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# CLUSTERING CLINICAL DEPARTMENTS FOR WARDS TO ACHIEVE A PRE-SPECIFIED BLOCKING PROBABILITY

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# PROBLEM STATEMENT

- Number of beds in HagaZiekenhuis is reduced by insurance companies.
- Possible solutions:
  - Reduce number of admissions
  - Reduce LOS
  - Level the bed usage by e.g. adapting the OR-schedule
  - Use the available beds in a different way

# PROBLEM STATEMENT

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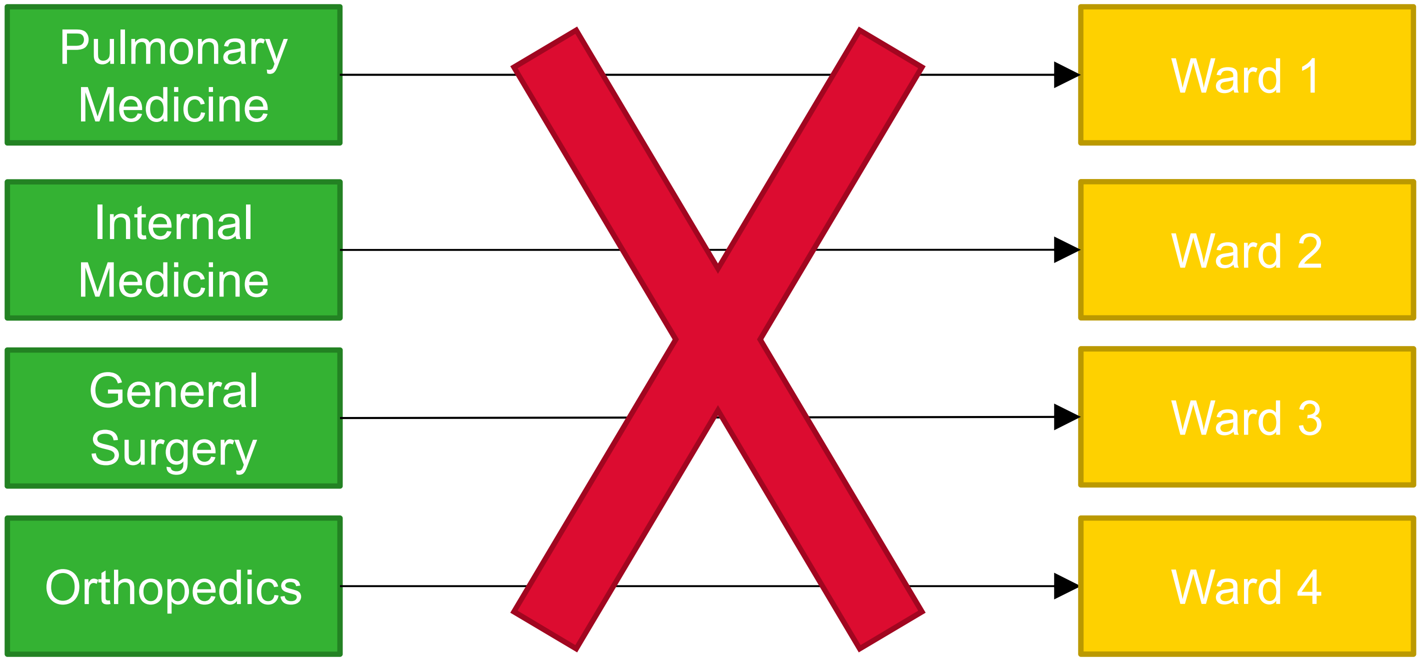

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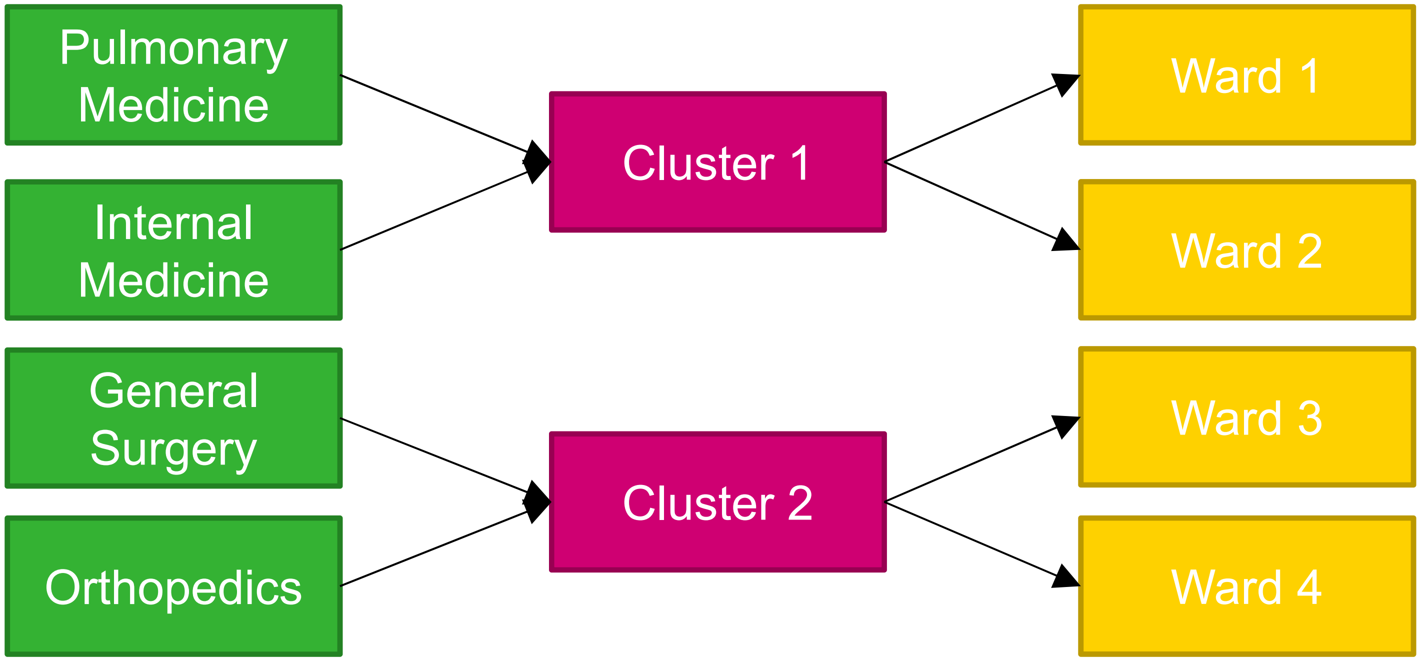

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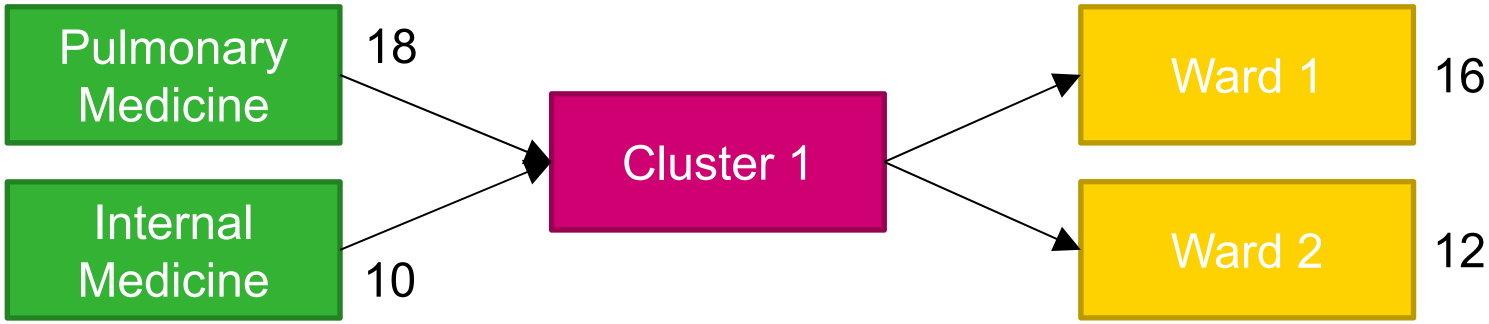


# DETERMINING NUMBER OF BEDS NEEDED FOR A CLUSTER

- The number of beds needed is determined by the Erlang loss formula:

$$\min x$$

$$\frac{(\lambda\mu)^x / x!}{\sum_{k=0}^{x} (\lambda\mu)^k / k!} \leq \rho$$

$\lambda =$ expected number admissions per day

$\mu =$ average LOS

$x =$ number of beds

$\rho =$ predefined blocking probability

# DETERMINING NUMBER OF BEDS NEEDED

EXAMPLE

- Clinical department 1: $\mu_1 = 7.1$, $\lambda_1 = 9$ and $\rho = 0.05 \rightarrow 70$ beds
- Clinical department 2: $\mu_2 = 6.6$, $\lambda_2 = 3$ and $\rho = 0.05 \rightarrow 25$ beds
- Clustered: $\frac{\mu_1\lambda_1+\mu_2\lambda_2}{\lambda_1+\lambda_2} = 6.975$, $\lambda_1 + \lambda_2 = 12$ and $\rho = 0.05 \rightarrow 89$ beds

# PROBLEM STATEMENT

- Which clinical departments should be clustered?
- How to assign the clusters to the available wards?

→ 2-phase problem

# CONSTRAINTS

- Assign each clinical department to exactly one cluster.
- Not all clinical department pairs can be clustered due to medical reasons.
- At most one cluster can be assigned to each ward.
- The number of beds on the assigned wards must be sufficient to guarantee the prespecified blocking probability.

# OBJECTIVE FUNCTION

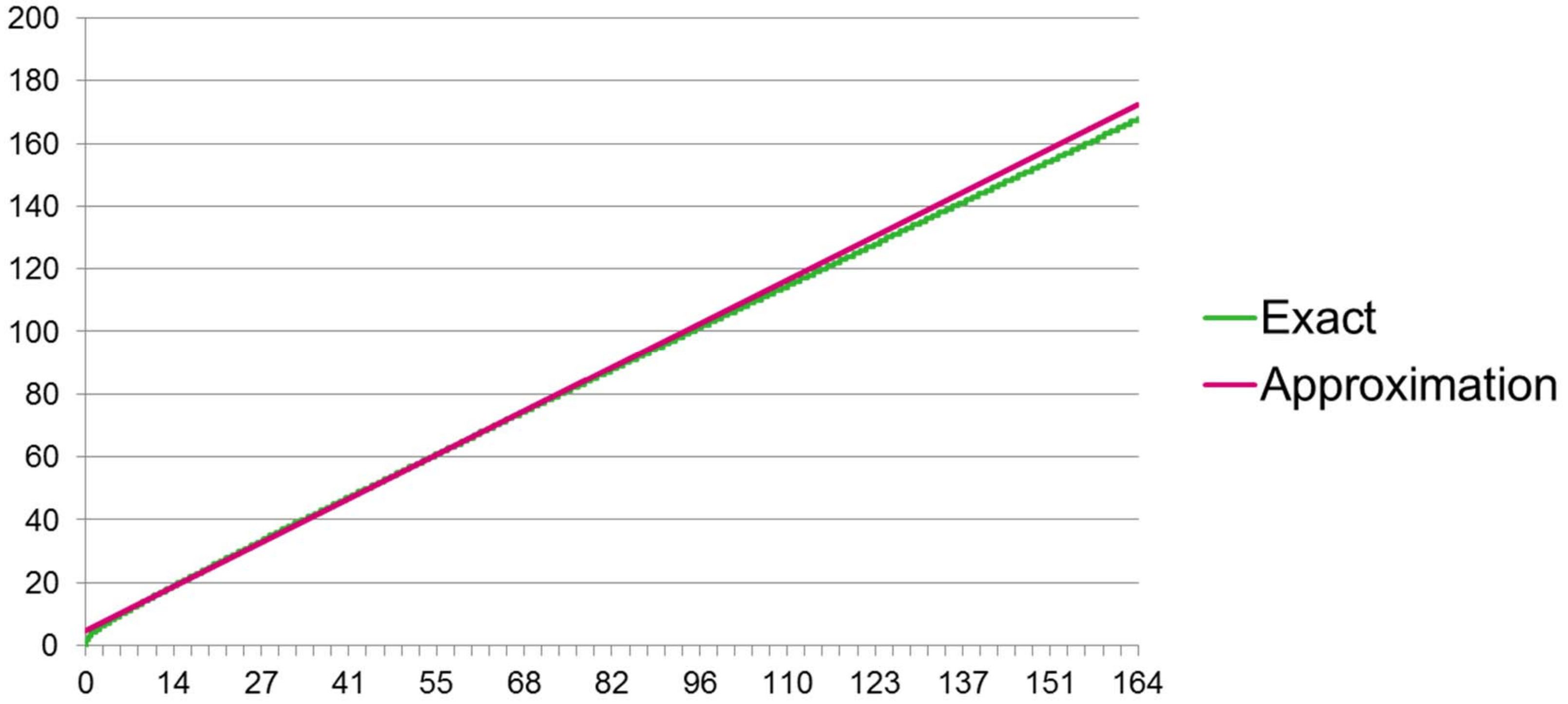
- Minimize number of clinical departments assigned to one cluster
- Minimize distance between wards assigned to a cluster
- Maximize the preferences of a clinical department for certain wards

# SOLUTION METHODS

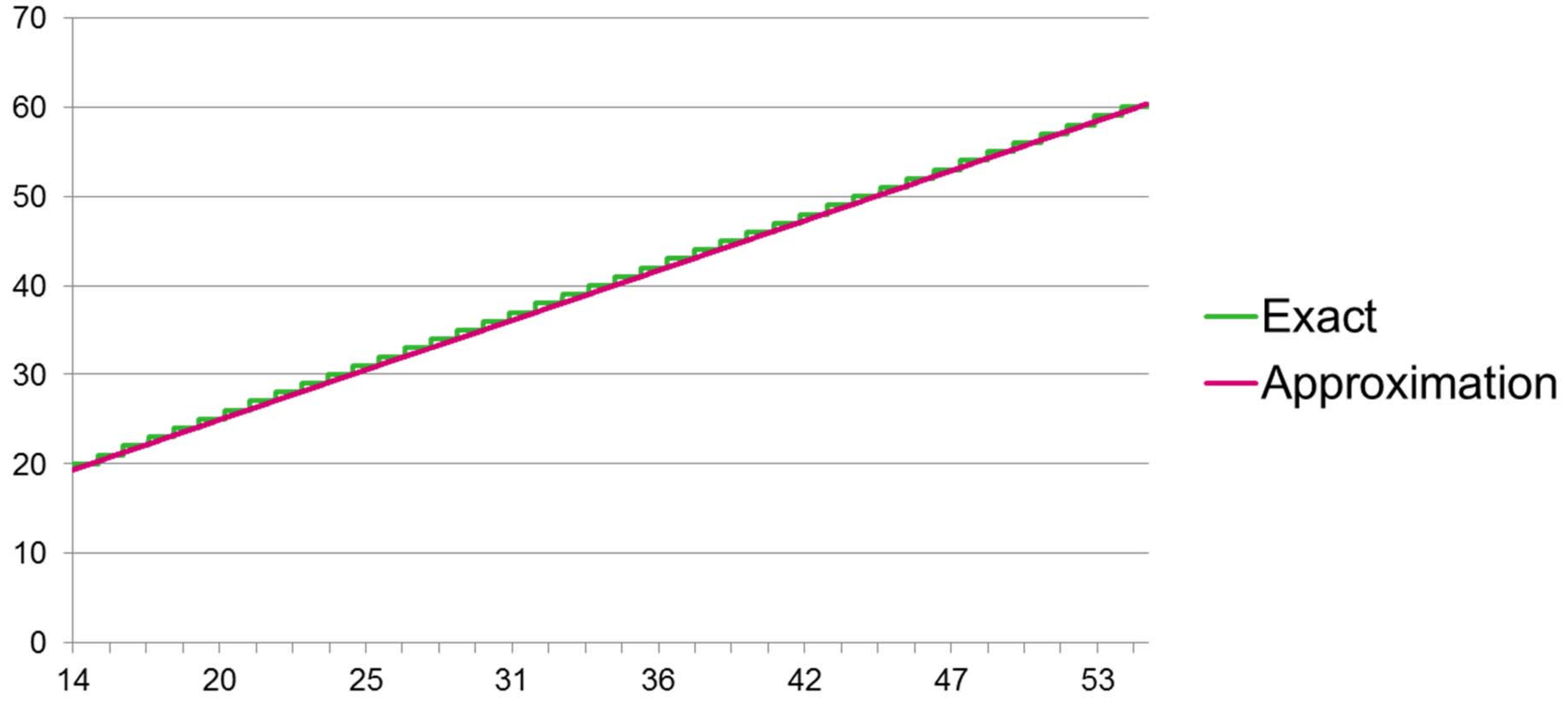
- Exact solution method → ILP
  - Problem 1: linearize number of beds needed for a cluster
  - Problem 2: quadratic term in objective function
- Approximation solution method → ILP with approximation number of beds
- Hybrid heuristic → Combine local search with ILP

# SOLUTION METHODS

## APPROXIMATION SOLUTION METHOD



# SOLUTION METHODS
## APPROXIMATION SOLUTION METHOD



# HYBRID HEURISTIC

- Based on column generation
- As columns we consider formed clusters

  → Building blocks of solutions of the ‘first phase’
- ILP selects a good combination of clusters and assigns them to wards

  → Solve ‘second phase’

- Use local search to select subset of generated clusters

# HYBRID HEURISTIC

1. Generate the set (a subset) of possible clusters
2. Solve ILP with an initial subset of these clusters
3. Solve ILP with a new subset of clusters that includes the clusters selected in the optimal solution of the previous iteration
4. Repeat step 3 until no improvement is made in $N$ iterations

# HYBRID HEURISTIC

- In the first iteration, a feasible solution is not guaranteed. Thus, the step is repeated until a feasible solution is found.
- In the next iterations, a feasible solution is guaranteed because the solution of the previous iteration is included.
- The obtained objective function values form a non-decreasing sequence, thus, this hybrid heuristic converges to a local optimum.

# COMPUTATION RESULTS

- Exact solution method → unpredictable and long solution time
- Approximation solution method → problems with overestimation number of beds needed
- Hybrid heuristic → good solutions to original problem in short time

# COMPUTATION RESULTS

- 16 clinical dep.
- 13 wards
- 378 beds

| | A | B |
|---|---|---|
| 11 | 28 | 32 |
| 10 | 32 | 32 |
| 9 | | 32 |
| 8 | | |
| 7 | 32 | 32 |
| 6 | 32 | 32 |
| 5 | 32 | 30 |
| 4 | 8 | 24 |

- Needed beds without clustering ($\rho$ = 0.05): 365
- Needed beds with maximal clustering ($\rho$ = 0.05): 321

# COMPUTATION RESULTS

| | A | B |
|---|---|---|
| 11 | NEU – ORA – OTO – PLA – URO | NEU – ORA – OTO – PLA – URO |
| 10 | GEN – GYN – OPH – ORT | GEN – GYN – OPH – ORT |
| 9 | | GEN – GYN – OPH – ORT |
| 8 | | |
| 7 | GAS – GER – PUL | GAS – GER – PUL |
| 6 | DER – INT – RHE | DER – INT – RHE |
| 5 | CAR | CAR |
| 4 | CAR | DER – INT – RHE |

- 5 clusters
- at most 5 clinical dep. per cluster
- needed beds: 335

# FURTHER RESEARCH

- $\mu$ and $\lambda$ are quite uncertain and may change over the years
- Develop robust solution methods to deal with these changes

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# THANK YOU FOR YOUR ATTENTION

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