Optimal resource scheduling for sample processing in centralized Biomaterial Banks

11. National Biobanking Symposium
Berlin, 26.05.2023

Julian Dörenberg[1], Daniel Martin[2], Tassilo Jehn[2], Friederike Schwager[2], Till Schmidt[2], Johannes Scheiermann[2], Torben Zeller[2], Edgar Dahl[1], Alexander Helber[3] und Marco Lübbecke[3]
[1] RWTH centralized Biomaterialbank, University Hospital Aachen
[2] RWTH Aachen University
[3] Chair of Operations Research, RWTH Aachen University

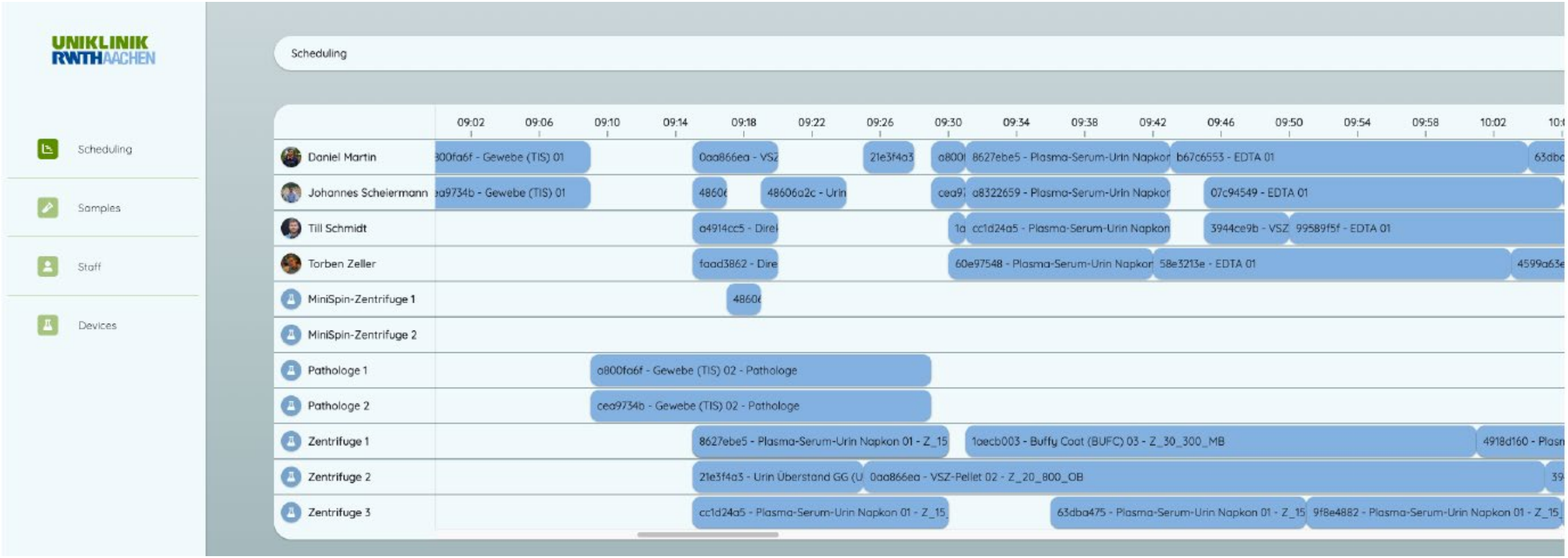
Outline

- Motivation and problem statement – How can mathematical optimisation help in Biobanking?
- Assumptions – E.g. how does the Computer handle part-time employees?
- Limitations – Runtime and why pathologists are not centrifuges
- Use Cases – Shift planning etc.
- (References)

Motivation and problem statement (I)

- Requirements to biobanks are increasing while (financial) resources are mostly stable
- Resource distribution differs e.g. when part-time employees are involved
- High sample processing times affect sample quality
- Different SOPs can apply to the same sample type – e.g. for NAPKON
- **Finding an optimal schedule in the lab is too complex for a human!**

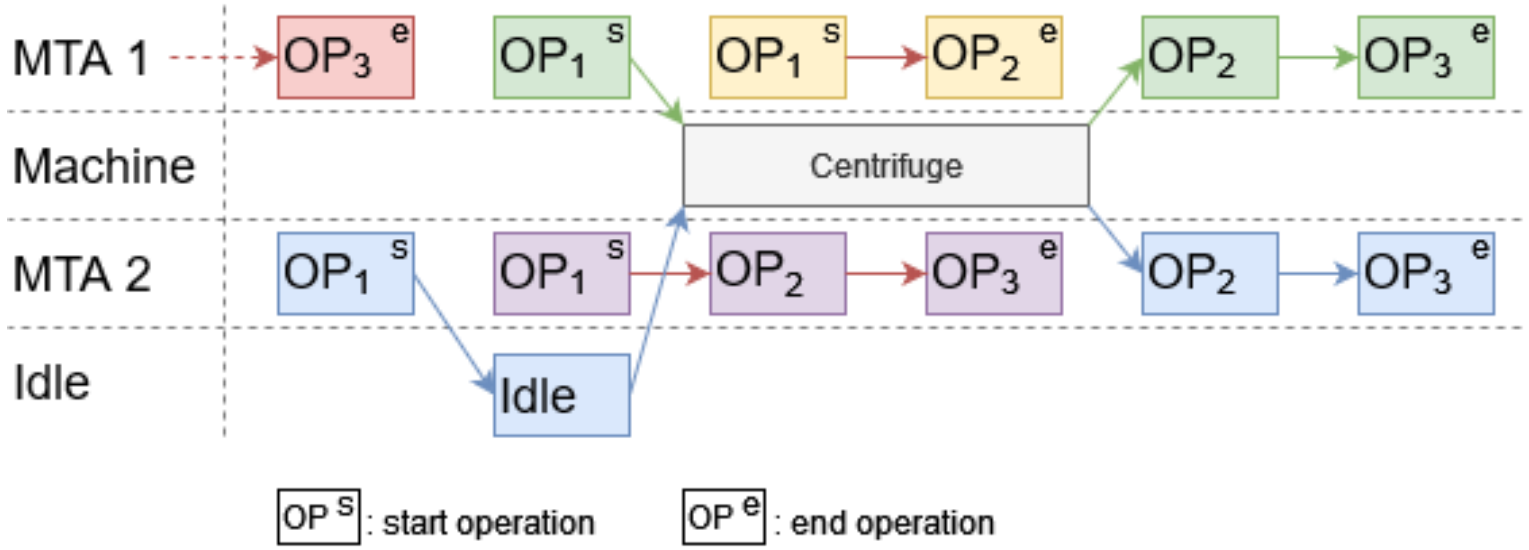
Motivation and problem statement (II)



How does mathematical optimisation help here?

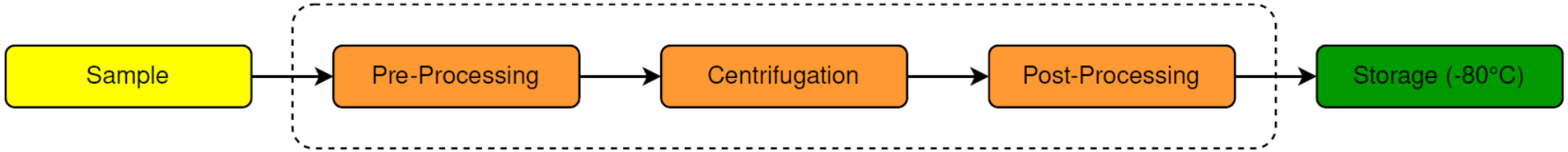
- Mathematical optimisation works as follows:
  - An abstract model - created based upon different assumptions – implicitly represents all possible resource plans
  - A specific instance of the model is created – e.g. “exactly two MTAs” instead of “a number of MTAs to-be-defined”
  - A so-called solver is used to compute the optimal resource plan(s) from the specific instance

- Our work: Focus on the model! [1, 2]



Assumptions and constraints

- Each day is self-contained: Sample processing is started and finished at the same day



- An infinite amount of pathologists is available 24/7
- Pathologists do not need support by an MTA
- Working time of pathologists is constant

- Certain constraints during sample processing have to be met
  - All steps according to the SOP are executed and in the right order
  - Each MTA performs only one step at a time
  - Capacities of laboratory equipment – e.g. centrifuges – are respected

Limitations (for now)

- Runtime is quite high (at the moment), hence using the tool to generate “live To-Do lists” for the MTAs is hard

- Pathologists are not centrifuges and are not available 24/7
  - Integration into pathology resource planning is required, this leads to further external influences to be considered in more detail (e.g. surgery planning)

- Pathologists time to extract sample is constant

- Differences in employees are not considered
  - Training of new employees is not considered
  - Different execution times for the same steps
  - Familiarisation with changes in SOPs – e.g. after parental time

- MTAs might need different time for the same tasks due to a lack of routine

Use cases

- Macroscopic staff planning: Delivers (mathematically irrefutable!) arguments for increasing the budget to hire additional staff
- Microscopic staff planning: When do I need how many (which) MTAs? Can I free up an MTA for a training? How to shift the MTAs if one is on vacation?
- Load prediction: Can we handle the newly upcoming project with the current shift planning?
- Identify bottlenecks in the lab – e.g. does lack of centrifuges cost more time than lack of pipettes? What happens if I buy an additional centrifuge?
- Consideration when generating a price model
- Further use cases will be investigated as soon as the runtime has been reduced

References

[1] Lancia, G., Rinaldi, F. & Serafini, P. (2011). *A time-indexed LP-based approach for min-sum job-shop problems*. Ann Oper Res 186, S. 175–198.

[2] J.M.Valério de Carvalho, (1998) *Exact solution of cutting stock problems using column generation and branch-and-bound.* 14th Triennial Conference of Operational Research Societies S. 35-44, Vancouver