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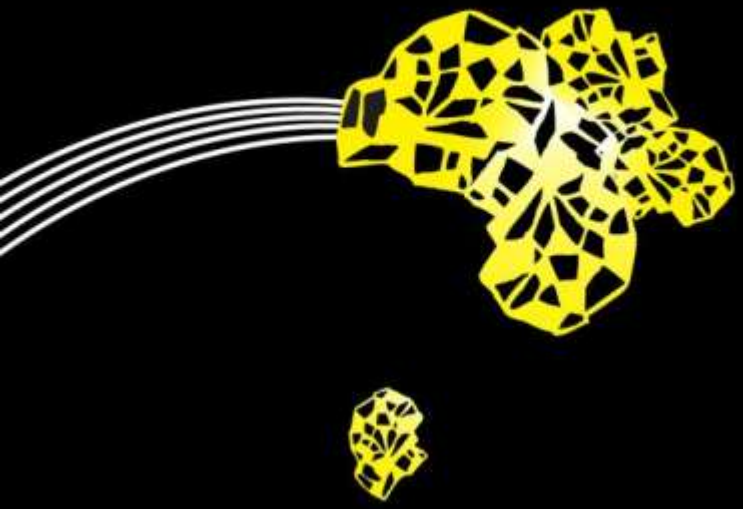


CHOIR SEMINAR

APRIL 19, 2013

RECENT UT PROJECTS AT MST

- Verminderen van wachttijden in de polikliniek urologie (Stijn Roersch)
- Zorgpaden op de polikliniek gynaecologie (Henrike Beltman en Roos Klever)
- Tackling the bed blocking problem at MST (Nienke van Dijk)
- Model for scheduling multi-skilled personnel at the Department of Clinical Neurophysiology (Bibianne Geerts)
- Matching capacity and demand - An analysis of the planning issues at the gynecology clinic at MST (Lieske Kobes)
- Tactical planning for the gastrointestinal and hepatology department of Medisch Spectrum Twente: designing a tactical conceptual planning model for the outpatient clinic and the endoscopic clinic (Chantal Olde Keizer)

UNIVERSITY OF TWENTE.

REUSABLE ITEMS: HOW MUCH TO STOCK WHERE?

Ingrid Vliegen - University of Twente

Simme Douwe Flapper - Eindhoven University of Technology

Pieter Wolbers - Logiqol Logistic Methods

Rogier Van Vliet - Medisch Spectrum Twente

REUSABLE ITEMS IN HOSPITALS

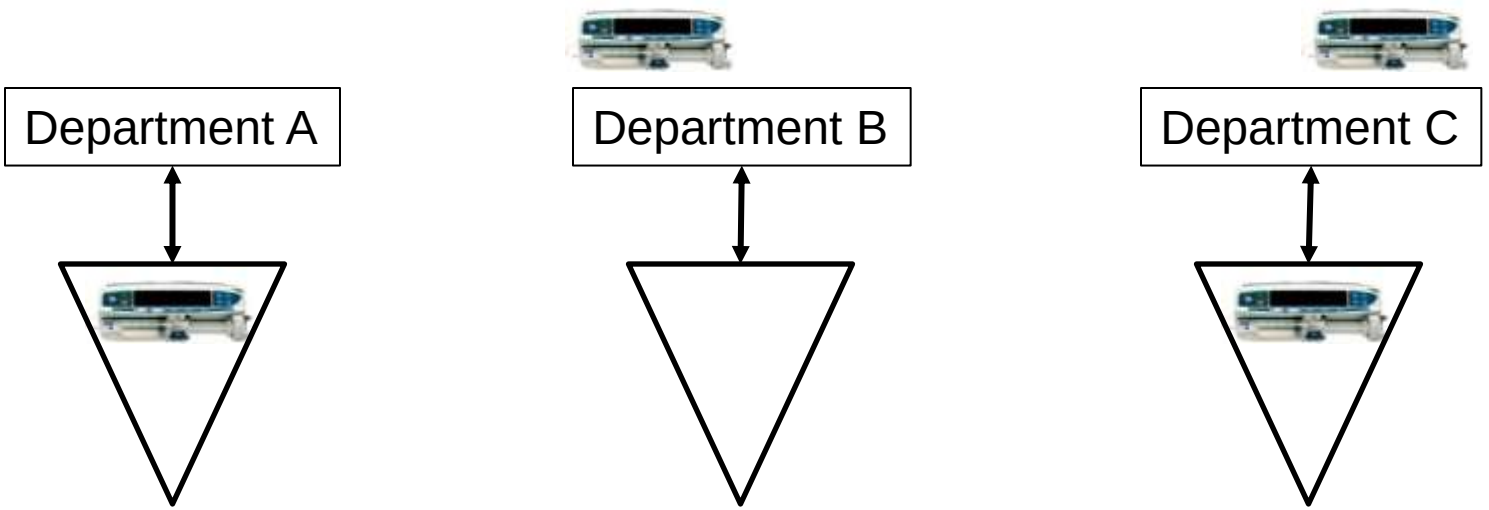
GENERAL SITUATION

- Demand for *items* (e.g., infusion pumps, beds)
- Demand occurs at *demand locations* (e.g., building, floors, departments)
- Items are stocked in a *stock point*
- An *employee* (nurse or logistics employee) has to collect the item

- In this presentation:
  - Focus on Syringe Infusion Pumps, departments and nurses.
- However, models are more general!

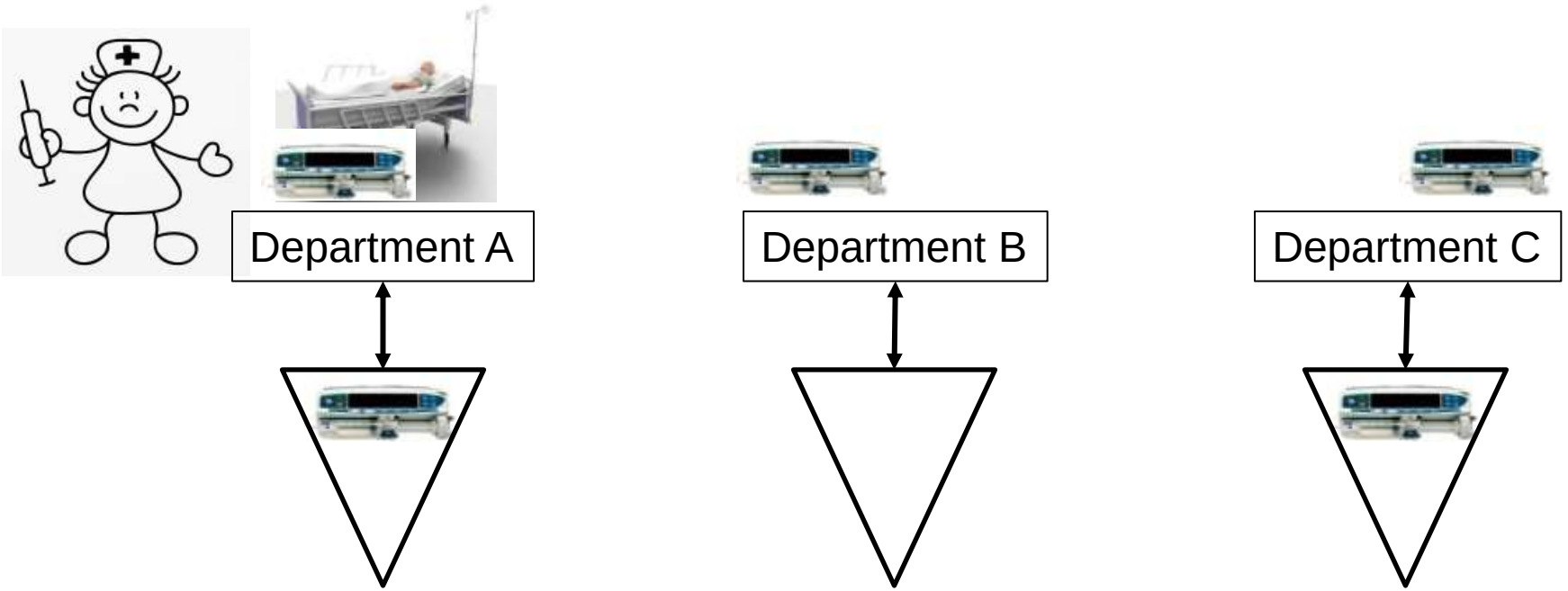
SITUATION

DEPARTMENTS IN HOSPITAL HAVE OWN STOCK OF PUMPS



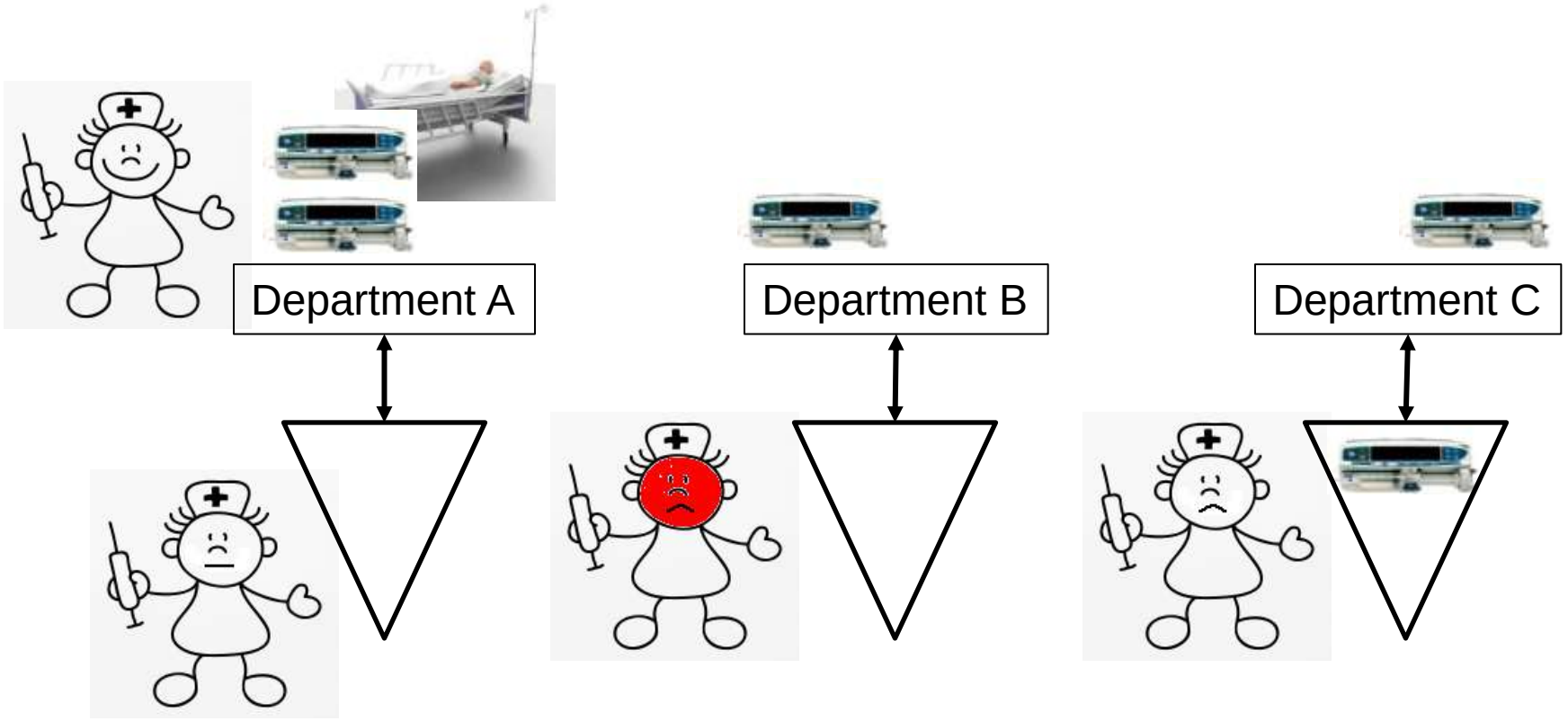
SITUATION

IF PATIENT NEEDS A PUMP, A NURSE WILL GET IT



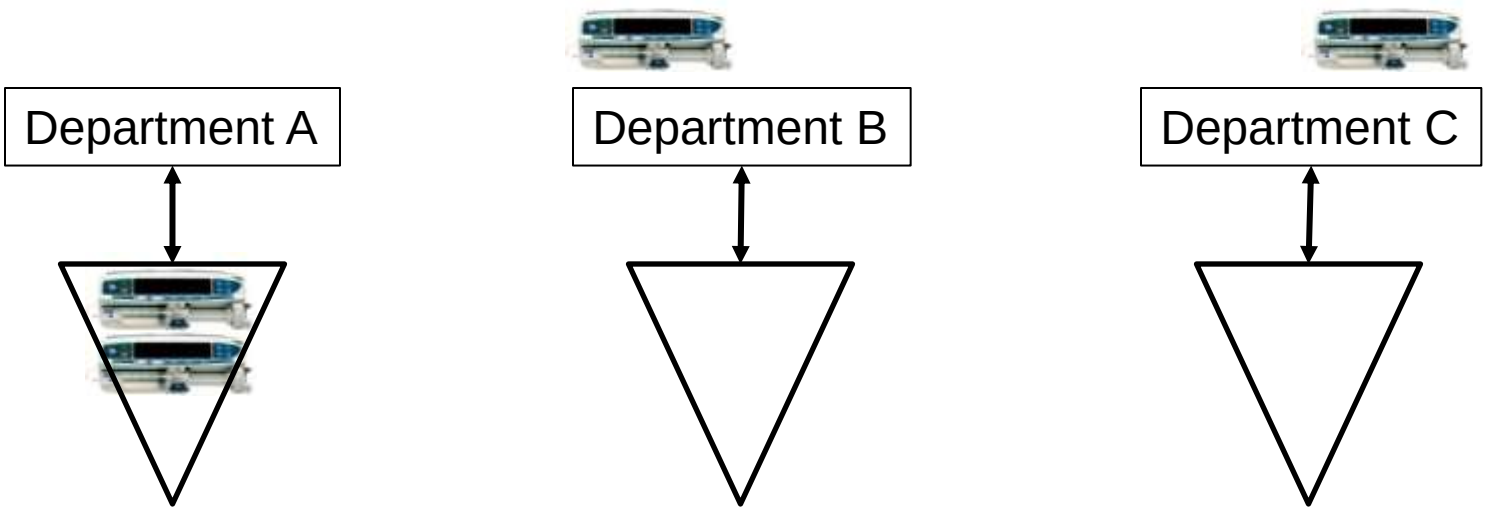
SITUATION

BUT WHAT IF MORE PATIENTS NEED A PUMP?



SITUATION

AFTER USAGE PUMPS ARE NOT ALWAYS RETURNED



SITUATION
SOME ISSUES

- A lot of walking and searching
  - Frustration
  - Feeling of shortage
  - Hoarding
- Longer waiting times for patients
  - Lower quality of care
- Not knowing where pumps are
  - Problematic for maintenance

GOAL

- Whenever a demand for a pump occurs:
  - The right pump
  - Needs to be available
  - At the right location
  - Within the allowed time frame

CONTENTS

- Situation
- Literature
- Models
- Results
- Experiences MST

LITERATURE
HEALTHCARE

- Reusable items have been studied, for instance:
  - Beds (Green, 2002, Nguyen et al., 2005, de Bruin et al., 2009)
  - Infusion pumps (Kemper et al., 2009)
  - …

- But main focus on how many items are needed, not on where they should be stocked.

LITERATURE
SERVICE LOGISTICS

- Multi-location models including:
  - Lateral transshipments (Kranenburg and van Houtum, 2009, Reijnen et al, 2010, van Wijk et al., 2011)
  - Back-up warehouse (Axsater et al., 2010, van Wijk et al., 2011)

- Assumption:
  - After usage items are replenished to the stock point they were delivered from

LITERATURE
REUSABLE ITEMS

- Transportation items
- Packaging materials
- Tools

- See Carrasco-Gallego et al. (2009) for a review

- Ongoing research; not in this presentation

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MODELS
ASSUMPTIONS

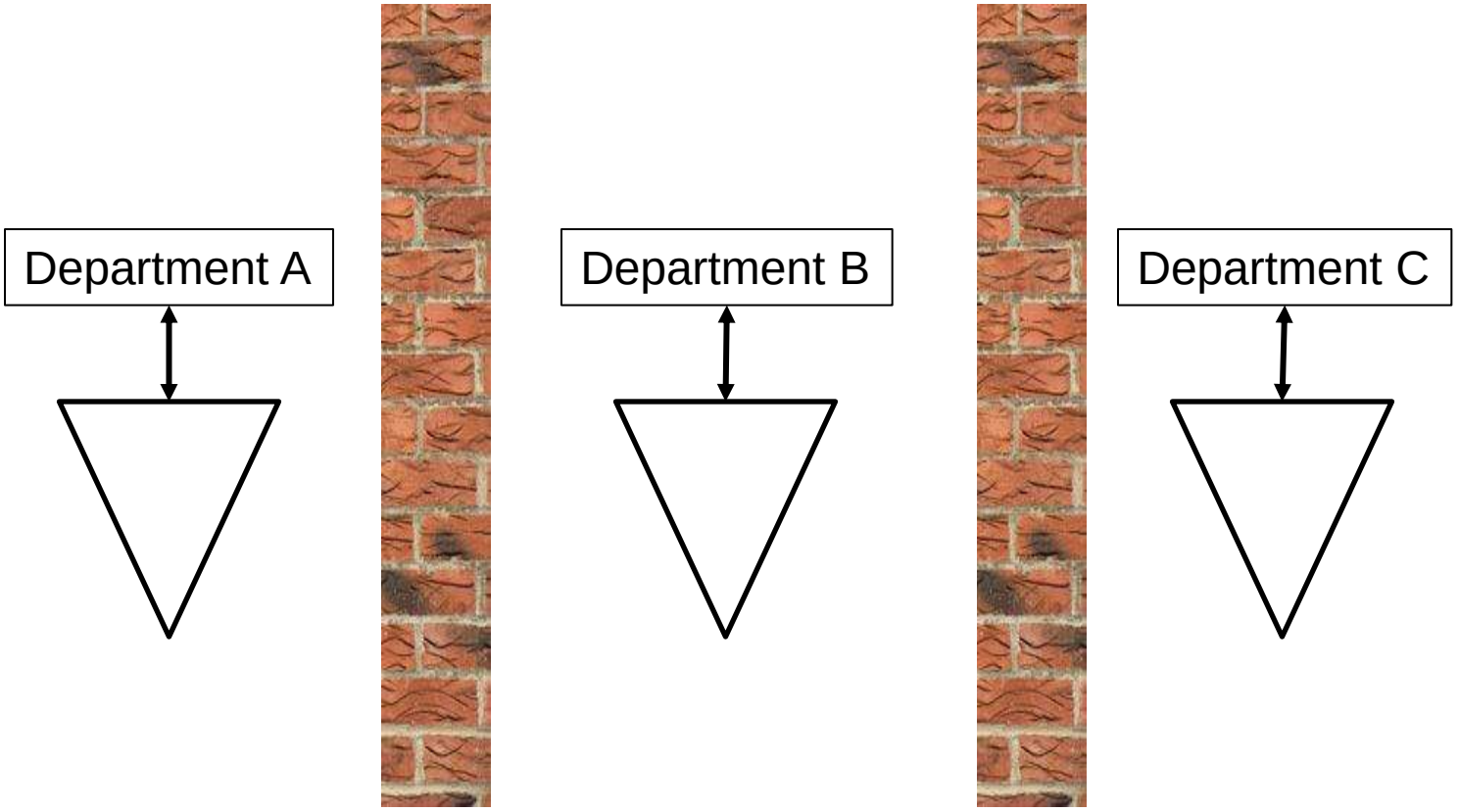
- Demand at each department occurs following a Poisson process
- If no of the stock locations has stock, an alternative needs to be found:
  - Renting from outside company or using a different treatment
  - Demand is lost for stock point under consideration
- Whenever the treatment of a patient is finished, the item goes back to the stock point where it was collected.

MODELS
PERFORMANCE MEASURES

- Item costs:
  - Acquisition cost of the pumps
- Patient service level:
  - Percentage of time that an item is available within 30 minutes after demand
- Employee satisfaction:
  - Walking distance
  - Probability that multiple stock points need to be visited

MODELS

EACH DEPARTMENT HAS OWN STOCK

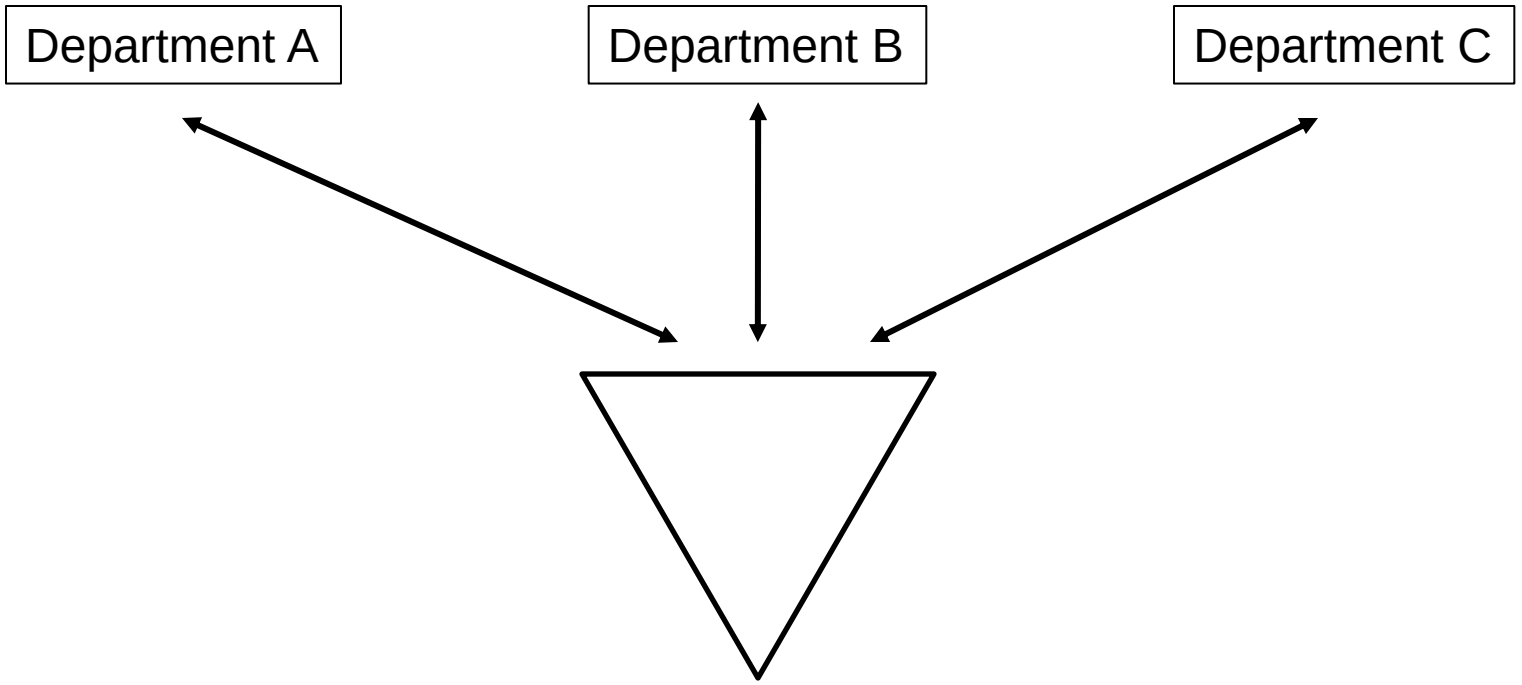


MODELS
EACH DEPARTMENT HAS OWN STOCK

- Due to Poisson assumption and lost sales
  - Can be analyzed by Erlang loss system
  - For each department *j*:
  - Min S_j S.t. $P_j^{lost} = \frac{\frac{(\frac{\lambda_j}{\mu})^{s_j}}{s_j!}}{\sum_{i=0}^{s_j} \frac{(\frac{\lambda_j}{\mu})^i}{i!}} < y$
  - Walking distance = 0

MODELS

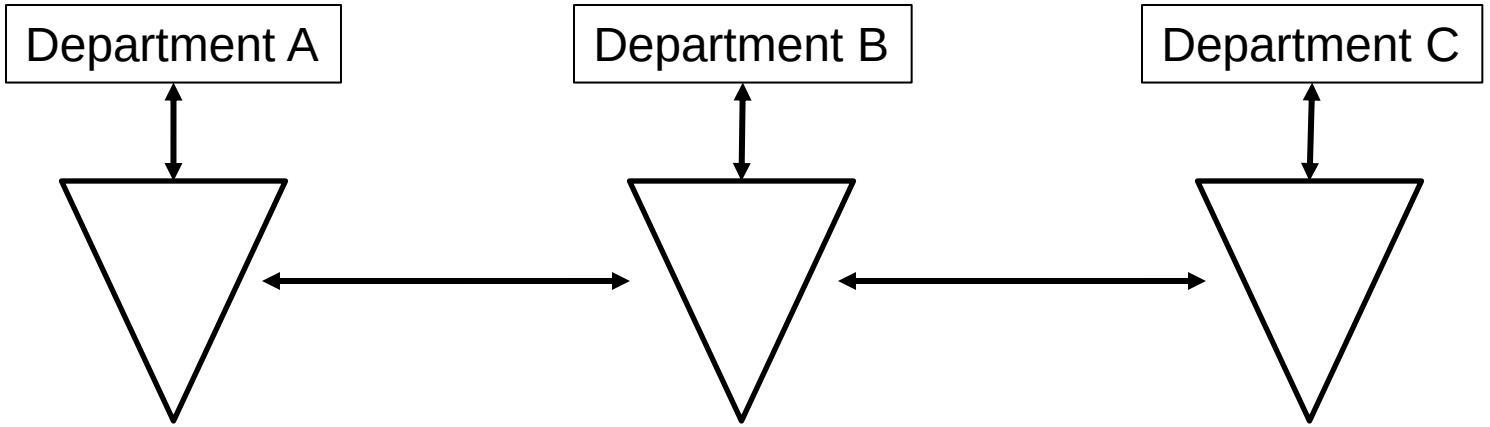
ONE CENTRAL STOCK POINT



MODELS
ONE CENTRAL STOCK POINT

- Due to Poisson assumption and lost sales
  - Can be analyzed by Erlang loss system
  - For all departments together:
    - Min S S.t. $$p^{lost} = \frac{\frac{(\frac{\lambda}{\mu})^S}{S!}}{\sum_{i=0}^{S} \frac{(\frac{\lambda}{\mu})^i}{i!}} < y$$
  - Where $\lambda = \sum \lambda_j$
  - Walking distance = $\Sigma_j \lambda_j$ * Distance to stock point from department *j*

MODELS
STOCKS ARE SHARED



MODELS
STOCKS ARE SHARED

- Assuming all stock points can be reached within the maximum allowed time, the needed stock is the same as for one stock point, so:
  - For all departments together:
    - Min S S.t. $$p^{lost} = \frac{\frac{(\frac{\lambda}{\mu})^S}{S!}}{\sum_{i=0}^{S} \frac{(\frac{\lambda}{\mu})^i}{i!}} < y$$

- The stock is divided over the different stock points using a marginal analysis

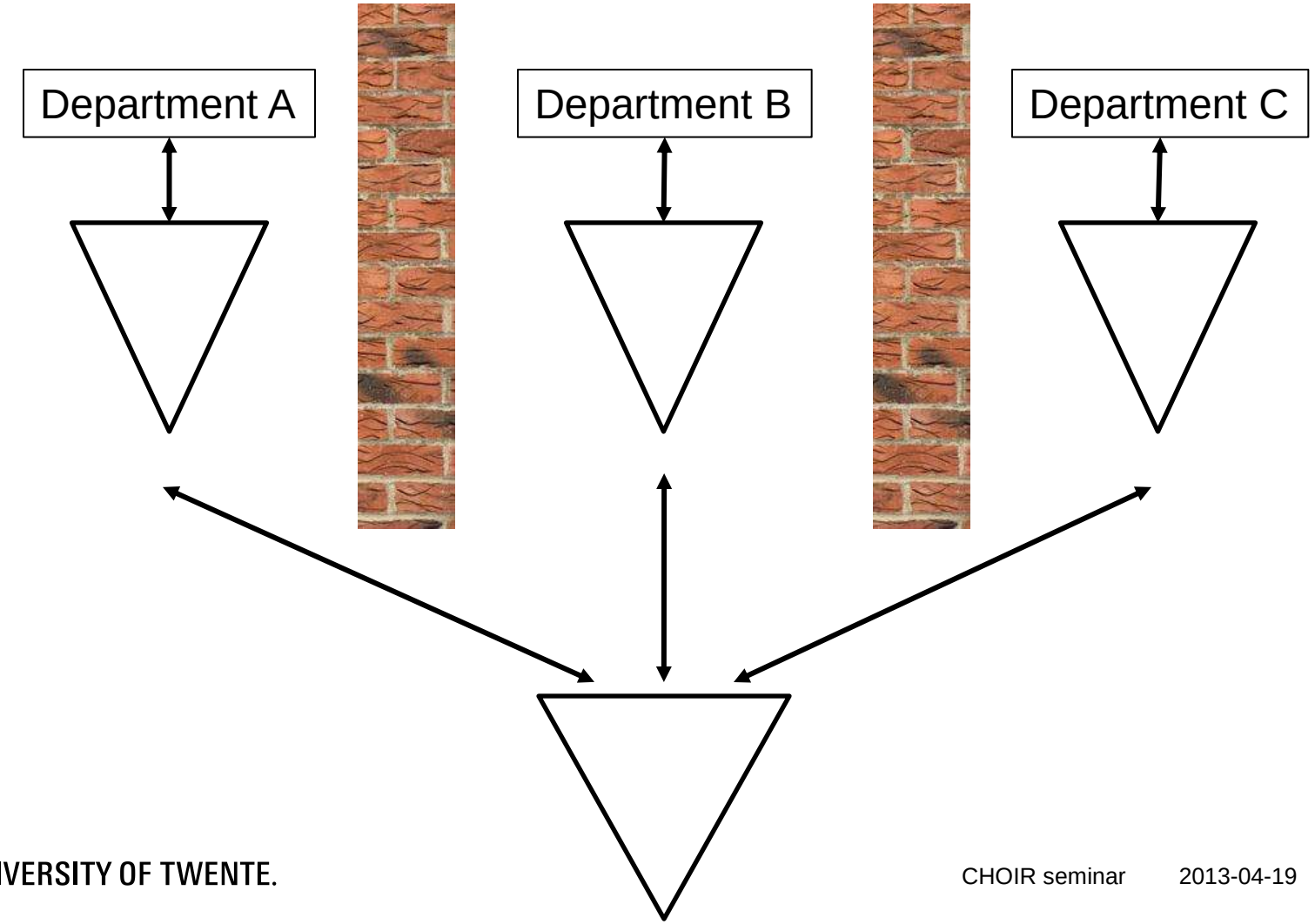
MODELS
STOCKS ARE SHARED

- Using the overflow algorithm of van Wijk et al. (2011), we can determine:
  - β_j: fraction of the demand for department *j* that is fulfilled directly from stock
  - α_{jk}: fraction of the demand for department *j* that is fulfilled from the stock point of department *k*
  - θ_j: fraction of the demand for department *j* that is lost

- Walking distance and average number of stock points visited can be determined from the above fractions, the order of which departments are visited and the distances.

MODELS

ONE BACK-UP LOCATION



MODELS
ONE BACK-UP LOCATION

- Using a greedy algorithm combined with the overflow algorithm of van Wijk et al. (2011), we can determine:
  - S
  - β_j: fraction of the demand for department *j* that is fulfilled directly from stock
  - α_{jk}: fraction of the demand for department *j* that is fulfilled from the back-up stock
  - θ_j: fraction of the demand for department *j* that is lost
  - Walking distance
  - Average number of stock points visited

MODELS
ADVANTAGES AND DISADVANTAGES

	Item costs	Patient service level	Employee satisfaction
Own stock	--	++	++
One stock point	++	--	+/-
Shared stock	++	+/-	--
Back-up stock point	+/-	+/-	+/-

MODELS
NOT TAKEN INTO ACCOUNT

- Feeling of shortage
  - Hoarding
- Not knowing where pumps are
  - Problematic for maintenance

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RESULTS
DEPARTMENTS AT EACH FLOOR

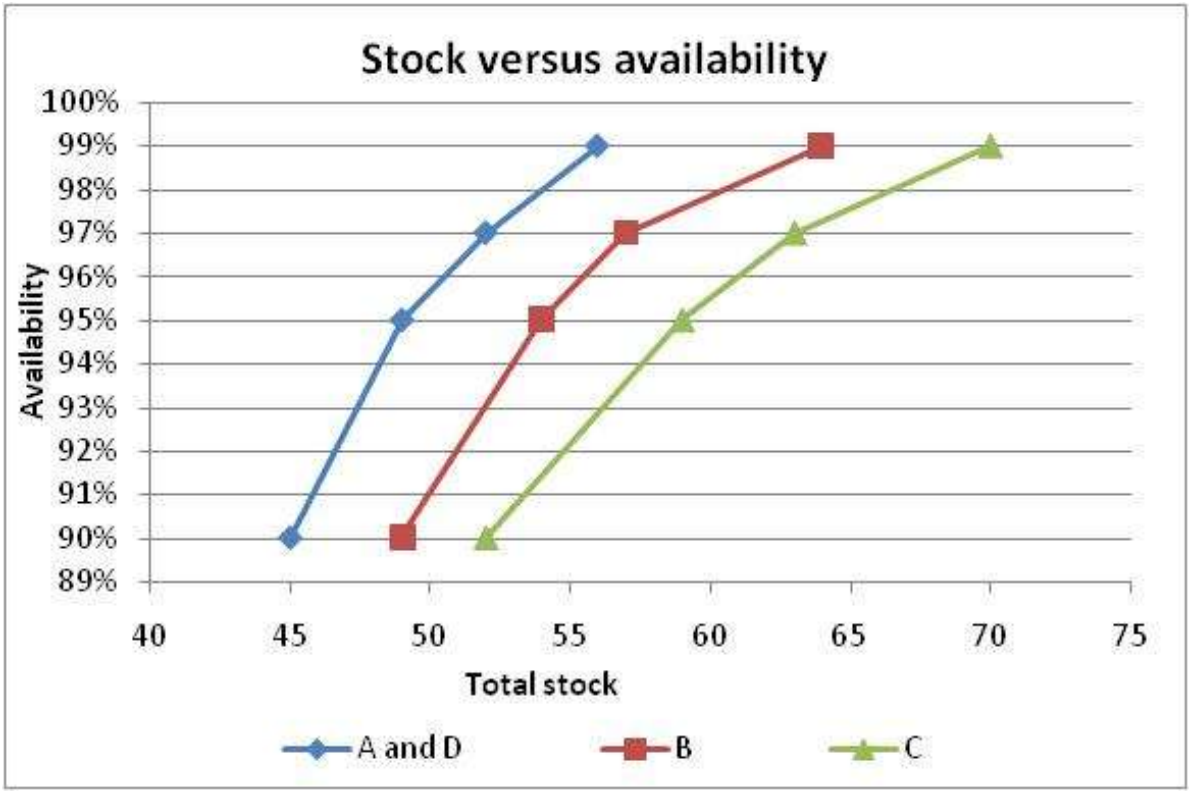
- Distances are small
- So, disadvantages one stock point disappear

	Item costs	Patient service level	Employee satisfaction
Own stock	--	++	++
One stock point	**++**	**+**	**+**
Shared stock	++	+/-	+/-
Back-up stock point	+/-	+	+

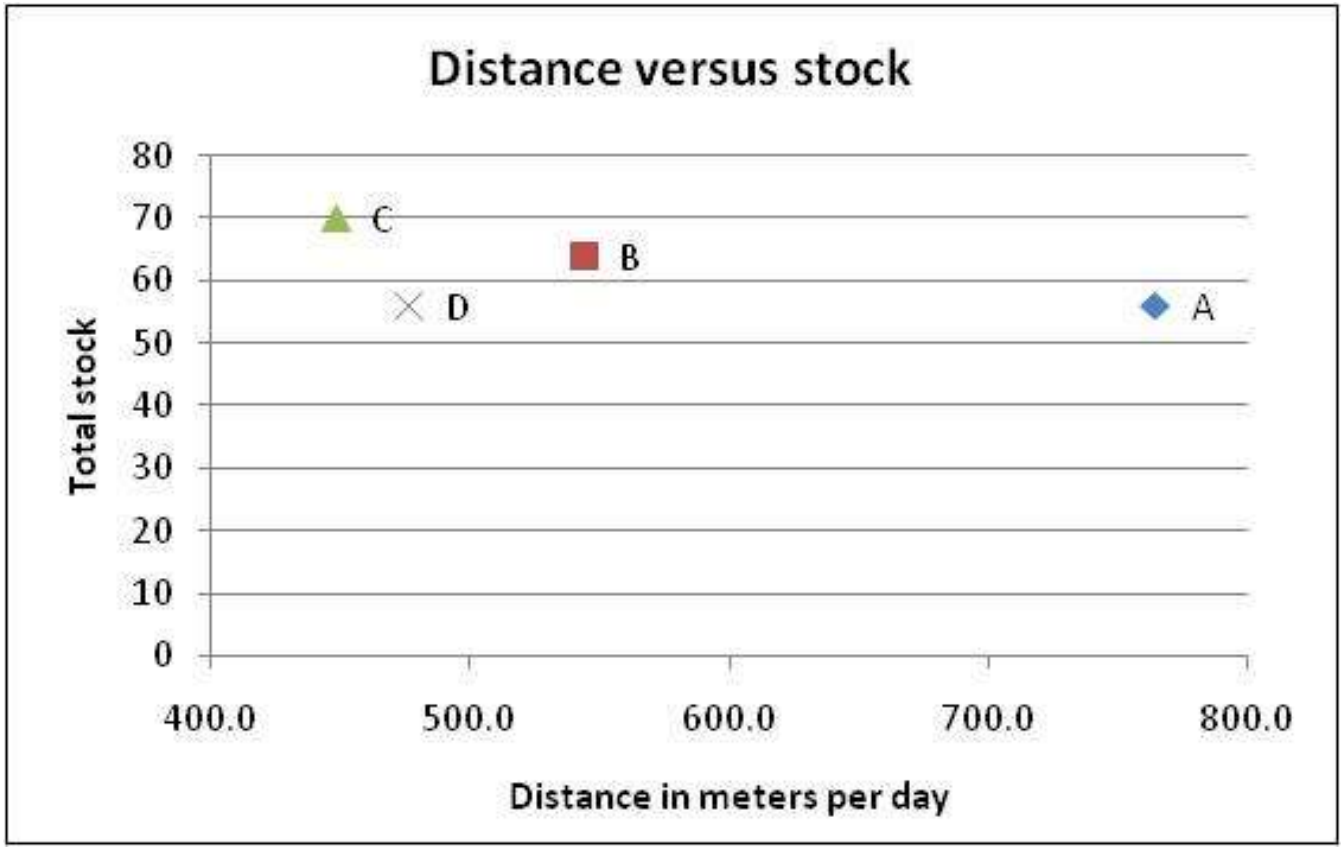
RESULTS
FLOORS

- 3 floors
- 4 options studied:
  A. One stock point
  B. Two stock points, no sharing
  C. Three stock points (each floor), no sharing
  D. Three stock points (sharing)

RESULTS


Stock versus availability
100%
99%
98%
97%
96%
95%
94%
93%
92%
91%
90%
89%
Availability
40
45
50
55
60
65
70
75
Total stock
A and D
B
C

RESULTS


Distance versus stock
Total stock
80
70
60
50
40
30
20
10
0
C
B
D
A
400.0
500.0
600.0
700.0
800.0
Distance in meters per day

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