersonal: voice concerns to supervisors

- Two fairness aspects in our mathematical model
  - Wish fulfillment with concave bonus function (1st wish more important than 2nd)
  - Fair distribution of (unpopular) shifts, weekends and holidays

- On-going collaboration with University of Berne (Algorithmic Fairness in Shift Scheduling)

Customer Feedback

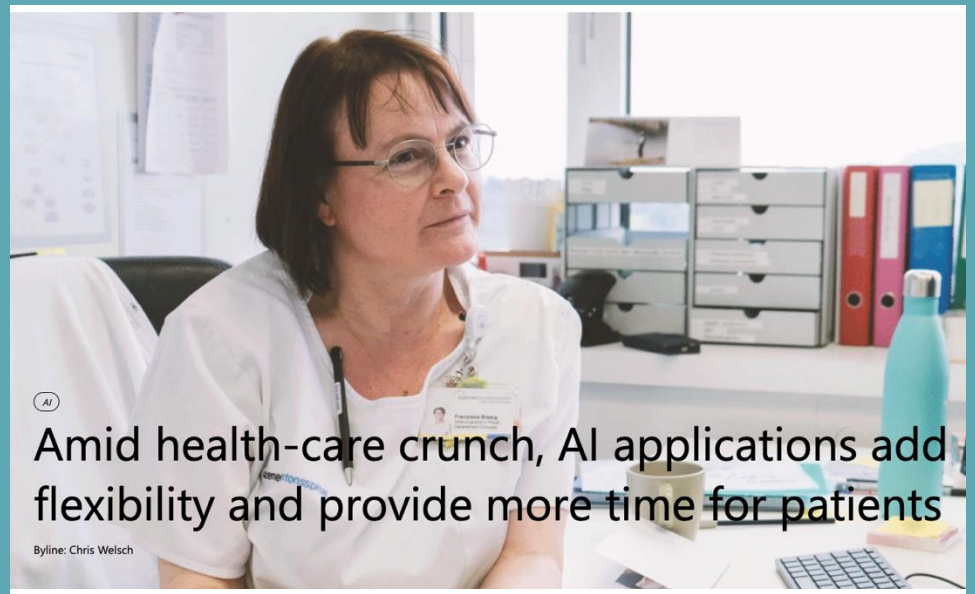
Michael Döring-Wermelinger • 2.
CNO LUKS Gruppe bei Luzerner Kantonsspital
1 Woche •

...

Inzwischen ist der Pilot erfolgreich abgeschlossen. Mehrere Pläne wurden realisiert und wurden genutzt. Das Team ist mit der Qualität zufrieden, die Umplanungswünsche haben abgenommen. Der Zeitaufwand für die Planerin hat sich bereits jetzt um 2/3 reduziert. Aufgrund des Erfolgs hat das Pflegeteam

...

Meanwhile, the pilot has been successfully completed. Several plans have been realized and used. The team is satisfied with the quality; the requests for replanning have decreased. The time required for the planner has already been reduced by 2/3. Due to the success, the care team...



https://news.microsoft.com/source/emea/features/amid-health-care-crunch-ai-applications-add-flexibility-and-provide-more-time-for-patients/

Some Reflections

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01 Address decision-problems with a significant impact

02 Solve the right problem

03 Combine automatic with manual planning

04 Flexible optimization method

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OPTIMIZATION