



University of Twente

O.R. based process optimization at Erasmus MC

Erwin Hans

Assistant professor Operational Methods
for Production and Logistics



University of Twente
The Netherlands



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Co-authors

Erasmus MC:

- **Mark van Houdenhoven**
division manager OR, ICU and Anesthesiology
- **Gerhard Wullink**
researcher, logistics advisor
- **Geert Kazemier**
head of OR department, surgeon



University of Twente:

- **Johann Hurink**





Presentation outline

- Overview of operating room (OR) related studies:
 - Project 1: Master surgical scheduling
 - Project 2: Robust optimization of the OR schedule to deal with emergency surgery
 - Project 3: “Safely through the night”: personnel rostering
 - Project 4: “Focused factory OR?” A simulation study
- Challenges for the future
 - Trends
 - Important issues



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Project 1:

Master surgical scheduling (MSS)

Jeroen van Oostrum (UT, EMC)



Master surgical scheduling

Motivation of research:

- OR-scheduling is time-consuming, and repetitive
Many elective surgery types are recurring
ErasmusMC: week: 30%, 2 weeks: 45%, 4 weeks: 55%
- Coordination problems between OR and subsequent departments lead to surgery cancellations
 - E.g., due to IC-bed unavailability
- Robust optimization using mathematical techniques:
 - Leads to “nervous schedules”
 - May interfere with autonomy of medical specialists
 - Hard to implement



Master surgical scheduling: idea

Idea: design a cyclic schedule of surgery types that:

- covers all frequent elective surgery types
- levels the workload of the specialties
- levels the workload of subsequent departments (ICU, wards)
- is robust against uncertainty
- improves OR-utilization
- maintains autonomy of clinicians

Assign patients to the “slots” in the schedule

MSS: problem description

Goal:

- Maximize the OR-utilization
- Level capacity usage of subsequent resources (ICU)

Constraints:

- OR-capacity constraints (probabilistic)
- All surgery types must be planned i.c.w. their frequency

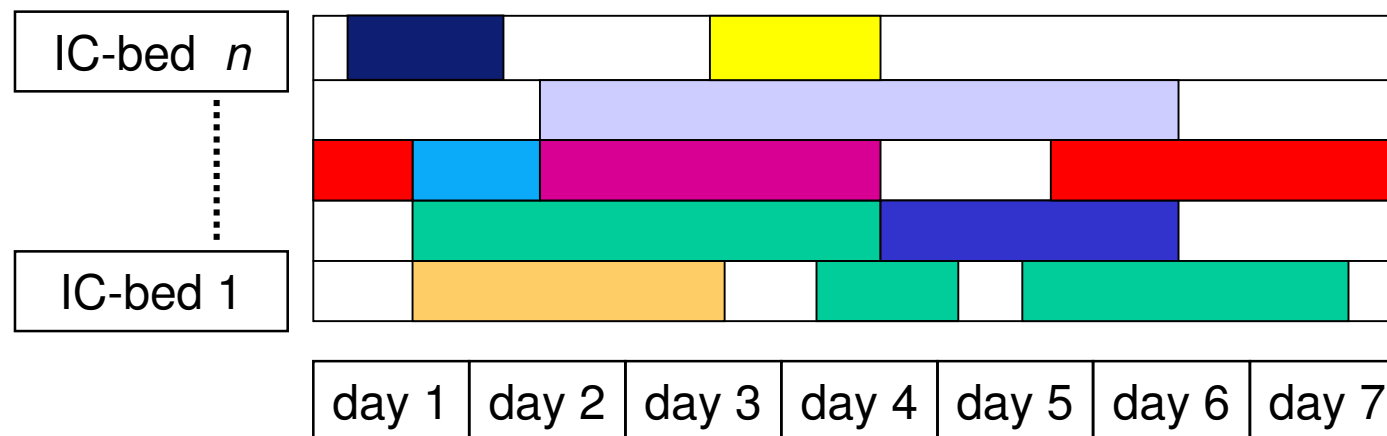
To determine:

- A list of surgery types for every OR-day (= “OR-day schedule”)
- Length of the planning cycle

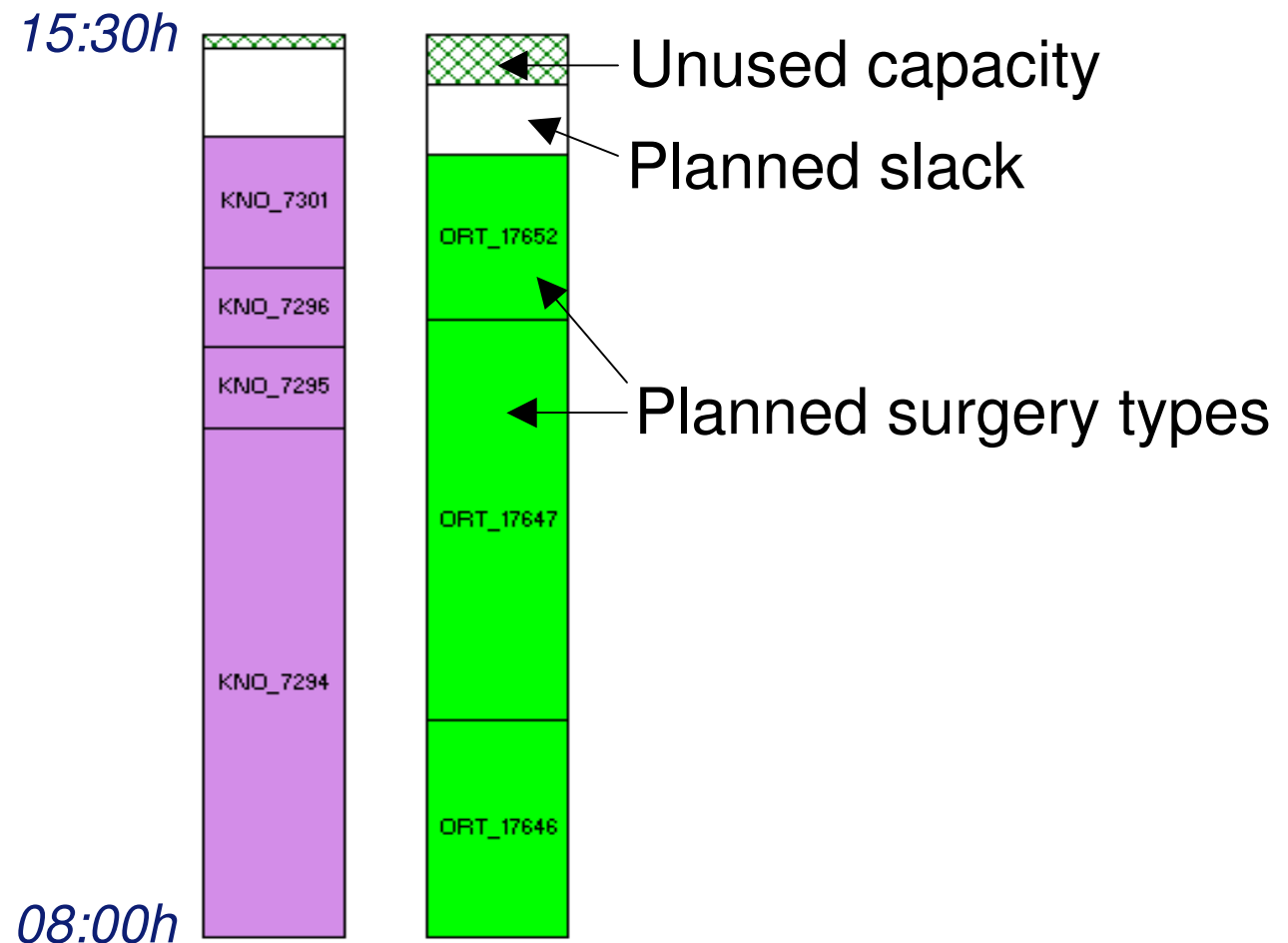


Leveling of OR-related (IC-)bed usage

Visualization of (IC-)bed usage after elective surgery



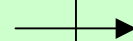
OR-day schedule example



Master surgical scheduling: approach

PHASE 1:
Generation of
“OR-day schedules”

Goal: capacity utilization



ILP, solved by column generation
and then rounding

Constraints:

- All surgeries must be planned
- OR-capacity (probabilistic)

PHASE 2:
Assignment of
“OR-day schedules”

Goal: bed usage leveling



ILP, solved using CPLEX in
AIMMS modeling language



MSS test approach

1. Statistical analysis of surgery frequencies
2. Select a cycle length (1, 2, or 4 weeks)
3. Construct an MSS (2-phase approach)

Tools: AIMMS modeling language with integrated CPLEX solver

4. Discrete event simulation (in: eM-plant)

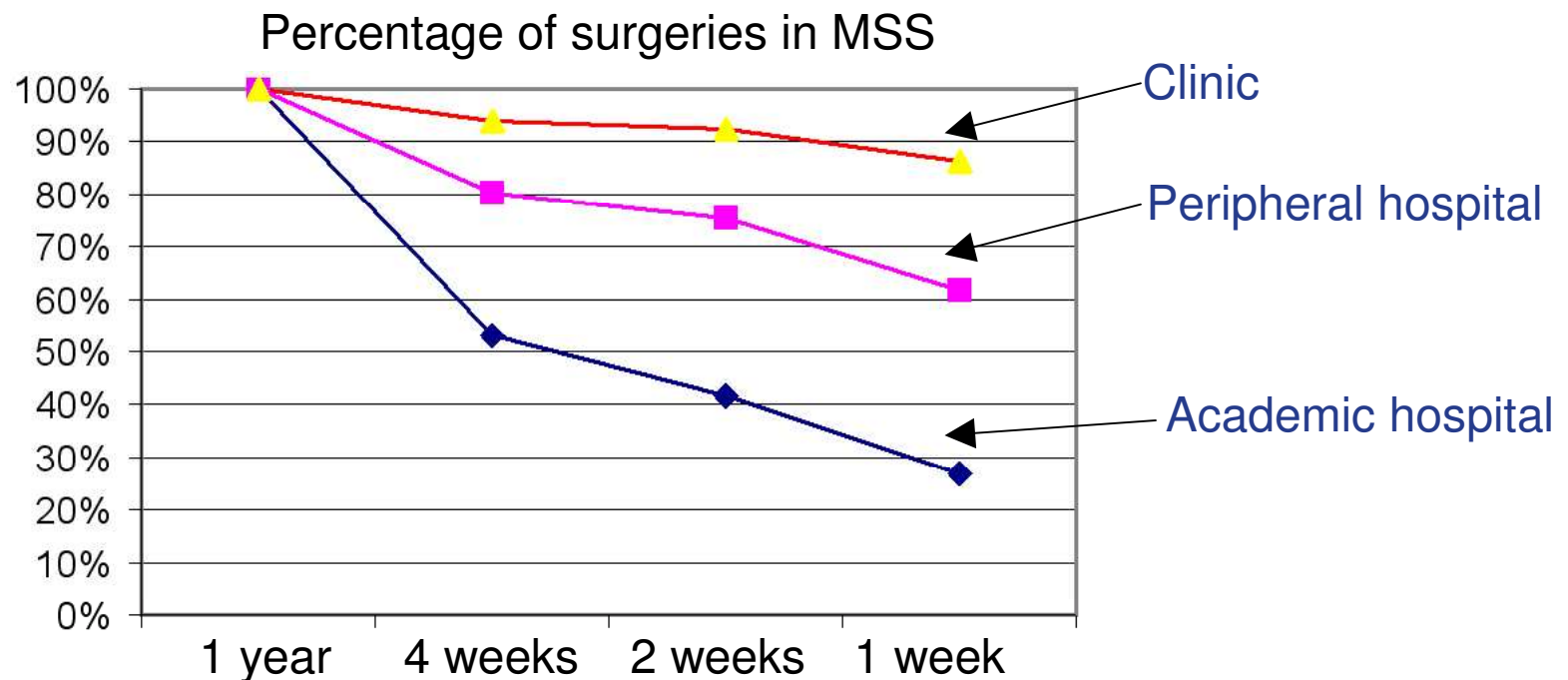
Schedule rare elective procedures in reserved capacity

Admission of emergency surgeries (add-on and online planning)

Data: historical data from 3 types of hospitals; **academic hospital**, **peripheral hospital**, and **clinic**

Master surgical scheduling: results

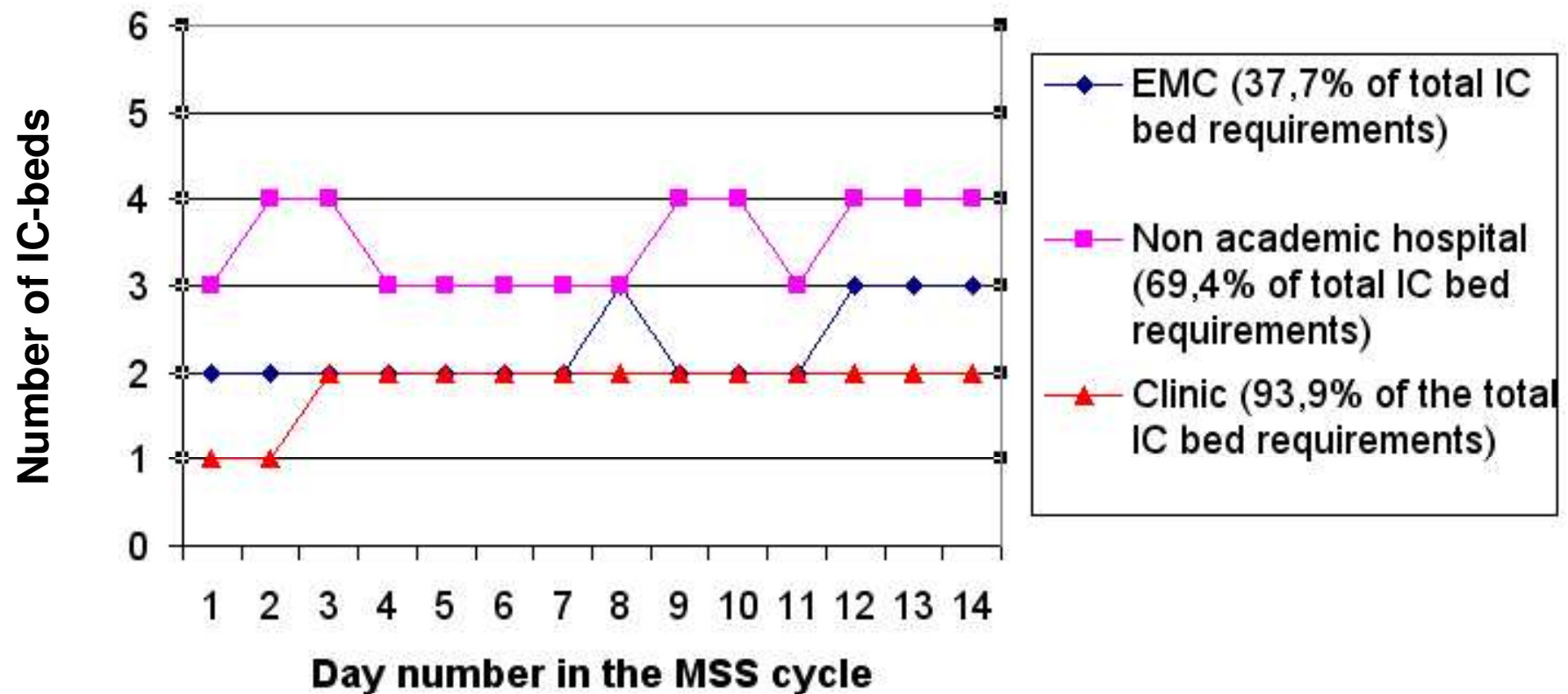
Results differ for different types of hospitals:



Reason: different volume and case mix range

Master surgical scheduling: results

Required number of IC-beds with MSS (2 week cycle):





Master surgical scheduling: results

Reduction OR-capacity:

Cycle length	1 week	2 weeks	4 weeks
Academic hospital	1,1 %	2,7 %	4,2 %
Peripheral hospital	2,8 %	5,7 %	6,3 %
Clinic	4,9 %	7,3 %	8,6 %



Master surgical scheduling

Advantages:

- Easy to implement
- Allows personnel coordination in early stage
- Less overtime, higher utilization
- Less surgery cancellations à shorter lead-times
- Improved coordination between departments

Disadvantage:

- Does not cover all surgeries



Project 2:

**Robust optimization of the OR schedule to
deal with emergency surgery**

Marieke van der Lans (UT, EMC)



Research motivation

The arrival of **emergency surgeries** is the most important source of **disturbances** in the OR

⌊ leads to: overtime, surgery cancellations, waiting time, reduced OR utilization

Options to deal with emergency surgery:

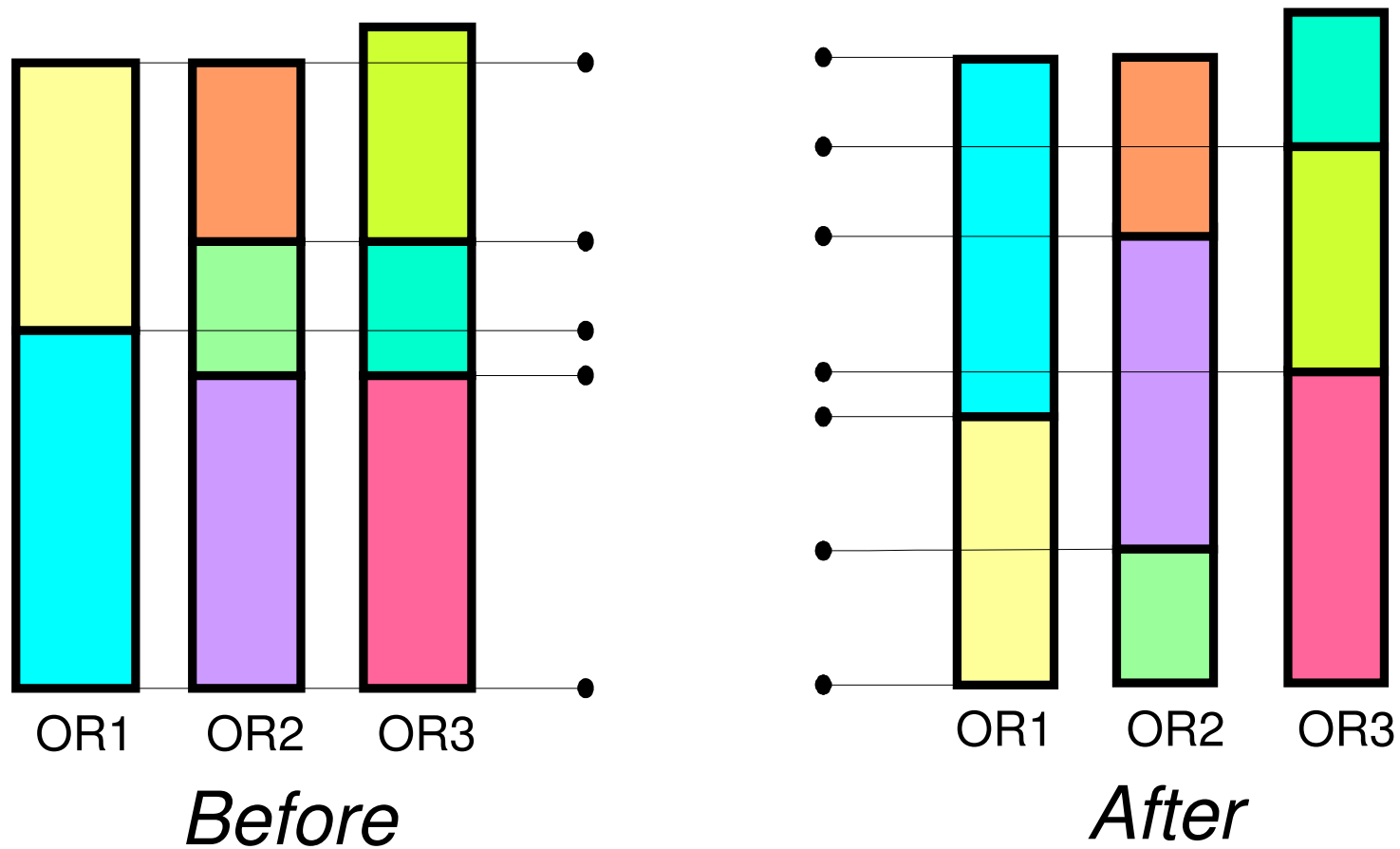
Dedicated emergency ORs

vs.

Schedule emergency surgery in elective ORs



Problem description





Solution approach

Goal: spread “Break-In-Moments” between elective surgeries as evenly as possible

Problem is NP-hard in the strong sense

Input: an elective surgery schedule for a given week

Optimization using local search heuristics,
implemented in Borland Delphi



Results after simulation

“Emergency surgery in elective program” instead of
“emergency ORs” yields:

- Improved OR utilization (3.1%)
- Less overtime (21%)

Break-in-moment optimization yields:

- Reduced waiting time for emergency surgery,
especially for the first emergency arrival
(patients helped within 10 minutes: from 28.8% à 48.6%)



Project 3:

“Safely through the night”: personnel rostering

Manon Vrielink (UT, EMC)



Safely through the night

Emergency team during the night:

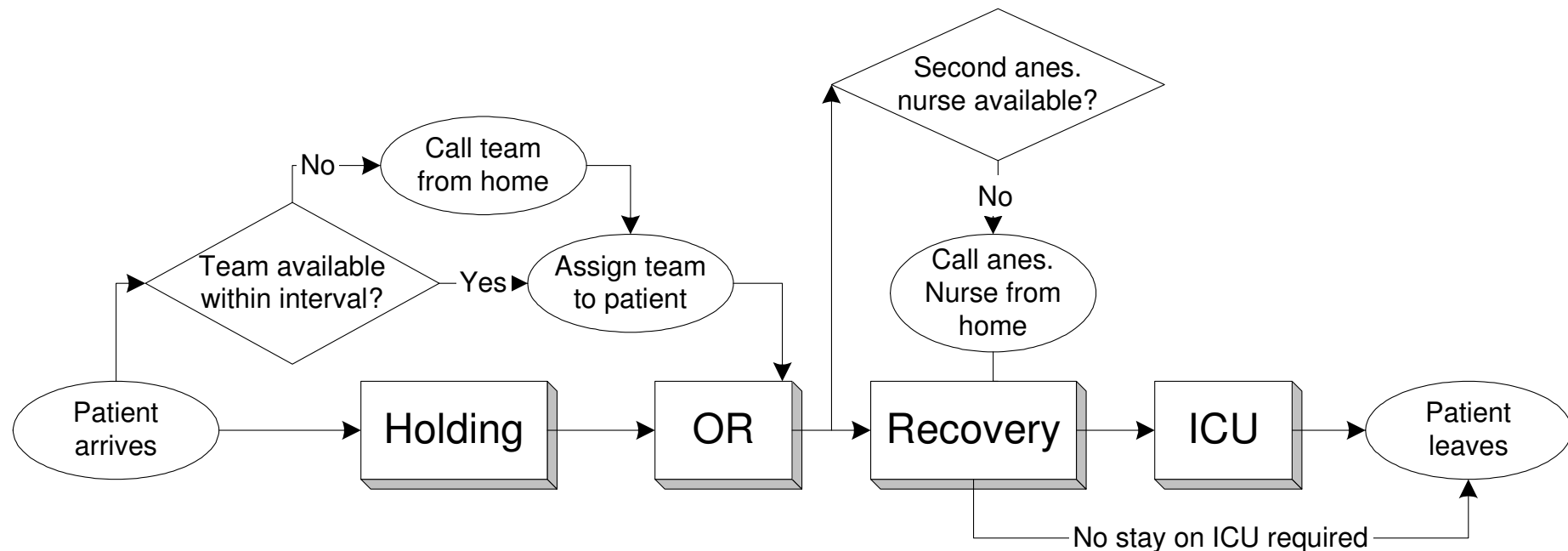
- costly
- low utilization
- impact on regular schedule
- capacity reduction jeopardizes patient safety

Goal: to determine the optimal size of the emergency team on call in the hospital during the night

Approach: simulation-based analyses of team configurations

Trade-off: quality of care, quality of labor, productivity

Simulation study



Input: team configurations, travel times, surgery durations, recovery LOS, arrival characteristics

Scenario: # anesthesia nurses “on-call at home” / “in house”
surgery nurses “on-call at home” / “in house”



Project 4:

“Focused factory OR?” a simulation study

Stijn Prinsen (UT, EMC)



“Focused Factory OR?”

Goal: to determine the effect of specializing ORs on:

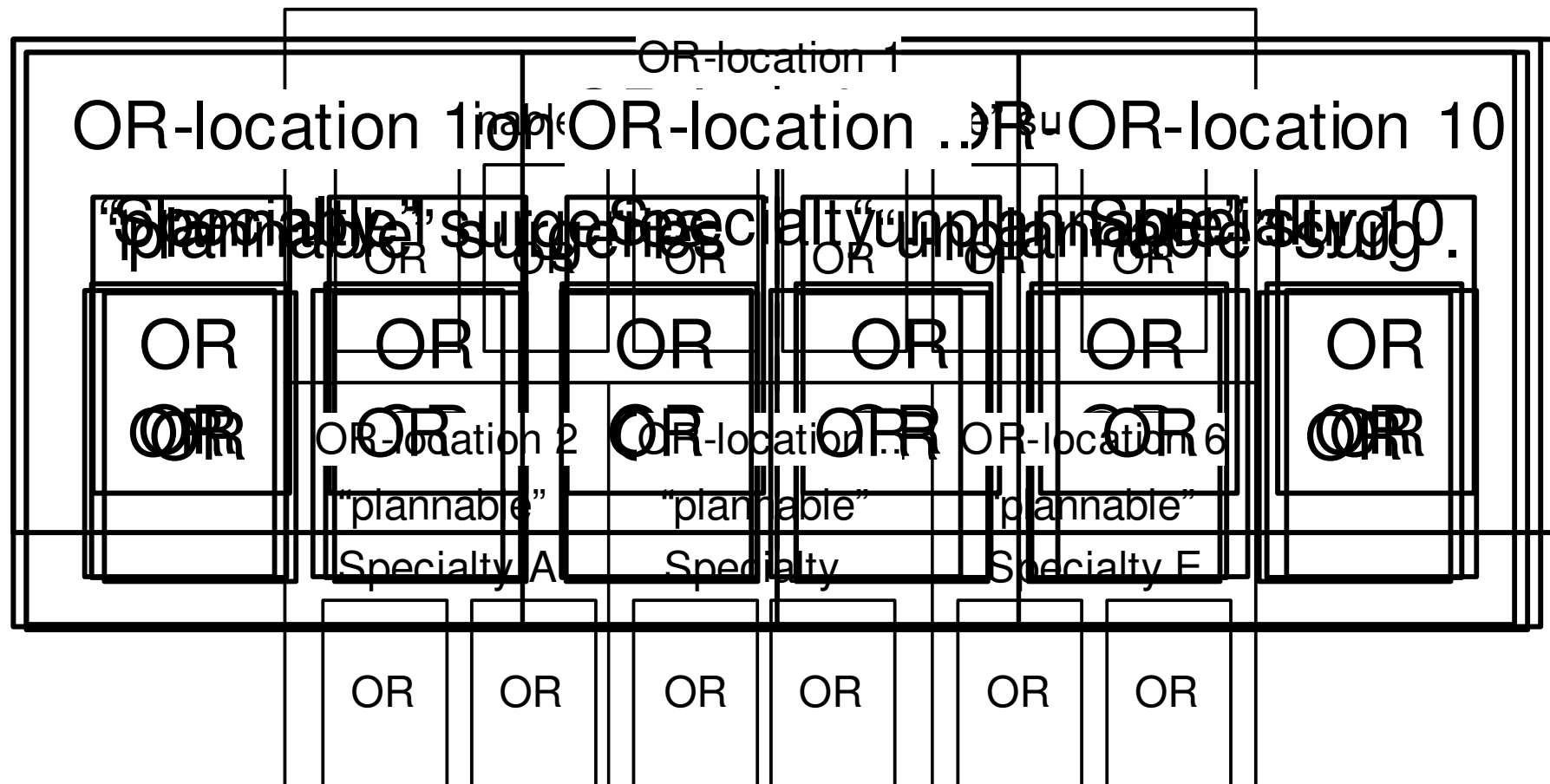
- Quality of care (e.g., waiting time emergency surgery)
- Quality of labor (e.g., overtime)
- Productivity (e.g., utilization)

à Strategic layout problem

Approach: compare several scenarios in a discrete event simulation environment (eM-plant, Tecnomatix)



Scenarios



“Planned” initially accepted to “plannable” and “plannable”
“Cherry picking”: multiple locations



Challenges (1)

TPG report suggests: “from **push** to **pull** planning”

But: current push planning can and must be improved:

- **Robust optimization** techniques combined with **discrete event simulation**
- Trade-off: **productivity, quality of care, quality of labor**



Challenges (2)

Current focus is mostly on one department

But: to a patient, the lead-time of the entire care pathway is important

- à Research focus must shift to designing techniques that contribute to a more **integral hospital planning and control**
- à Approach: start from within departments, looking beyond



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Questions...?