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Fakultät

Destination Assignment Problem (DAP)

Agenda

1. Einführung
2. Modell
3. Genetischer Algorithmus
4. Fragen

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Beschaffung → Produktion → Distribution → Absatz

Destination Assignment Problem
„Zielzuweisungsproblem“

Distributionsnetze

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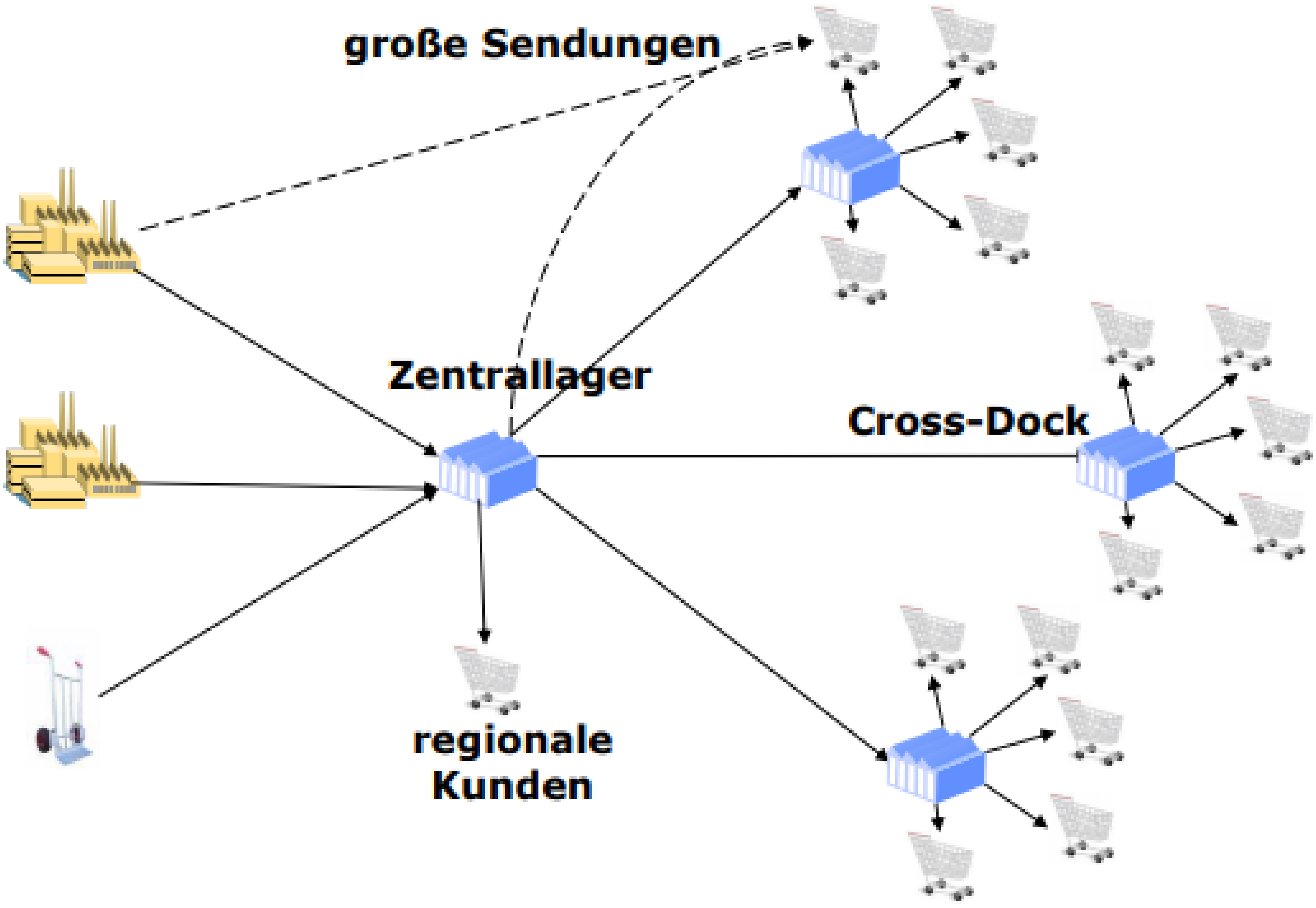

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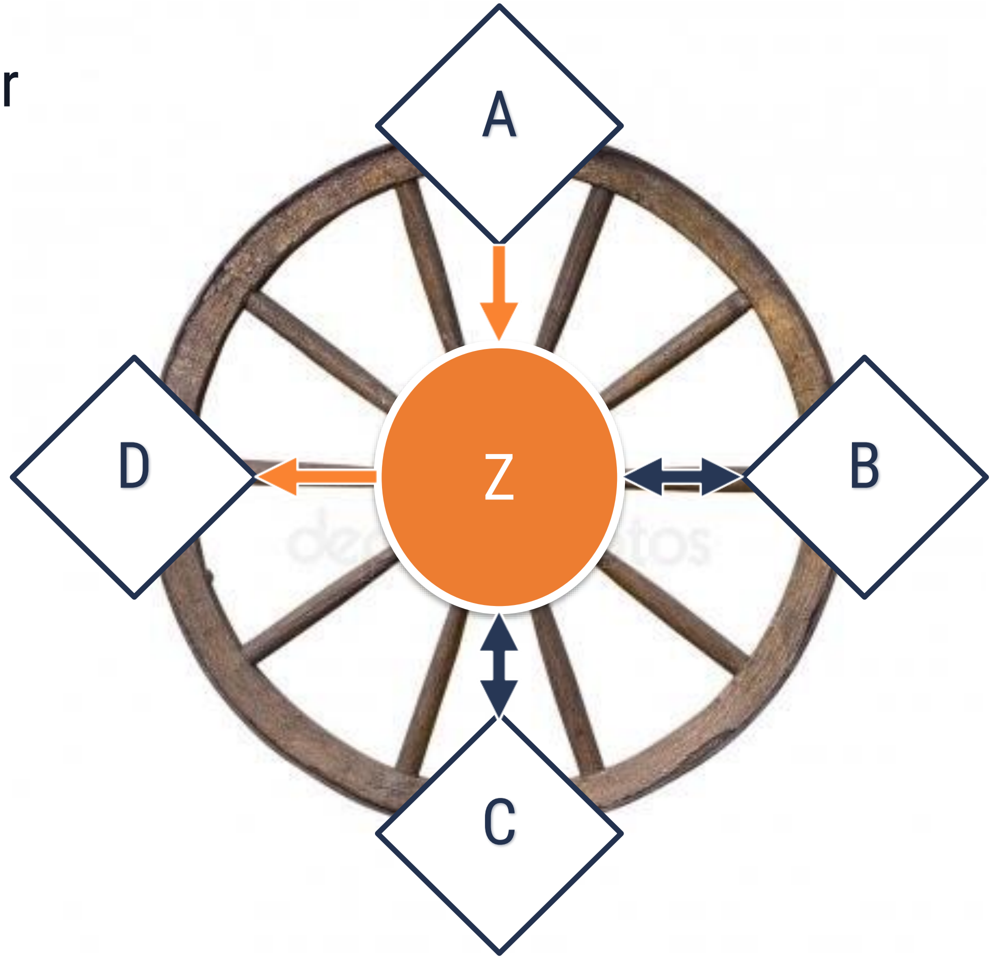
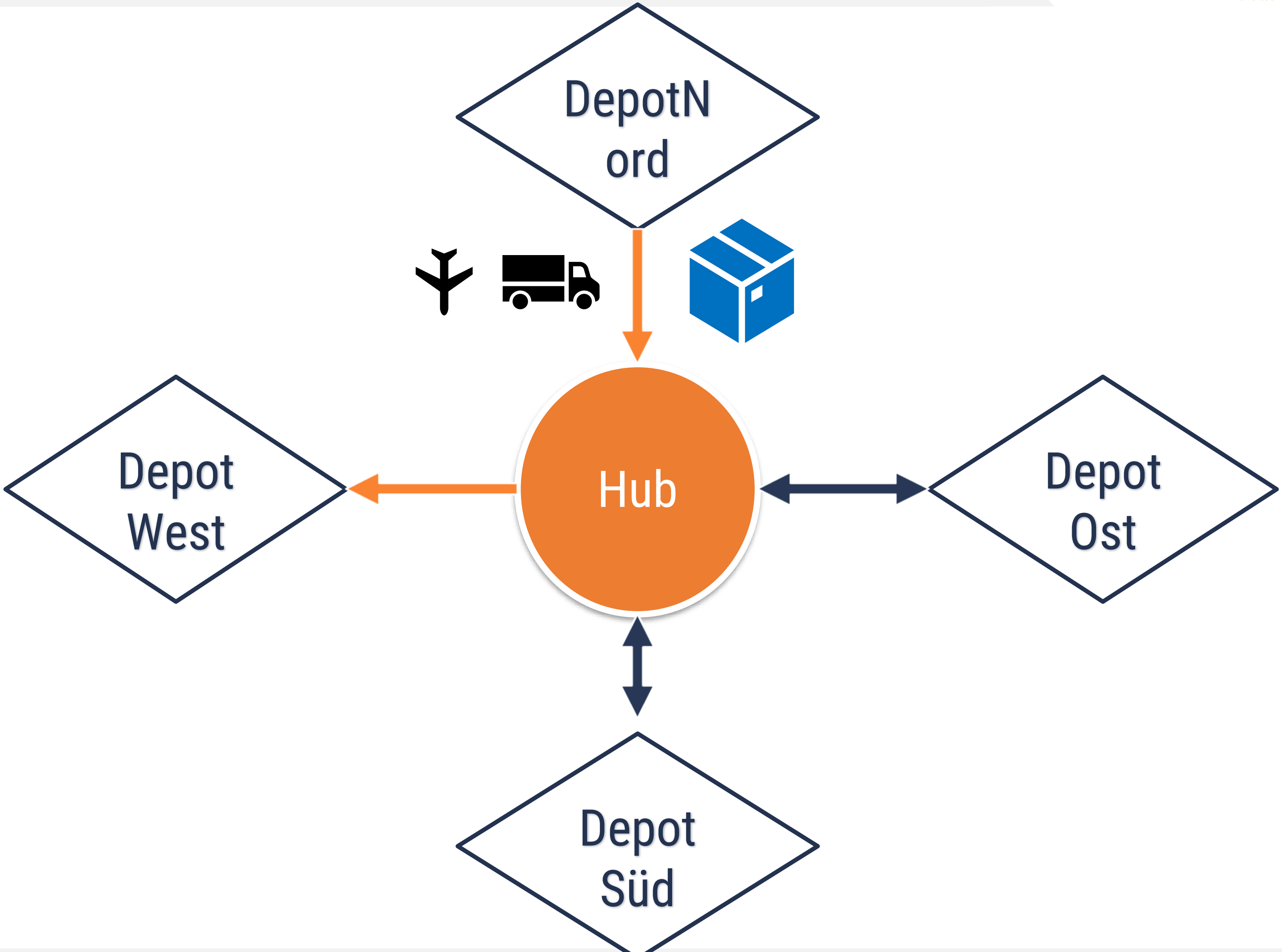
- „Nabe Speiche System“
- Transportnetzstruktur
- Sterntopologie



Hub & Spoke Netze



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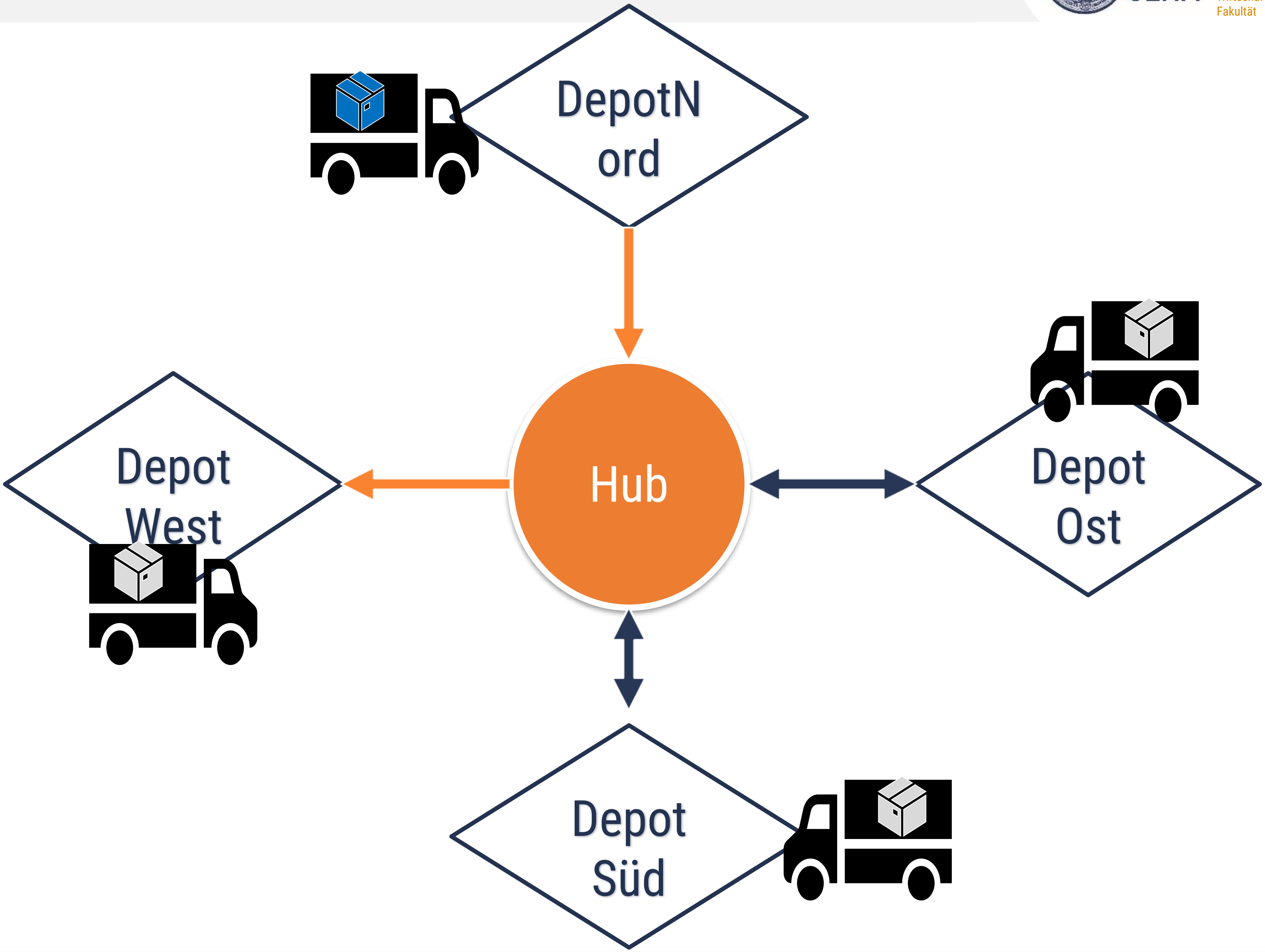

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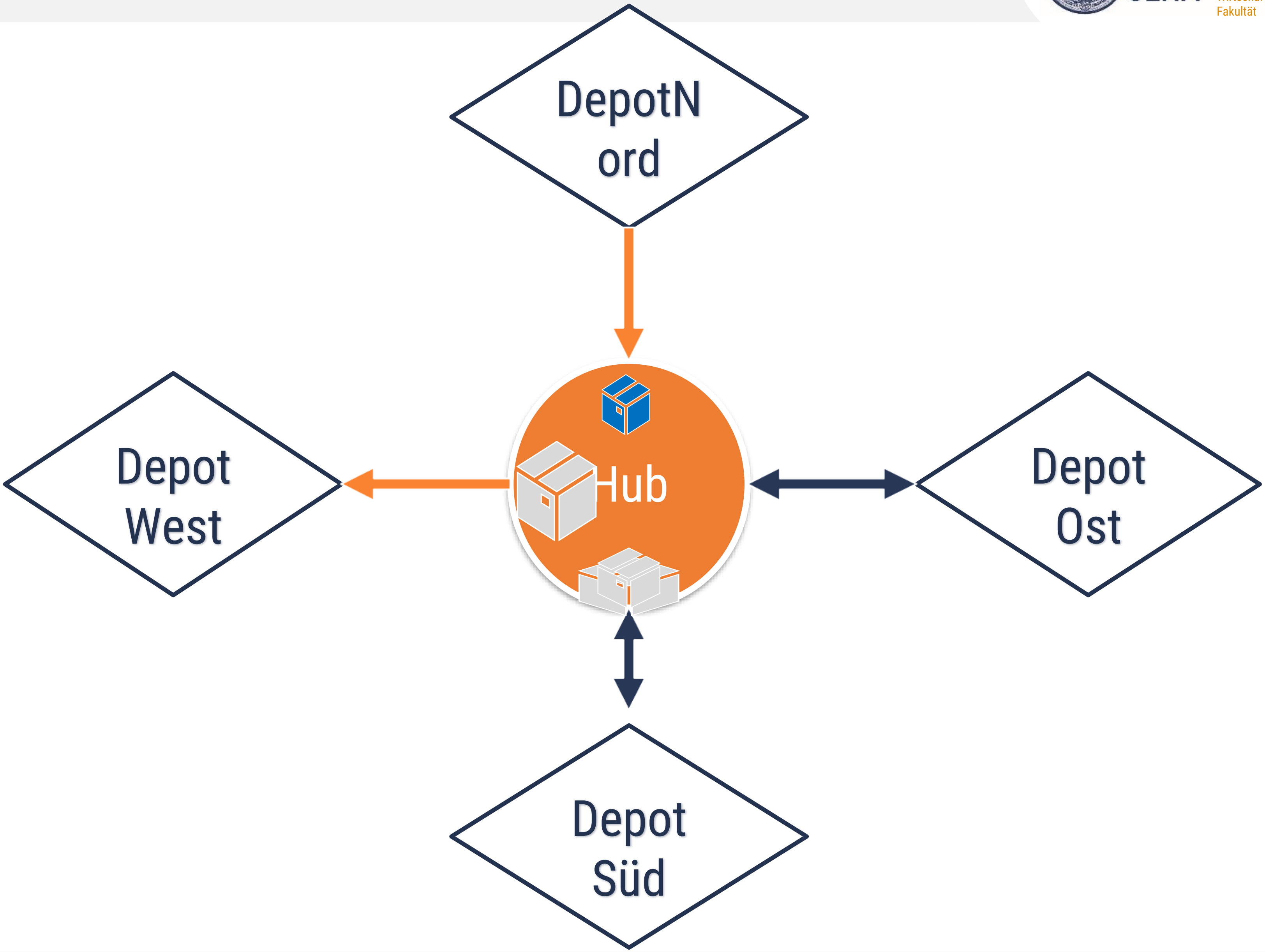
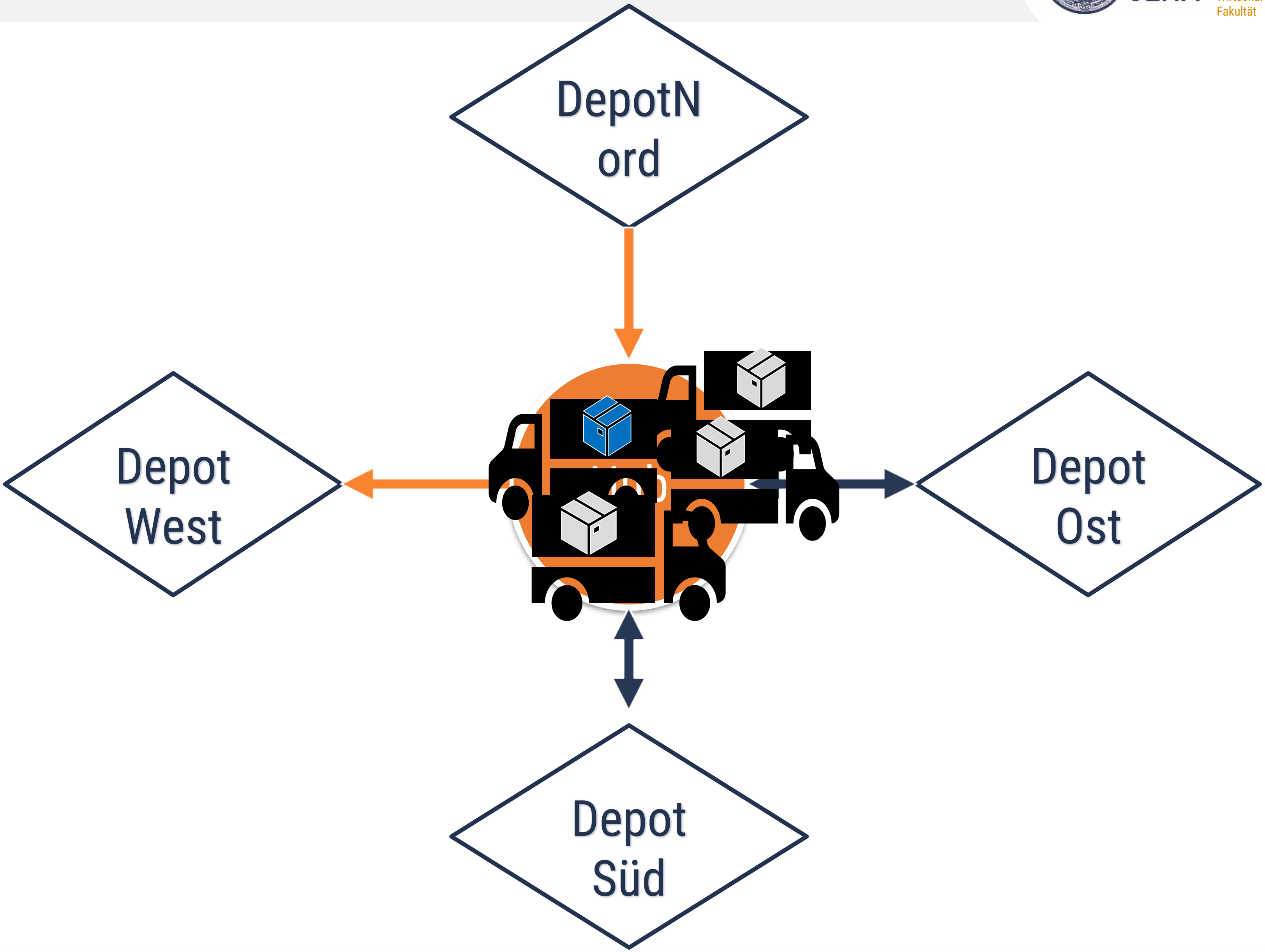


Hub & Spoke Netze



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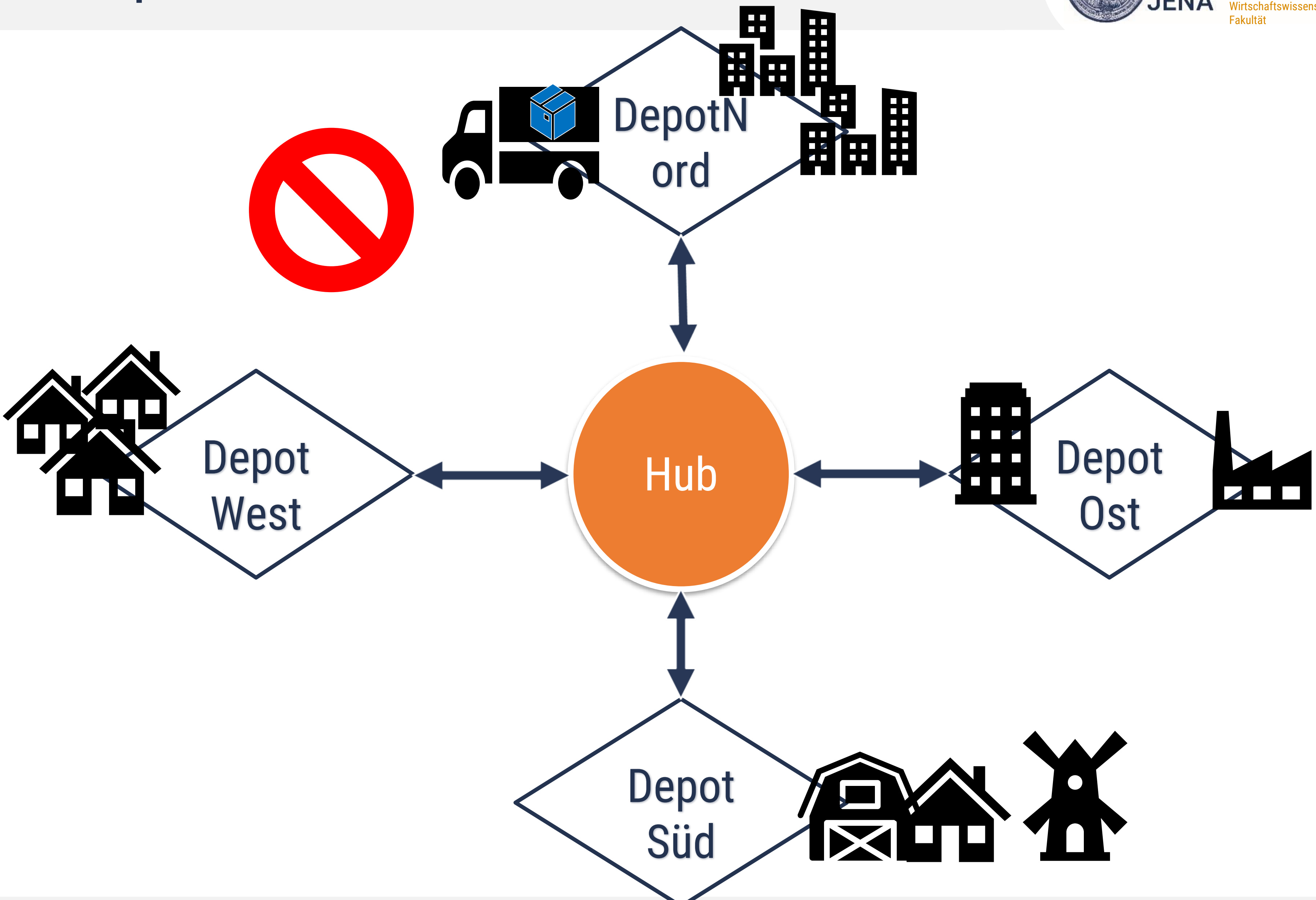
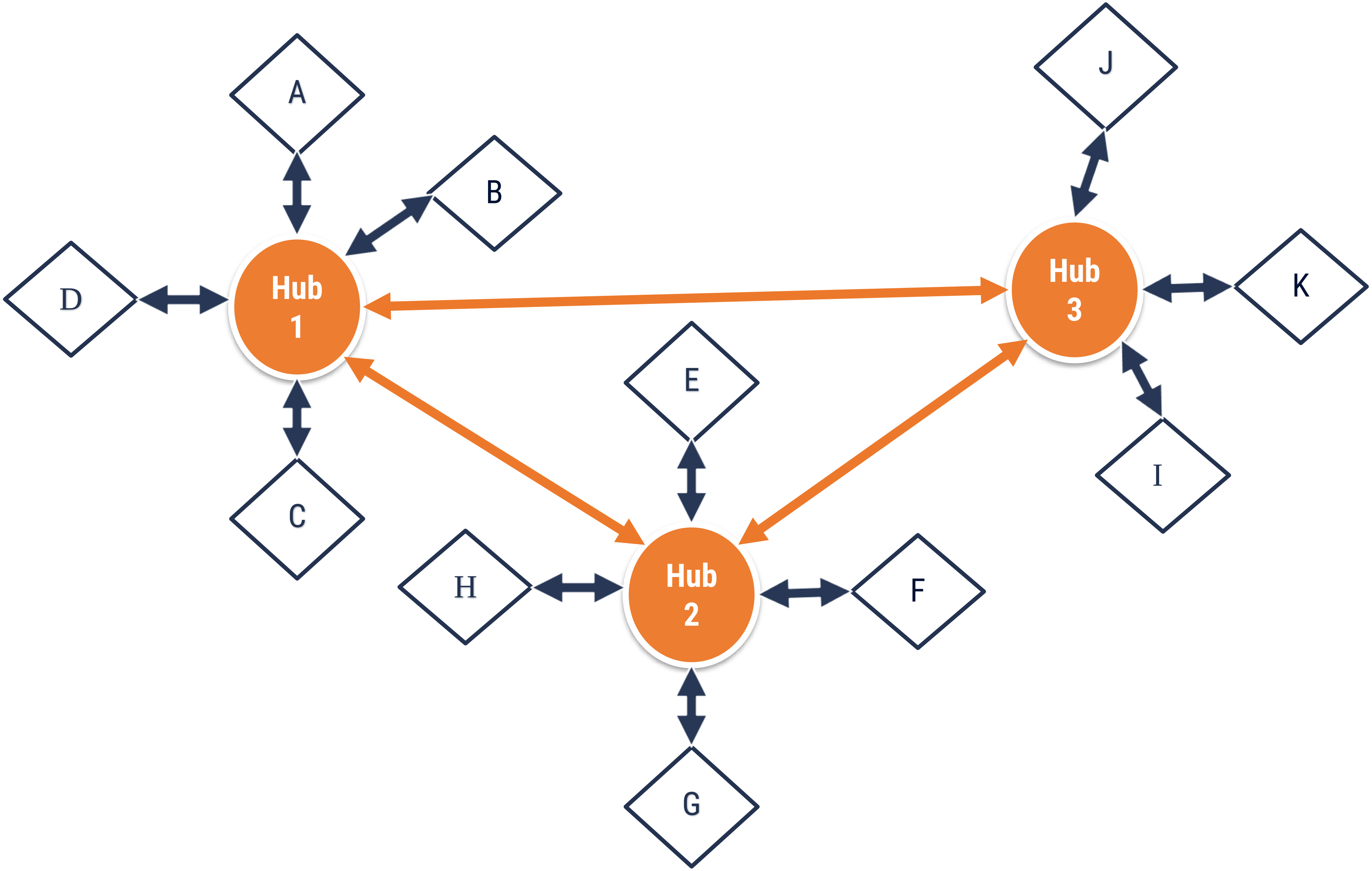


Multi-Hub Netz

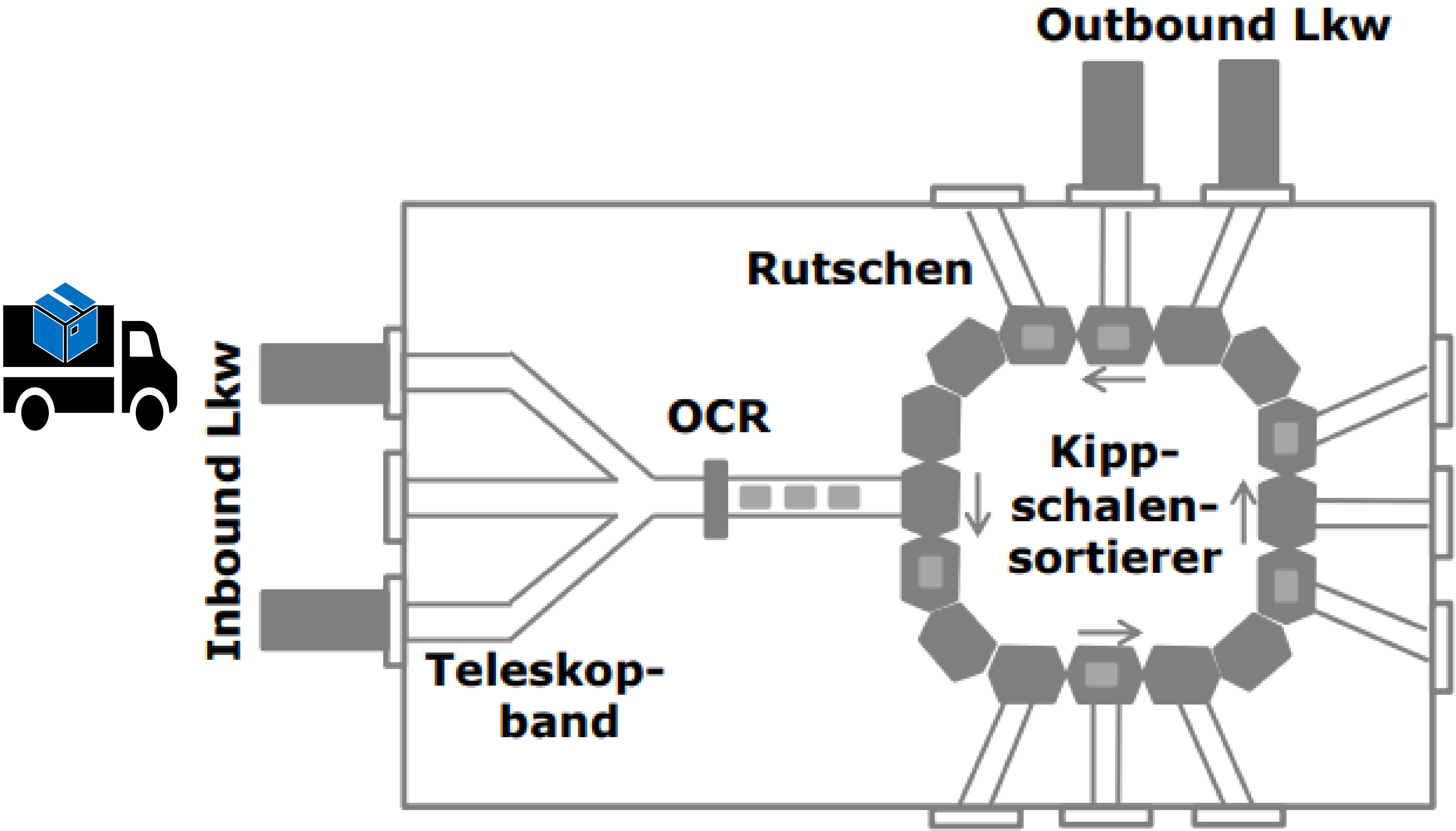


Vor- und Nachteile der Hub & Spoke Netze

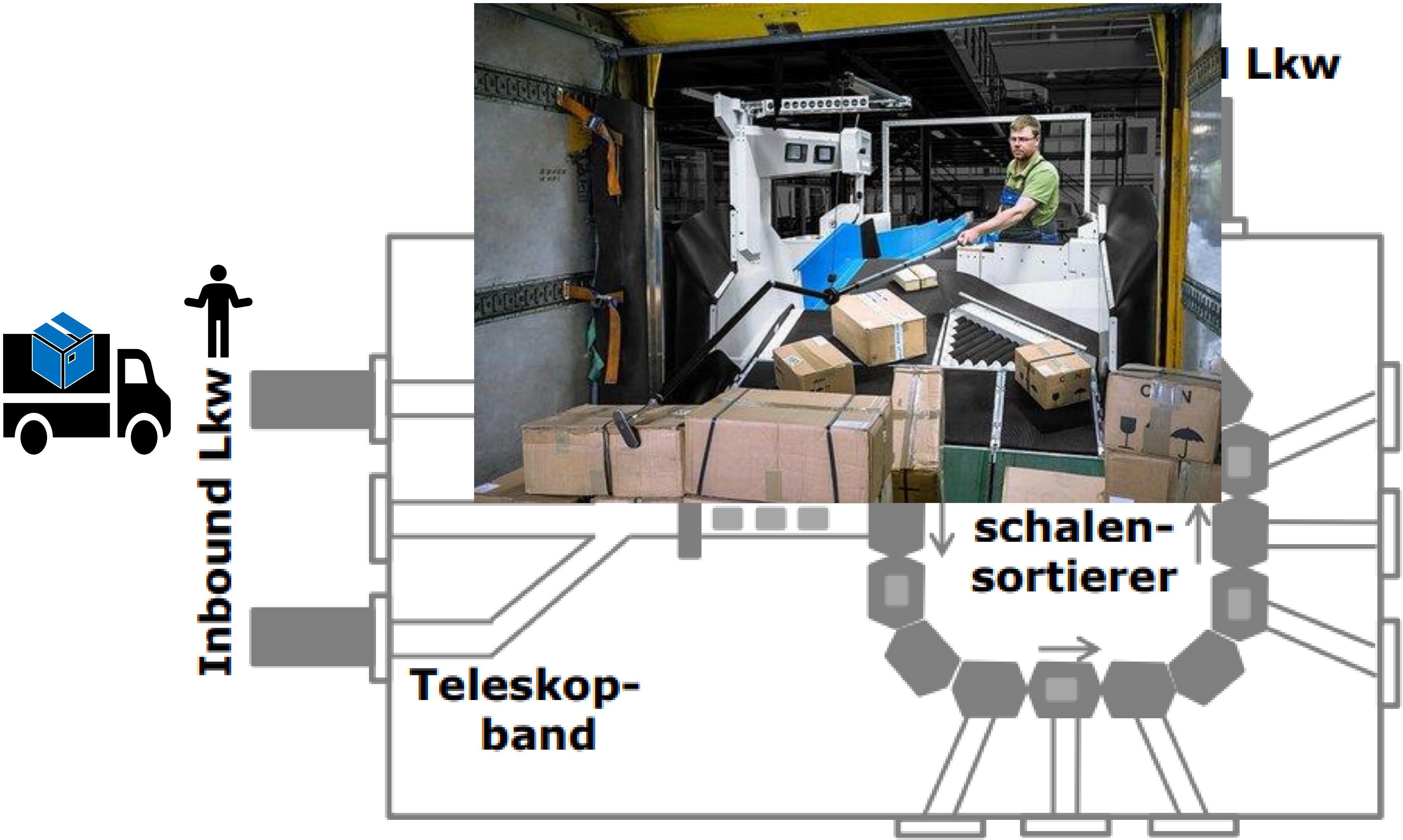
Vorteil	Nachteil
+ Bündelungseffekt	– Längere Transportwege
+ geringere Transportkosten	– Koordinationsaufwand
+ Erschließung strukturschwacher Regionen möglich	– Kosten für Errichtung und Betrieb der Hubs
+ Sammel- und Verteiltouren über mehrere Anbieter bündelbar	
+ Hubs außerhalb der Ballungsräume	

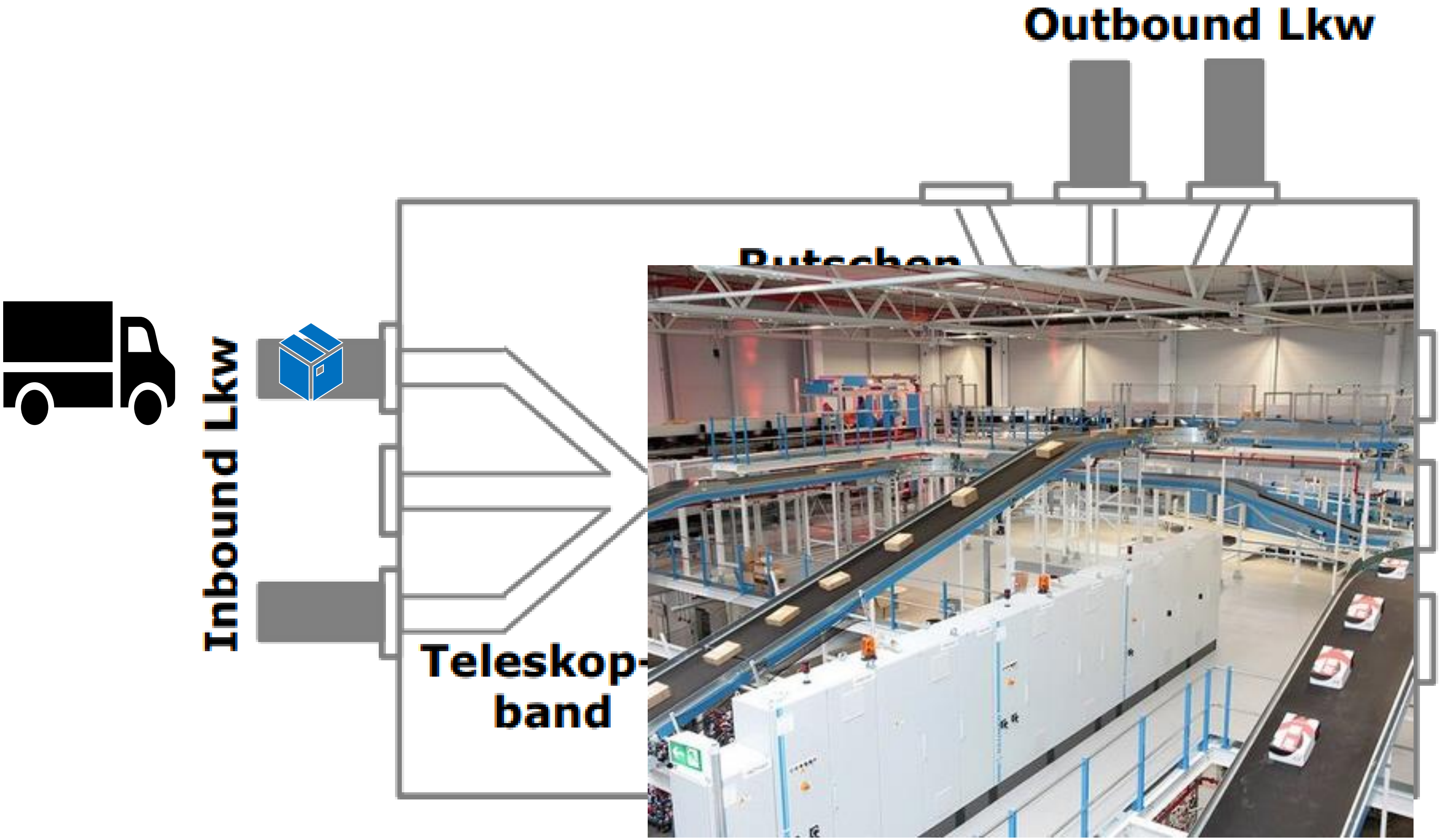
Beispiel DHL-Hub Leipzig

Hub Aufbau


Outbound Lkw
Rutschen
Inbound Lkw
OCR
Kipp-
schalen-
sortierer
Teleskop-
band

Hub Aufbau




Outbound Lkw
Inbound Lkw
Teleskop-
band

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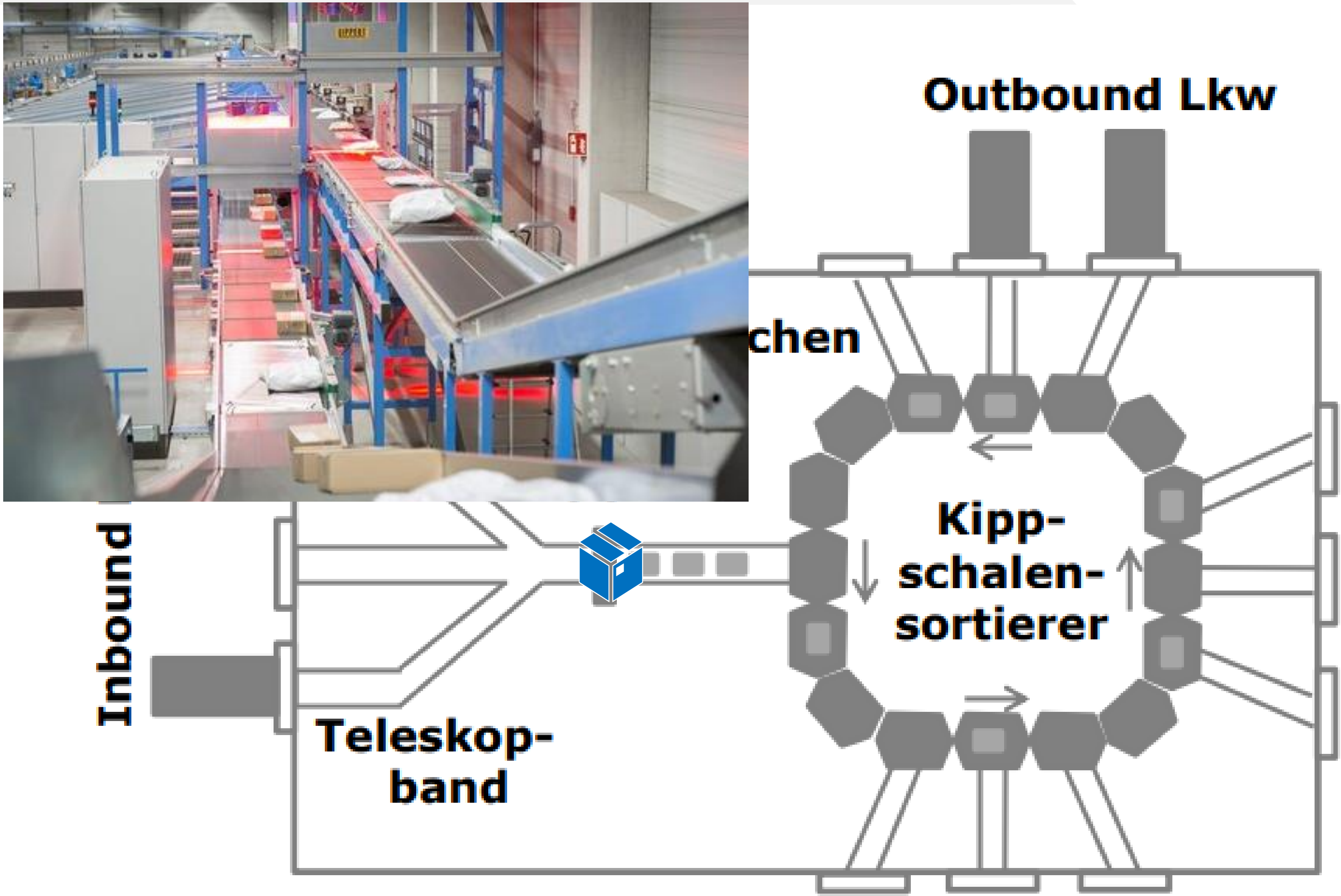

Hub Aufbau

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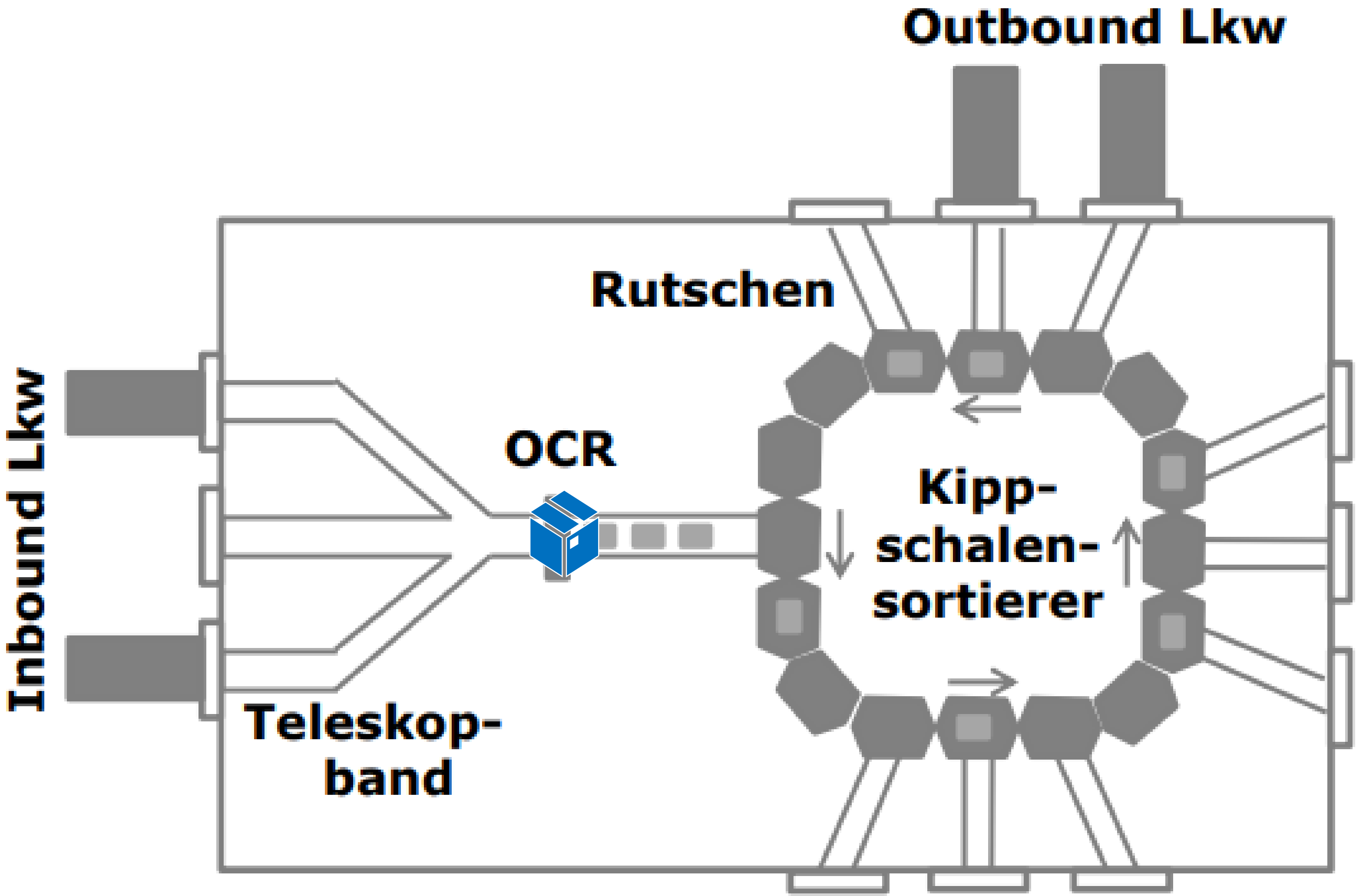

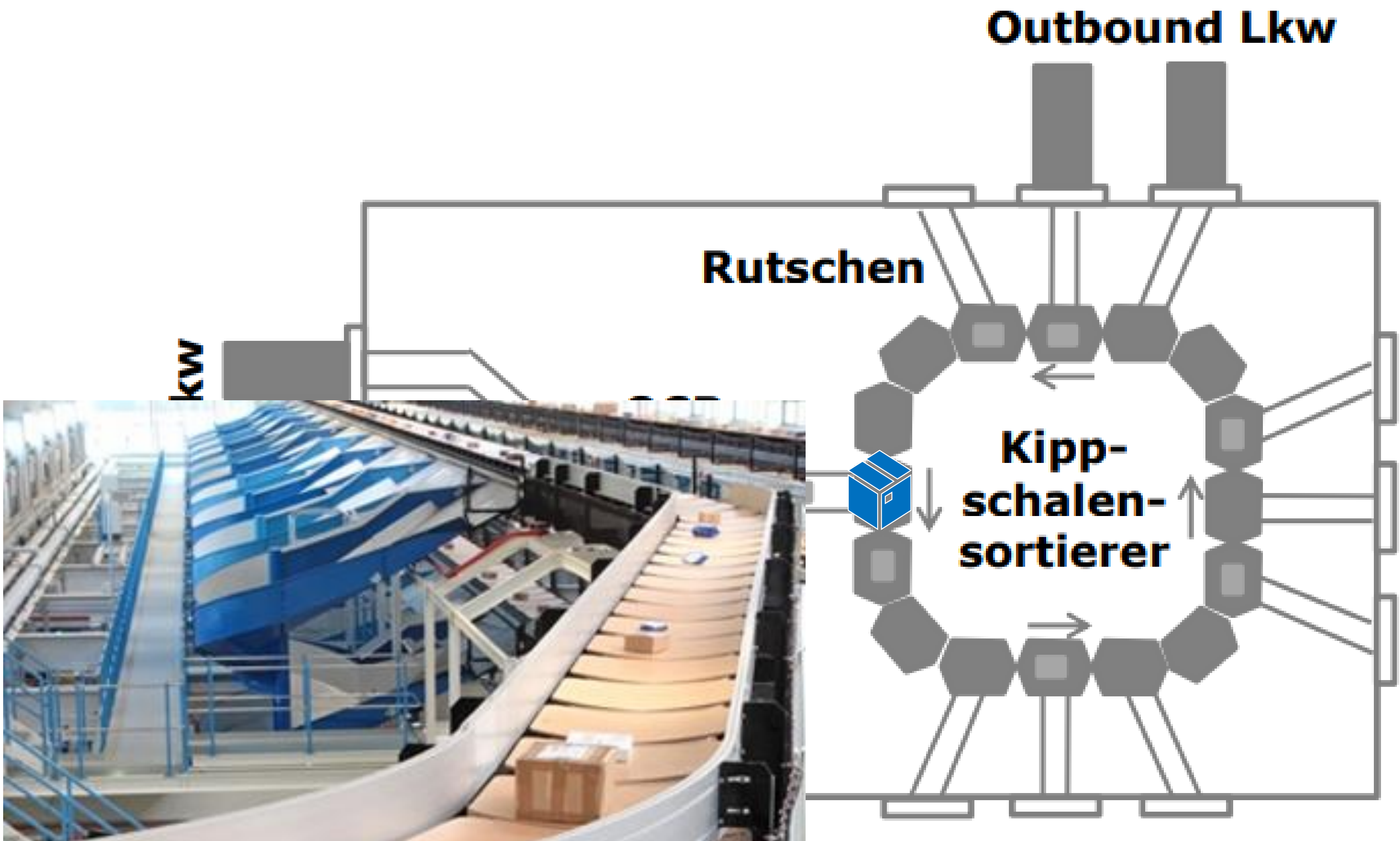
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Rutschen
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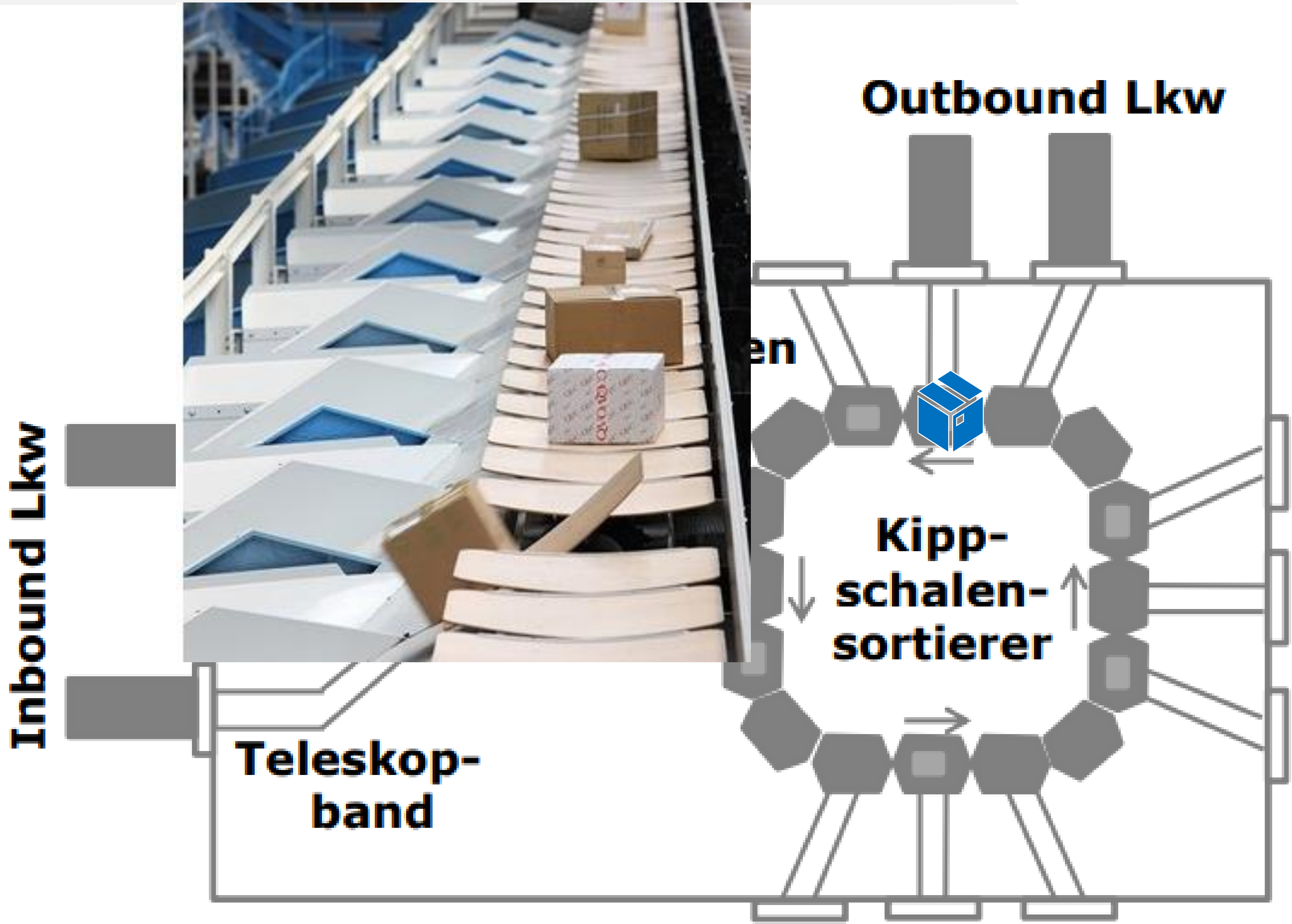
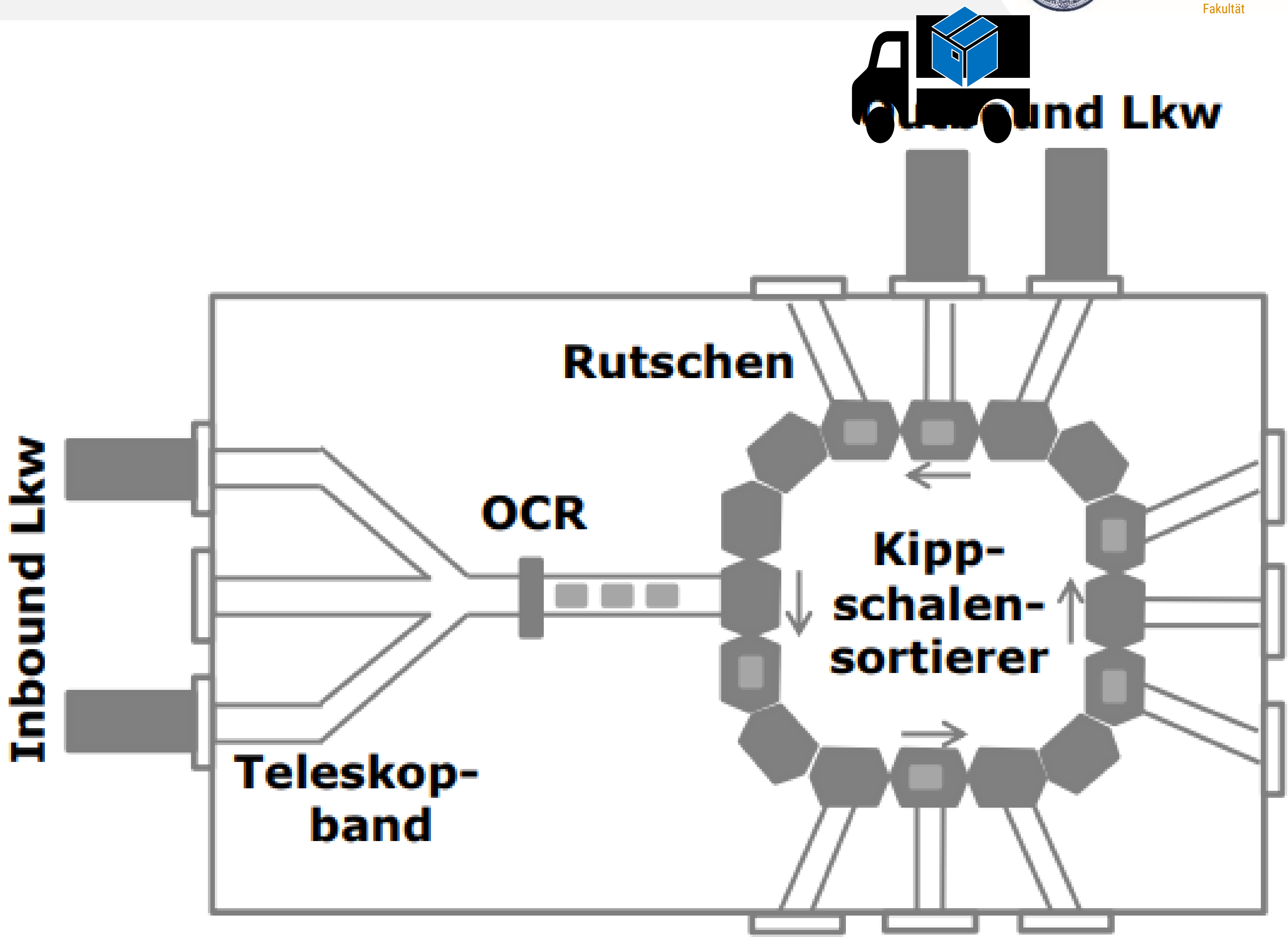


Hub Aufbau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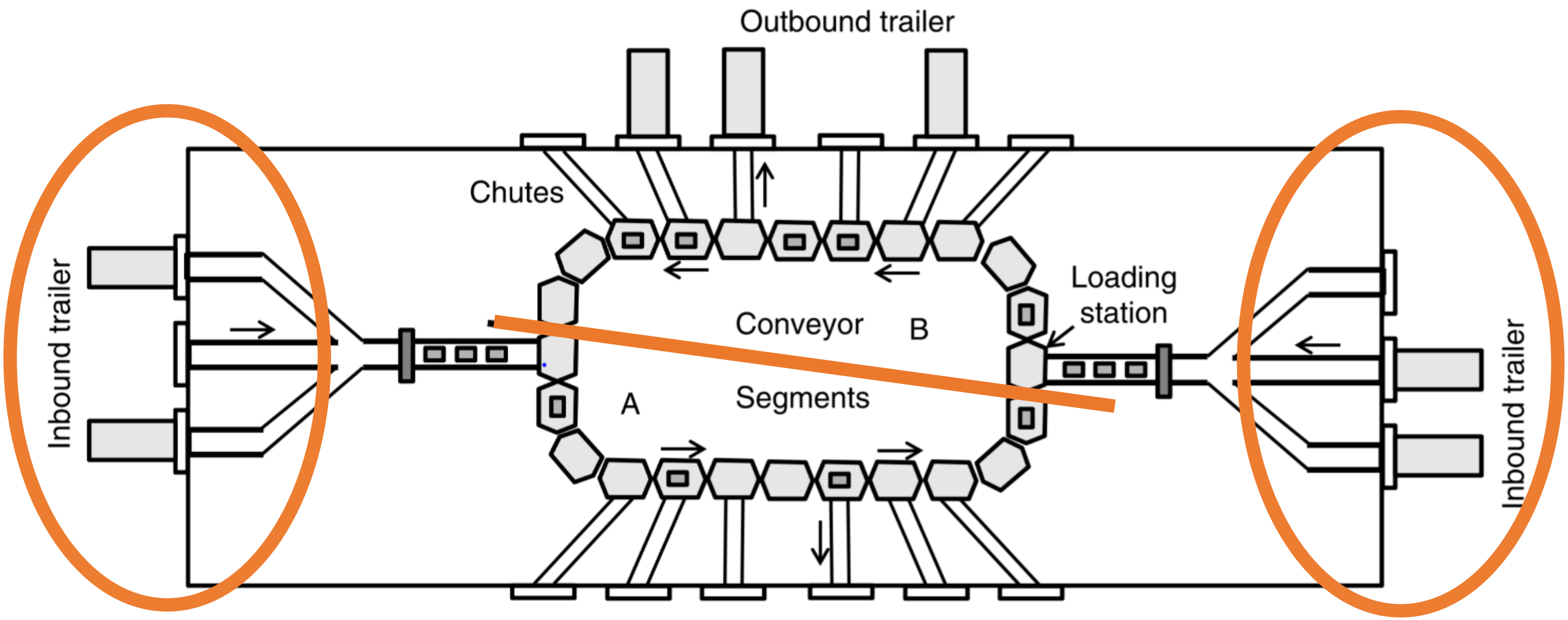
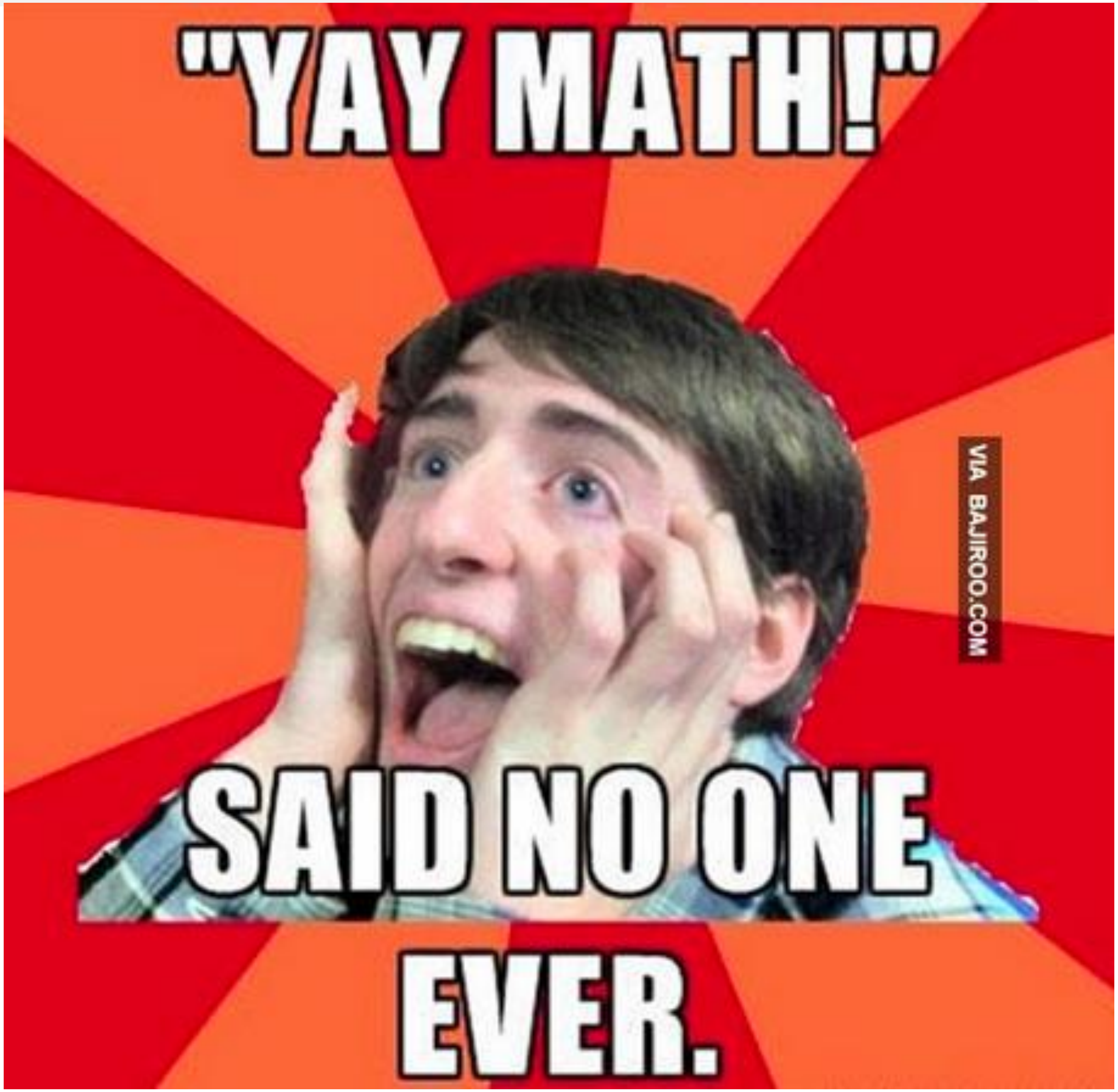
Teleskop-
band

Destination Assignment Problem



Modell



Modell

I	*Set of inbound destinations*
O	*Set of outbound destinations*
S	*Set of door segments* $S = \{1, \dots, n\}$
D_s^{in}	*Number of inbound doors in segment s*
D_s^{out}	*Number of outbound doors in segment s*
b_{io}	*Number of parcels to be shipped from inbound destination i to outbound destination o*
x_{is}	*Binary variables:* 1 *if inbound destination i is assigned to door segment s,* 0 *otherwise*
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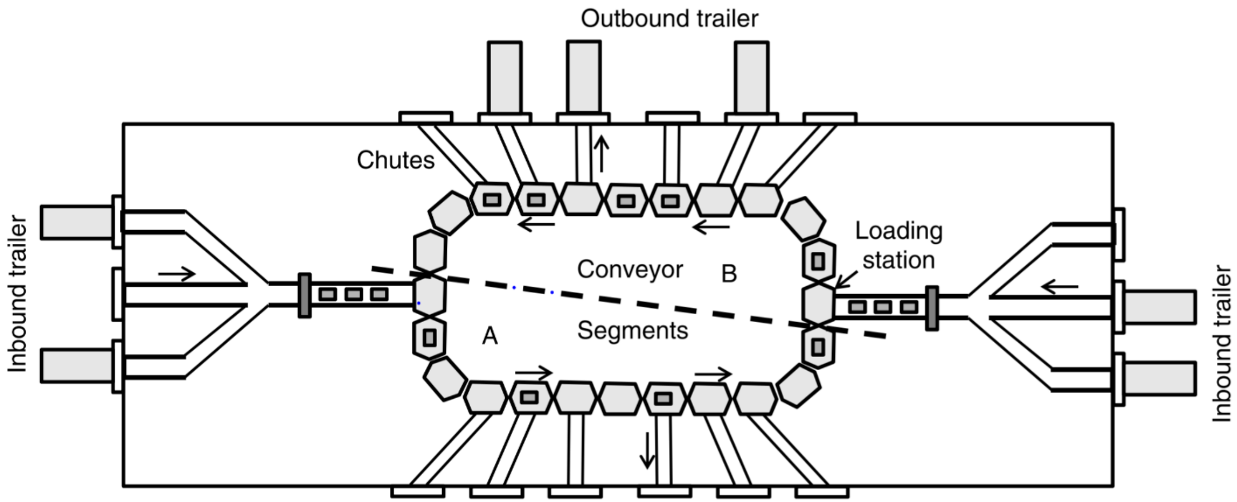

Modell

I — *Set of inbound destinations*

O — *Set of outbound destinations*

S — *Set of door segments* $S = \{1, \dots, n\}$

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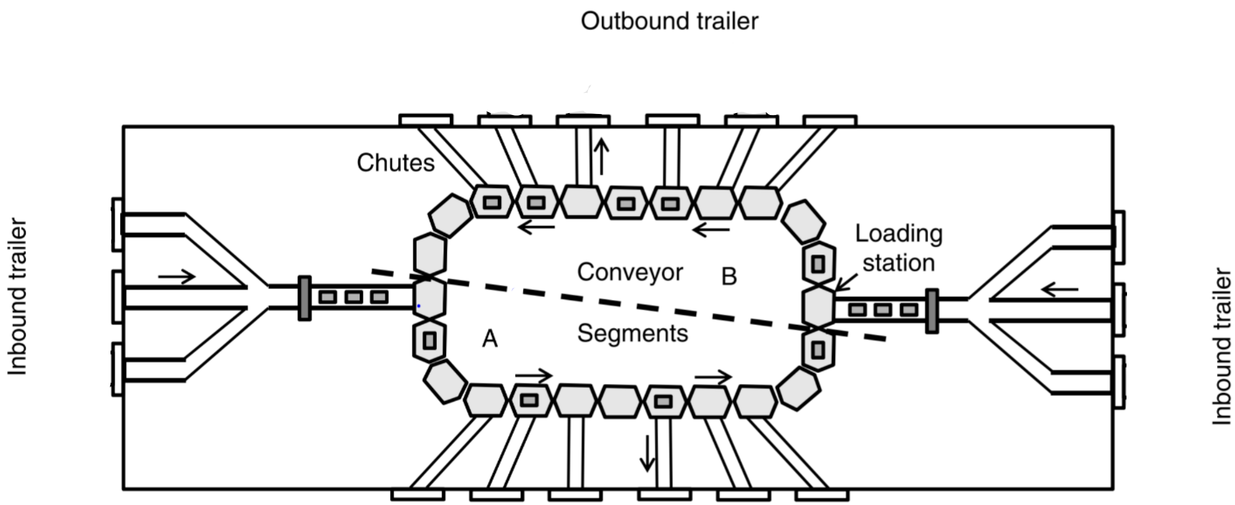
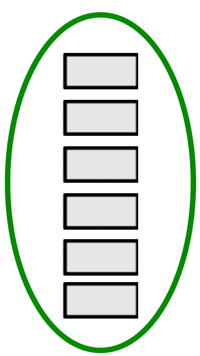
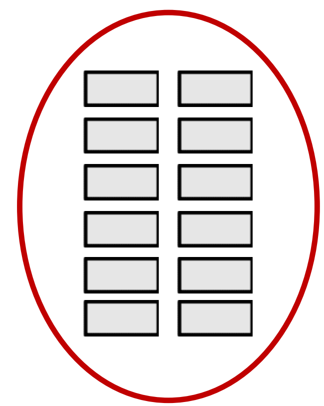


$|I| = 6$



$$1\ destination \equiv 1\ trailer$$

$|O| = 12$



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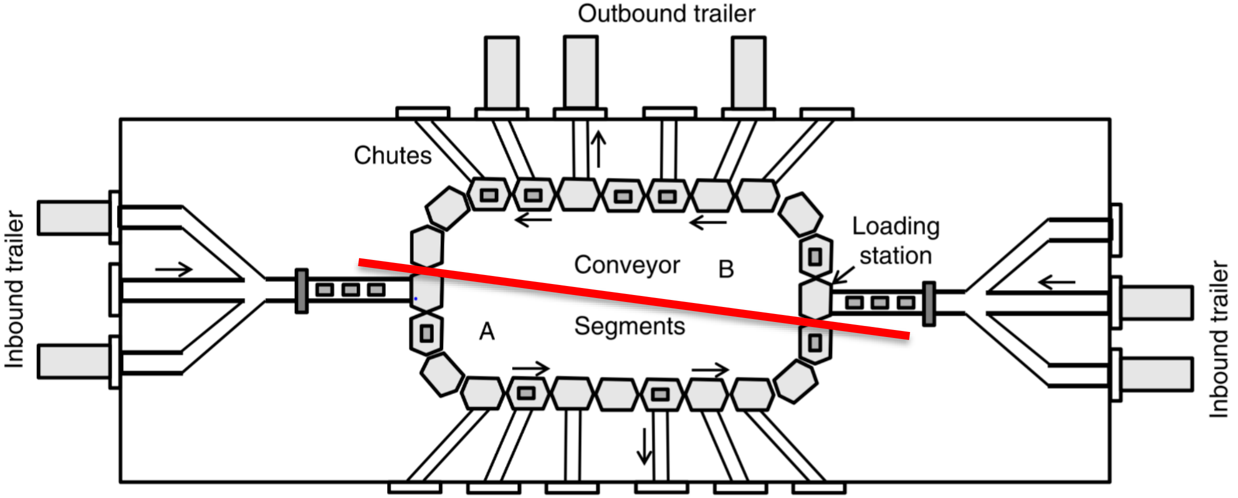

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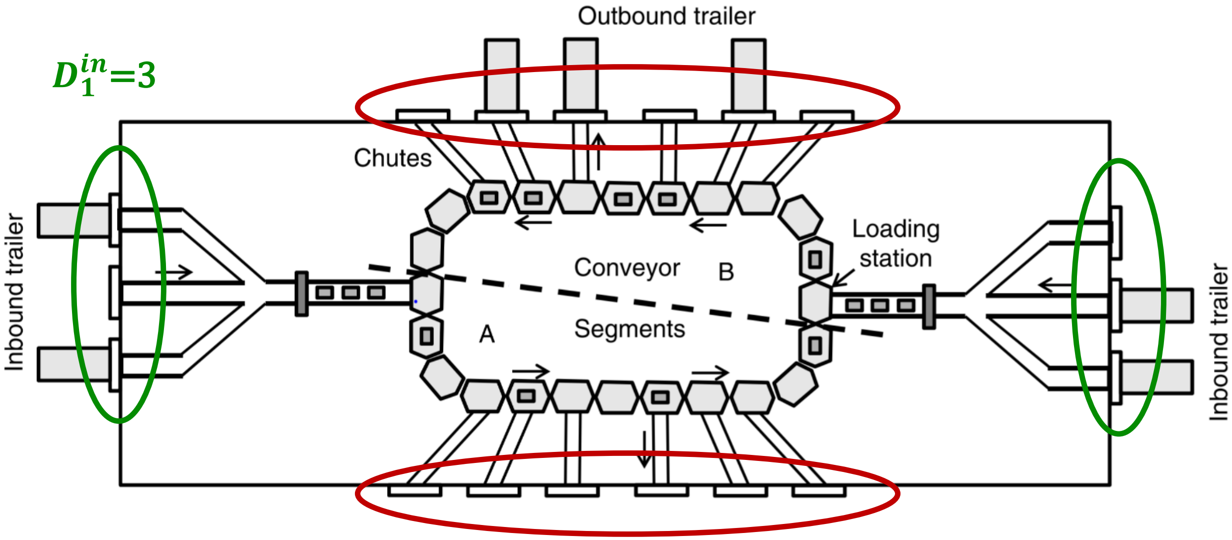
D_1^{in}=3



$D_1^{out} = 6$

$$|I| \leq \sum_{s=1}^{n} D_s^{in}$$

$$|O| \leq \sum_{s=1}^{n} D_s^{out}$$

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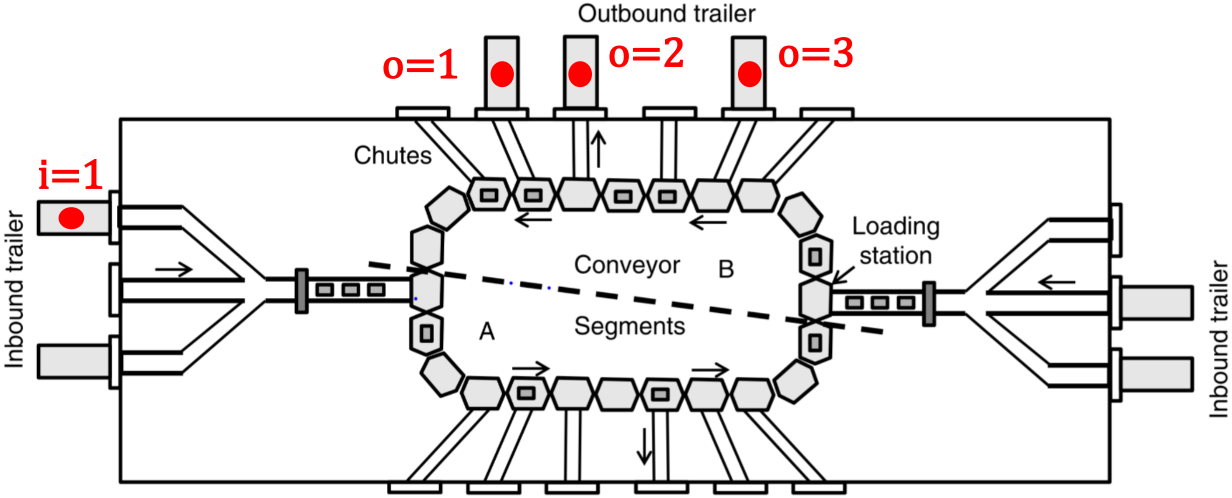

$\rightarrow b_{11} = 2$
$\rightarrow b_{12} = 5$
$\rightarrow b_{13} = 0$

Modell

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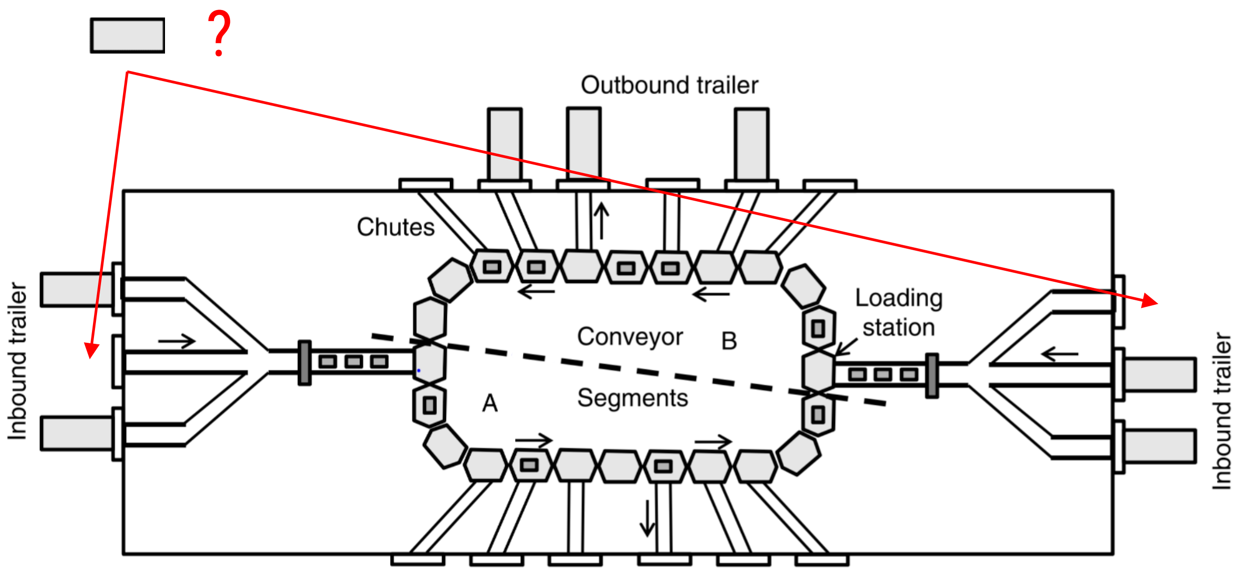

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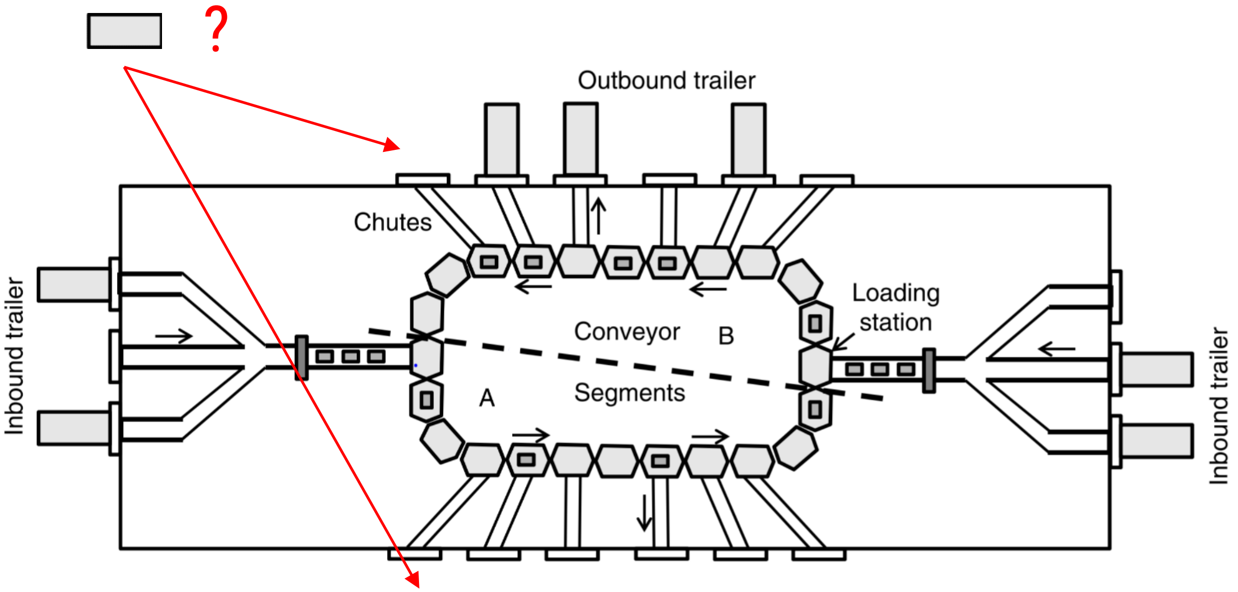

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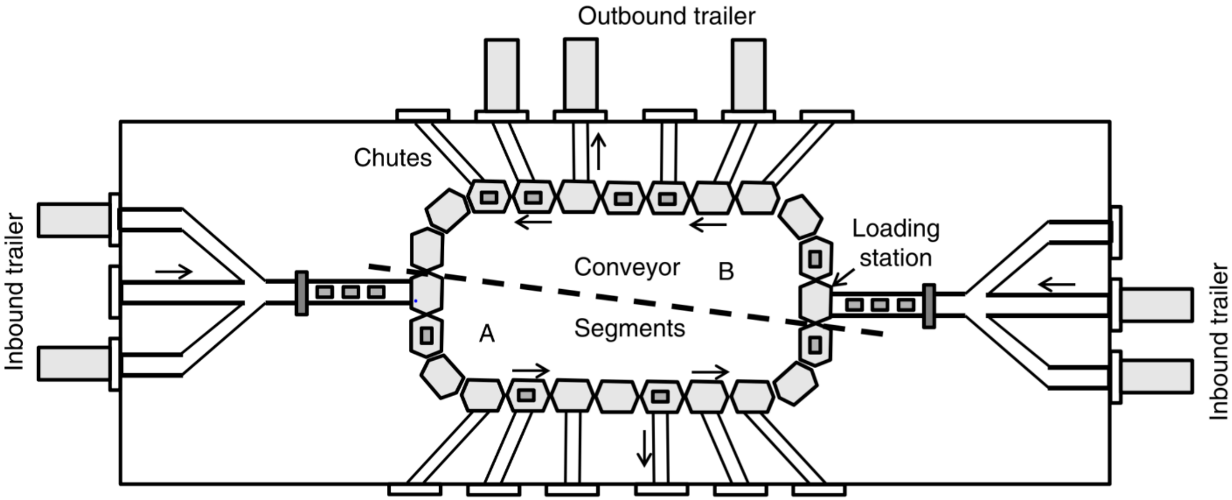

$$z_{isos'} = x_{is} * y_{os'}$$

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$$(ZF)\ \sum_{i \in I} \sum_{o \in O} b_{io} \cdot \left(\sum_{s=1}^{n} \sum_{s'=1}^{s-1} (n - (s - s')) \cdot z_{isos'} + \sum_{s=1}^{n} \sum_{s'=s}^{n} (s' - s) \cdot z_{isos'} + 1 \right) \rightarrow min$$

$$(1)\ \sum_{s \in S} x_{is} = 1 \quad \forall\, i \in I$$

$$(2)\ \sum_{s \in S} y_{os} = 1 \quad \forall\, o \in O$$

$$(3)\ \sum_{i \in I} x_{is} \leq D_s^{in} \quad \forall\, s \in S$$

$$(4)\ \sum_{o \in O} y_{os} \leq D_s^{out} \quad \forall\, s \in S$$

$$(5)\ 2 \cdot z_{isos'} \leq x_{is} + y_{os'} \quad \forall\, i \in I; o \in O; s, s' \in S$$

$$(6)\ z_{isos'} \leq x_{is} + y_{os'} - 1 \quad \forall\, i \in I; o \in O; s, s' \in S$$

$$(7)\ x_{is}, y_{os'}, z_{isos'} \in \{0,1\}$$

Modell

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Binärbedingungen für alle Entscheidungsvariablen

Modell

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$$x + y \neq 2 \rightarrow z = 0$$

$$2*0 \leq 0 + 1$$
$$2*0 \leq 1 + 0$$
$$2*0 \leq 0 + 0$$

Zulässig:

$$\mathbf{2*1 \leq 1 + 1}$$
$$\mathbf{2*0 \leq 1 + 1}$$

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$$(6)\ z_{isos'} \geq x_{is} + y_{os'} - 1 \quad \forall\, i \in I; o \in O; s, s' \in S$$

$$x + y = 2 \rightarrow z = 1$$

$$0 \geq 1 + 1 - 1$$

$$0 \geq 1$$

Unzulässig!

→ Sicherstellung: $z = 1$ wenn $x + y = 2$

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$$(3) \sum_{i \in I} x_{is} \leq D_s^{in} \quad \forall\, s \in S$$

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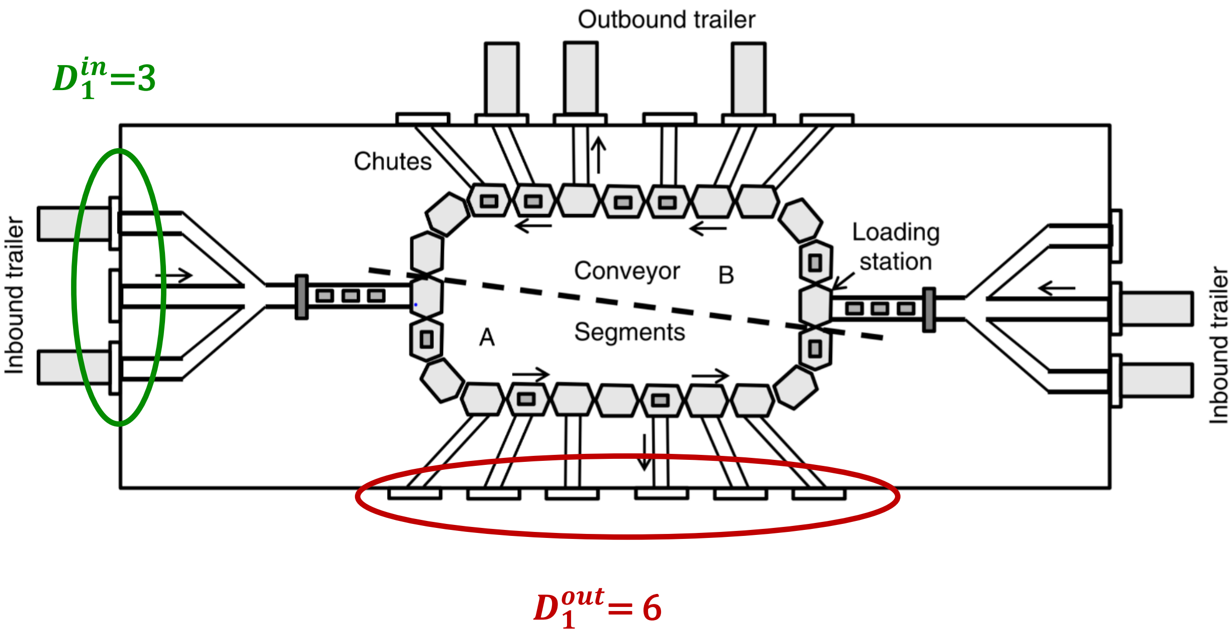

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$$(1) \sum_{s \in S} x_{is} = 1 \quad \forall\, i \in I$$

$$(2) \sum_{s \in S} y_{os} = 1 \quad \forall\, o \in O$$

→ Jeder (1) in- / (2) outbound destination wird genau einem Segment zugeordnet

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Modell

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Gewichtung

$$\sum_{i \in I} \sum_{o \in O} b_{io} \cdot (\dots) \rightarrow min$$

→ Minimiere die Summe der gewichteten Pakete

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I	*Set of inbound destinations*
O	*Set of outbound destinations*
S	*Set of door segments* $S = \{1, \dots, n\}$
D_s^{in}	*Number of inbound doors in segment s*
D_s^{out}	*Number of outbound doors in segment s*
b_{io}	*Number of parcels to be shipped from inbound destination i to outbound destination o*
x_{is}	*Binary variables:* 1 *if inbound destination i is assigned to door segment s,* 0 *otherwise*
y_{os}	*Binary variables:* 1 *if outbound destination o is assigned to door segment s,* 0 *otherwise*
$z_{isos'}$	*Auxiliary variables* $z_{isos'} = x_{is} * y_{os'}$

$$(ZF) \sum_{i \in I} \sum_{o \in O} b_{io} \cdot \left(\sum_{s=1}^{n} \sum_{s'=1}^{s-1} (n - (s - s')) \cdot z_{isos'} + \sum_{s=1}^{n} \sum_{s'=s}^{n} (s' - s) \cdot z_{isos'} + 1 \right) \rightarrow min$$

Gewichtung entsprechend dem zurückgelegten **Weg der Pakete** von **i zu o**

↑ Anzahl der Pakete & ↑ Weg der Pakete
→ ↑ ZFW

Modell

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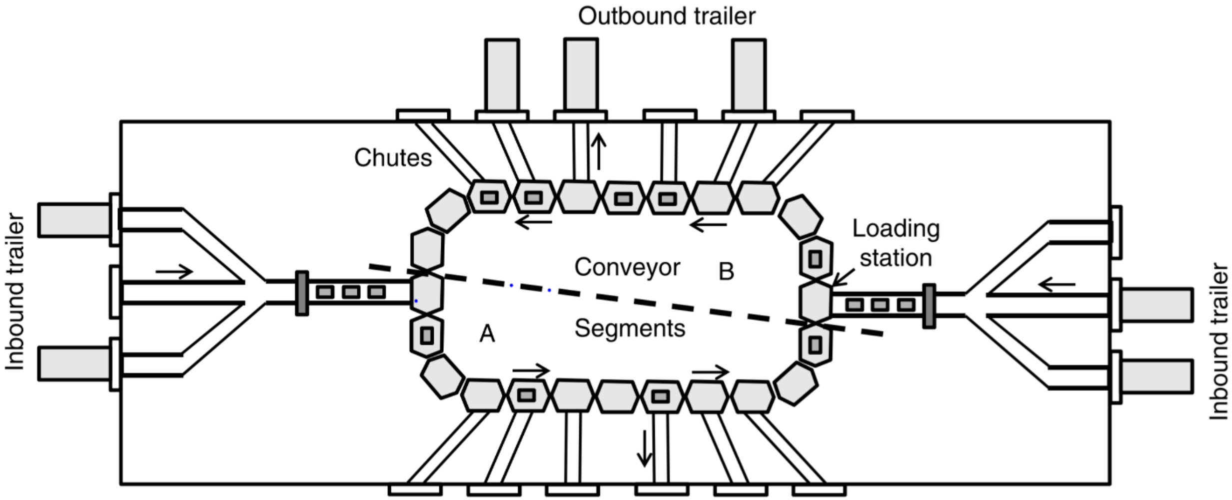
$$\sum_{s=1}^{n} \sum_{s'=1}^{s-1} (n - (s - s')) \cdot z_{isos'}$$

wird einbezogen wenn: s > s'

Beispiel: n=2, s=2, s'=1

(2 – (2 – 1)) = 1



Modell

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$z_{isos'}$	*Auxiliary variables* $z_{isos'} = x_{is} * y_{os'}$

$$\sum_{s=1}^{n} \sum_{s'=s}^{n} (s' - s) \cdot z_{isos'}$$

wird einbezogen wenn: s ≤ s‘

Beispiel: n=2

s=1, s‘=1

(1 – 1) = 0

s=1, s‘=2

(2 – 1) = 1

Modell

I	*Set of inbound destinations*
O	*Set of outbound destinations*
S	*Set of door segments* $S = \{1, \dots, n\}$
D_s^{in}	*Number of inbound doors in segment s*
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b_{io}	*Number of parcels to be shipped from inbound destination i to outbound destination o*
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$z_{isos'}$	*Auxiliary variables* $z_{isos'} = x_{is} * y_{os'}$

$$(ZF)\ \sum_{i\in I}\sum_{o\in O} b_{io}\cdot\left(\sum_{s=1}^{n}\sum_{s'=1}^{s-1}\left(n-(s-s')\right)\cdot z_{isos'} + \sum_{s=1}^{n}\sum_{s'=s}^{n}(s'-s)\cdot z_{isos'} + 1\right)$$

n=3 s|s'	(n - (s - s'))	(s'-s)	1	Σ
2|1	2-(2-1)=1		1	2
1|1		(1-1)=0	1	1
1|2		(2-1)=1	1	2

Modell

I	*Set of inbound destinations*
O	*Set of outbound destinations*
S	*Set of door segments* $S = \{1, \dots, n\}$
D_s^{in}	*Number of inbound doors in segment s*
D_s^{out}	*Number of outbound doors in segment s*
b_{io}	*Number of parcels to be shipped from inbound destination i to outbound destination o*
x_{is}	*Binary variables:* 1 *if inbound destination i is assigned to door segment s,* 0 *otherwise*
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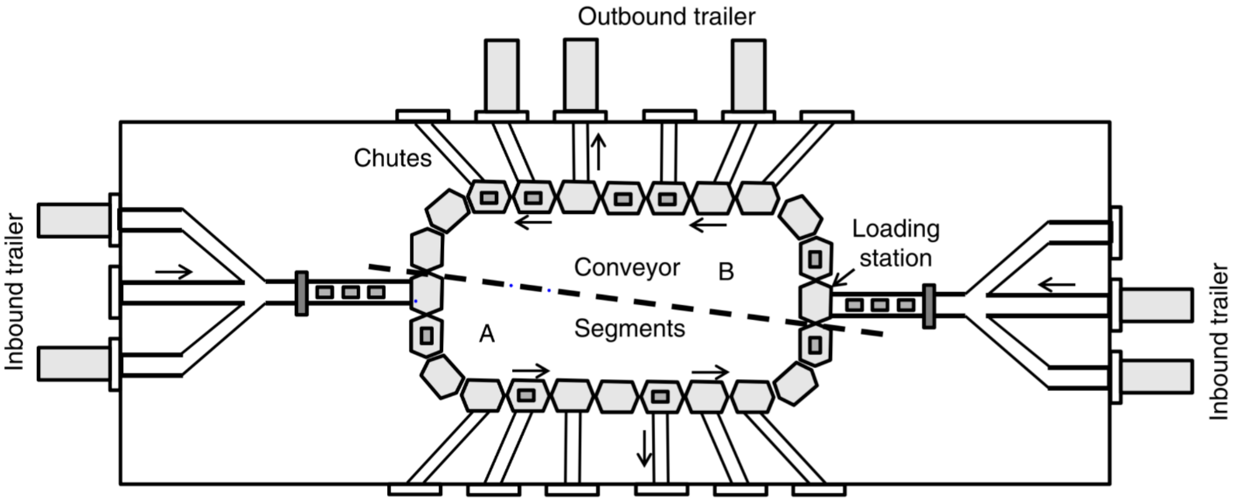
$z_{isos'}$	*Auxiliary variables* $z_{isos'} = x_{is} * y_{os'}$

n=3 s|s'	(n - (s - s'))	(s'-s)	1	Σ
2|1	2-(2-1)=1		1	2
1|1		(1-1)=0	1	1
1|2		(2-1)=1	1	2

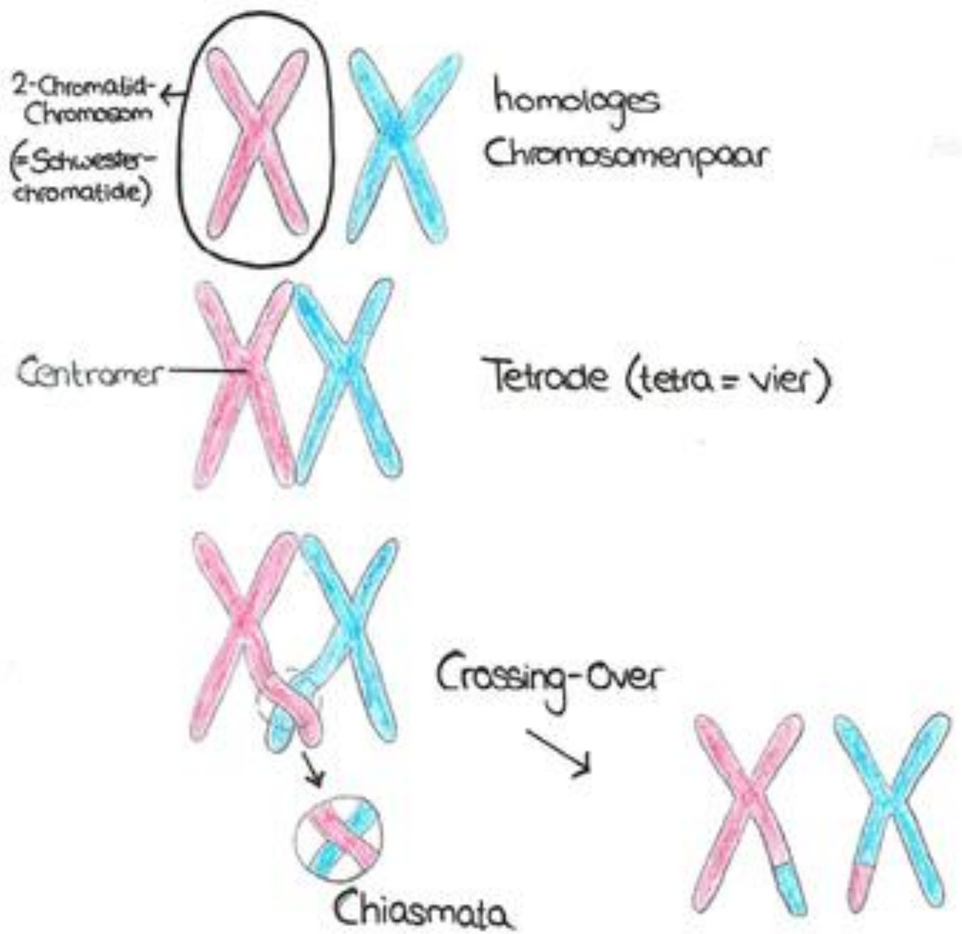


Modell

I	*Set of inbound destinations*
O	*Set of outbound destinations*
S	*Set of door segments* $S = \{1, \dots, n\}$
D_s^{in}	*Number of inbound doors in segment* s
D_s^{out}	*Number of outbound doors in segment* s
b_{io}	*Number of parcels to be shipped from inbound destination* i *to outbound destination* o
x_{is}	*Binary variables:* 1 *if inbound destination* i *is assigned to door segment* s, 0 *otherwise*
y_{os}	*Binary variables:* 1 *if outbound destination* o *is assigned to door segment* s, 0 *otherwise*
$z_{isos'}$	*Auxiliary variables* $z_{isos'} = x_{is} * y_{os'}$

$$(ZF) \sum_{i \in I} \sum_{o \in O} b_{io} \cdot \left(\sum_{s=1}^{n} \sum_{s'=1}^{s-1} \big(n - (s - s')\big) \cdot z_{isos'} + \sum_{s=1}^{n} \sum_{s'=s}^{n} (s' - s) \cdot z_{isos'} + 1 \right) \rightarrow min$$

Genetischer Algorithmus


2-Chromatid-Chromosom
(=Schwester-chromatide)
homologes Chromosomenpaar
Centromer
Tetrade (tetra = vier)
Crossing-Over
Chiasmata

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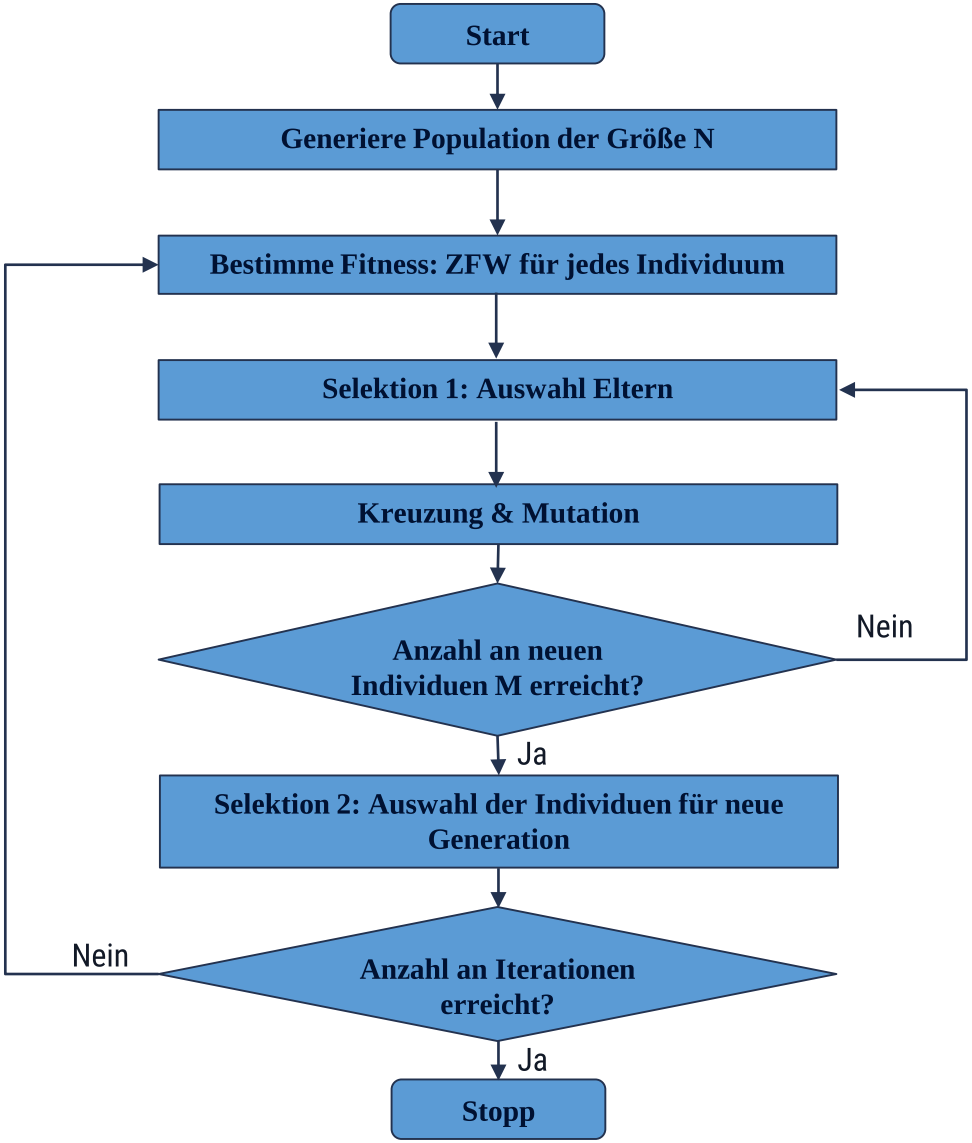
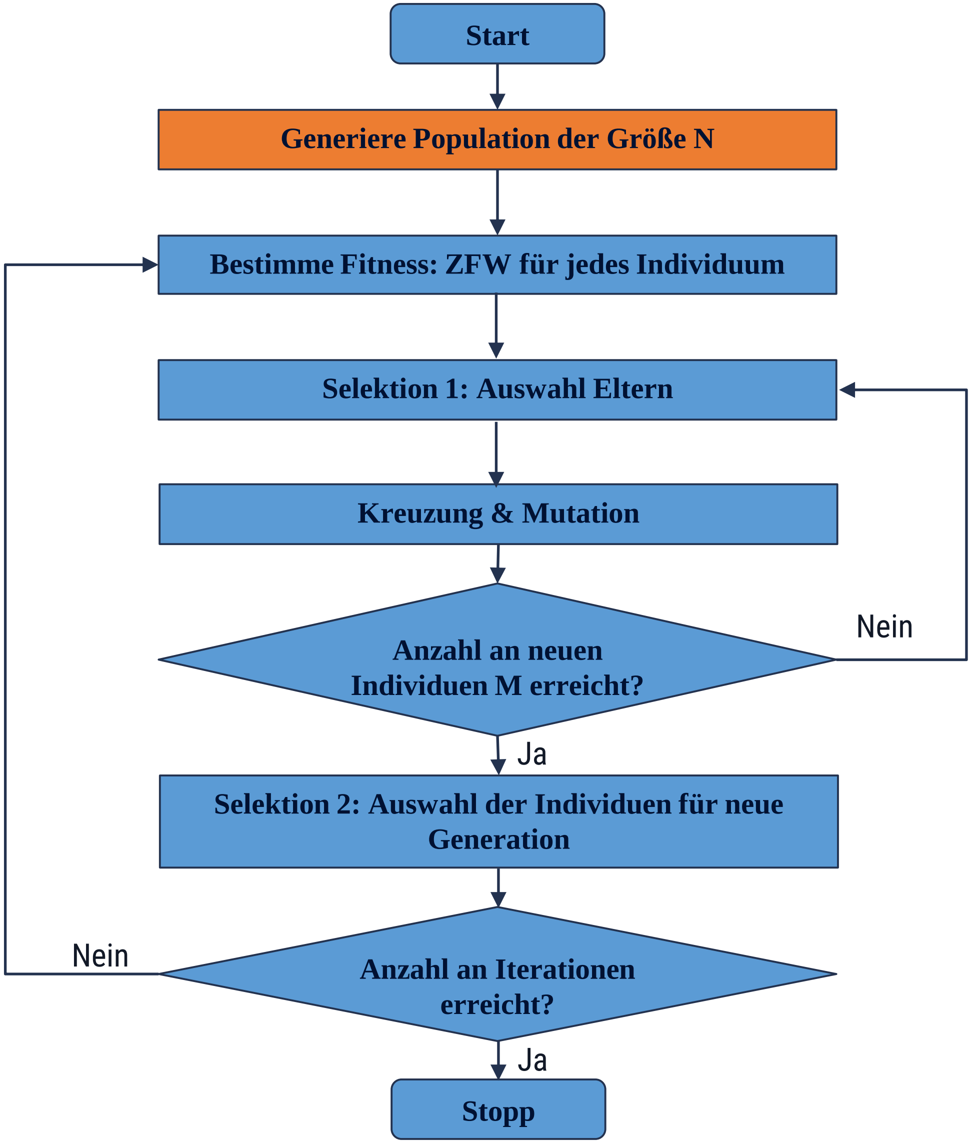


Ablaufdiagramm



Beispiel

$$I = \{1,2,3\}$$
$$O = \{1,2,3,4,5,6\}$$

$$n = 2$$
$$\pi_i = [1,2,1] \rightarrow fix!$$

$$D_1^{out} = 4$$
$$D_2^{out} = 2$$

$$\mu_o \rightarrow optimieren$$

b_{io}	1	2	3	4	5	6
1	2	3	0	2	0	4
2	0	1	0	3	2	0
3	2	0	4	3	2	0

1. generieren von Ausgangslösungen(Zufall), der Größe N = 4

Outbound destination o:

1	2	3	4	5	6

Lösung 1:

1	1	1	1	2	2

Lösung 2:

1	2	2	1	1	1

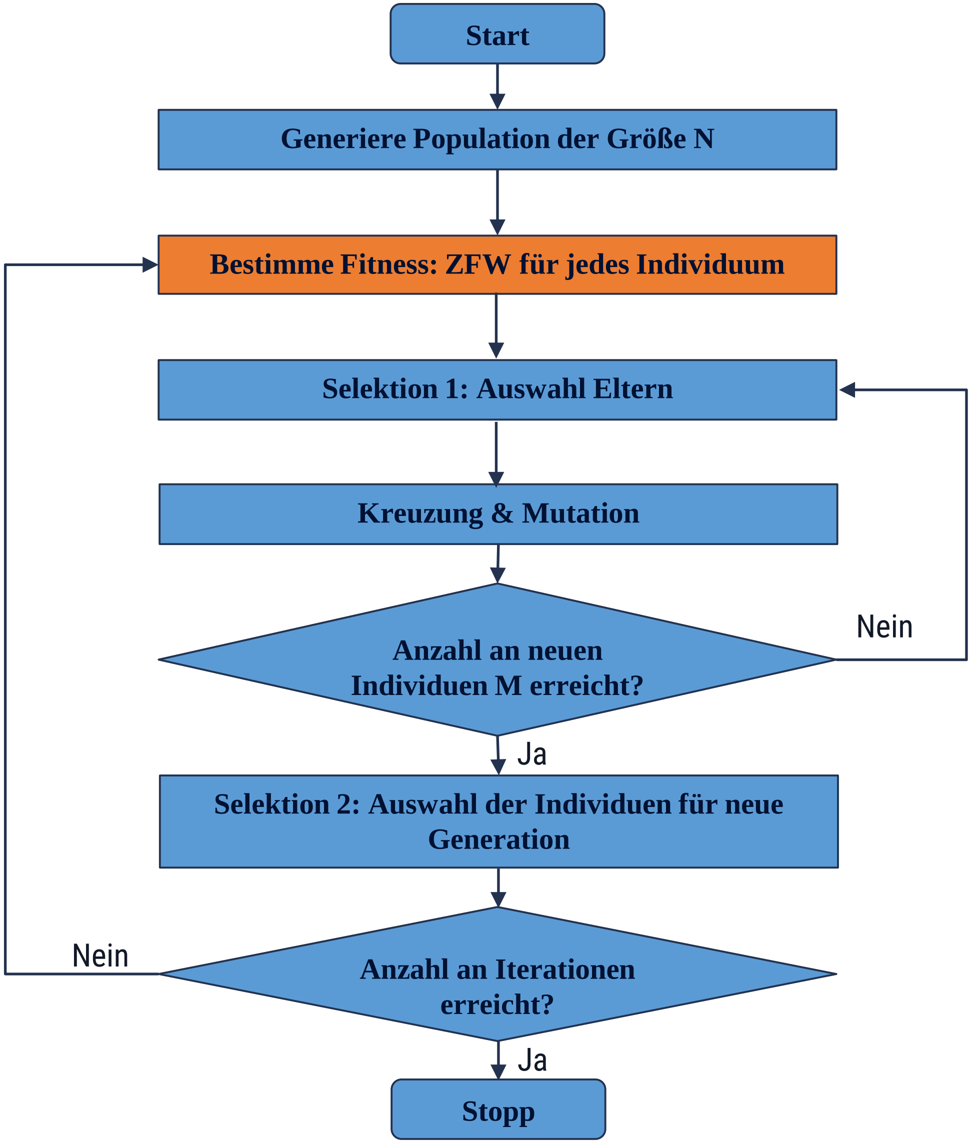
Lösung 3:

2	1	1	1	2	1

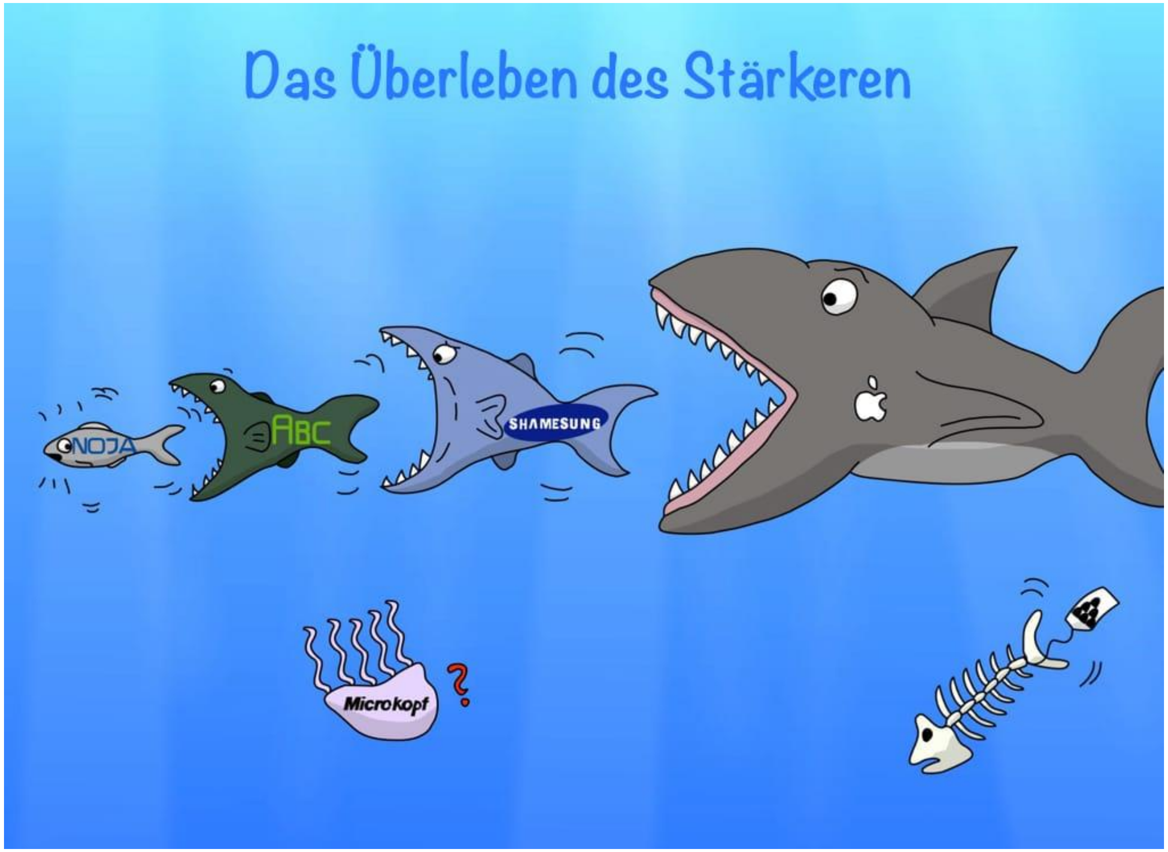
Lösung 4:

1	2	1	2	1	1

Ablaufdiagramm



Lösungen bewerten (Fitnesswert)



ZFW berechnen: $Z(\mu) = \sum_{i \epsilon I} \sum_{o \epsilon O} b_{io} \cdot \left(\left((\mu_o - \pi_i) mod\ n \right) + 1 \right) \rightarrow min$

$Z^1 = 2 \cdot \left(\left((1 - 1) mod\ 2 \right) + 1 \right) + 3 \cdot \left(\left((1 - 1) mod\ 2 \right) + 1 \right) + 0 \cdot \left(\left((1 - 1) mod\ 2 \right) + 1 \right) +$
$2 \cdot \left(\left((1 - 1) mod\ 2 \right) + 1 \right) + 0 \cdot \left(\left((2 - 1) mod\ 2 \right) + 1 \right) + 4 \cdot \left(\left((2 - 1) mod\ 2 \right) + 1 \right)$

$+0 \cdot \left(\left((1 - 2) mod\ 2 \right) + 1 \right) + 1 \cdot \left(\left((1 - 2) mod\ 2 \right) + 1 \right) + \cdots$
$+2 \cdot 1 + 0 \cdot 1 + \cdots$

$Z^1 = 38$

$\pi_i = [1,2,1]$

b_{io}	1	2	3	4	5	6
1	2	3	0	2	0	4
2	0	1	0	3	2	0
3	2	0	4	3	2	0

Lösung 1:

o	1	2	3	4	5	6
s	1	1	1	1	2	2

Fitness

Lösung 1:

1	1	1	1	2	2

Lösung 2:

1	2	2	1	1	1

Lösung 3:

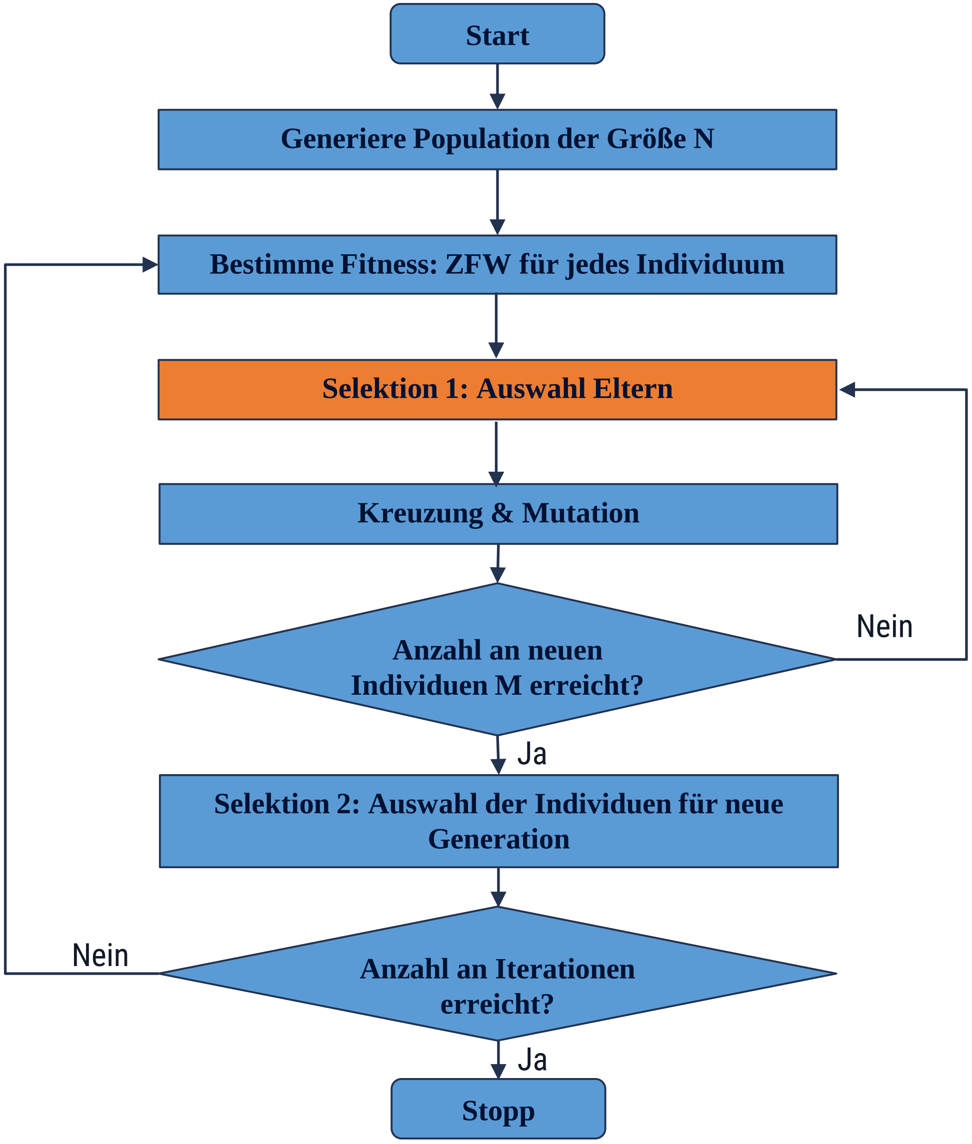
2	1	1	1	2	1

Lösung 4:

1	2	1	2	1	1

$$Z^1 = 38$$
$$Z^2 = 40$$
$$Z^3 = 38$$
$$Z^4 = 40$$

Ablaufdiagramm



Selektion: Rangbasierte Selektion

Erstelle eine Rangliste der Individuen bzgl. ihrer Fitness
Sei I_1 das beste und I_N das schlechteste Individuum
Wähle I_k mit Wahrscheinlichkeit:

$$Pr[I_k] = \frac{2}{N} \cdot \left(1 - \frac{k-1}{N-1}\right)$$

$$Z^1 = 38 \quad Z^2 = 40 \quad Z^3 = 38 \quad Z^4 = 40$$

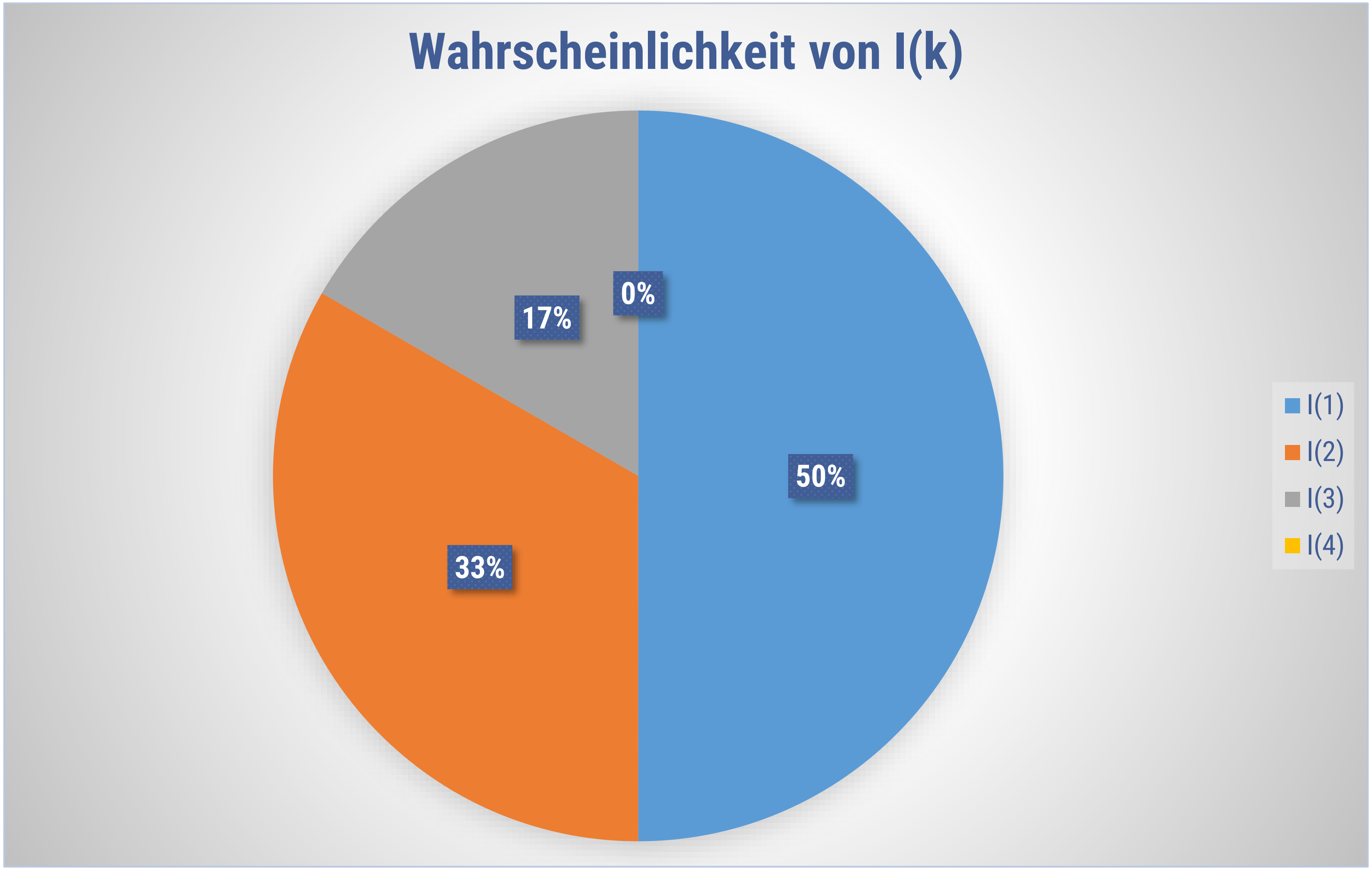
$$\longrightarrow \quad I_1 \quad I_3 \quad I_2 \quad I_4 \quad \longrightarrow$$

$$Pr[I_1] = \frac{2}{4} \cdot \left(1 - \frac{1-1}{4-1}\right) = \mathbf{\frac{1}{2}}$$

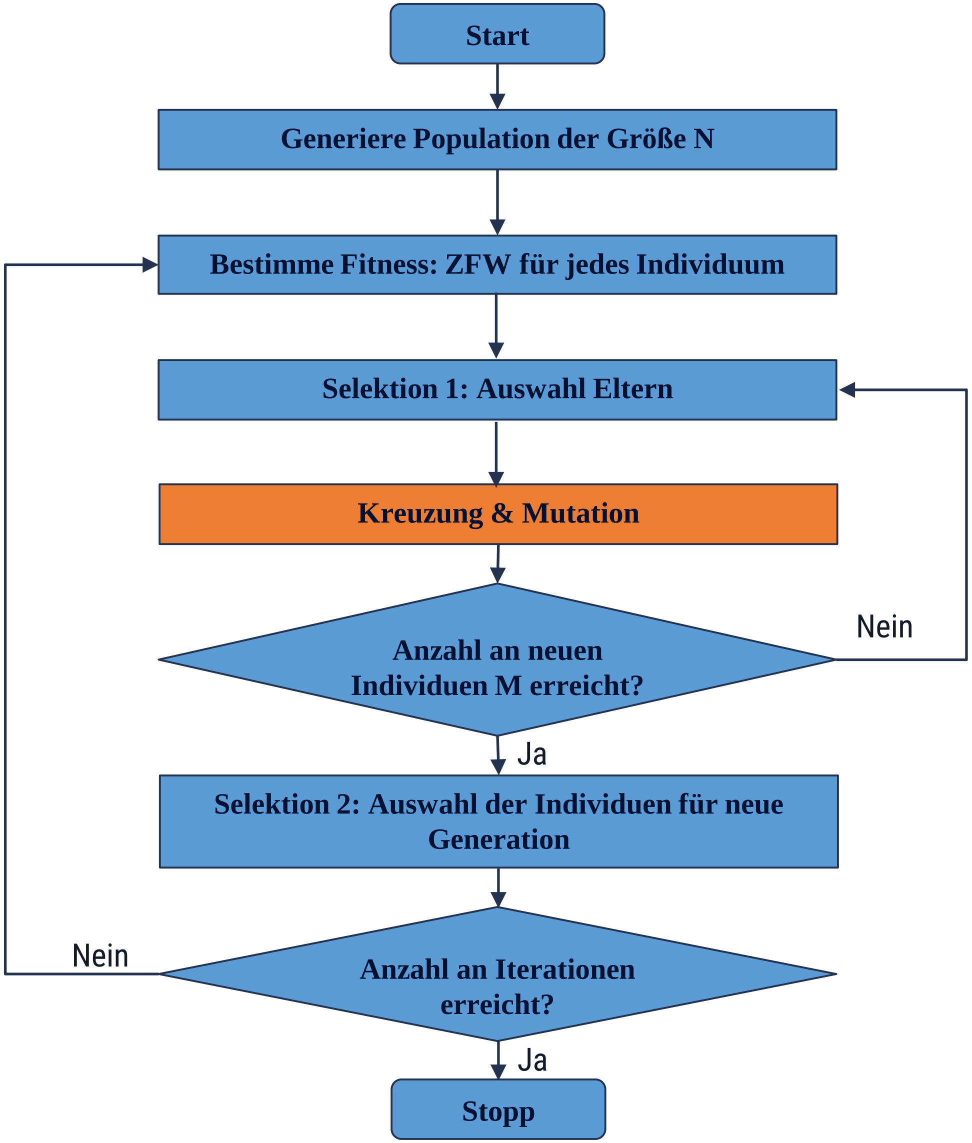
$$Pr[I_3] = \frac{2}{4} \cdot \left(1 - \frac{3-1}{4-1}\right) = \mathbf{\frac{1}{6}}$$

$$Pr[I_2] = \frac{2}{4} \cdot \left(1 - \frac{2-1}{4-1}\right) = \mathbf{\frac{1}{3}}$$

$$Pr[I_4] = \frac{2}{4} \cdot \left(1 - \frac{4-1}{4-1}\right) = \mathbf{0}$$


Wahrscheinlichkeit von I(k)
0%
17%
50%
33%
I(1)
I(2)
I(3)
I(4)

Ablaufdiagramm



Kreuzung

- One-Point crossover: Bestimme Cross-Over-Point(COP) und kombiniere die Eltern

Lösung 1:

1	1	1	1	2	2

Lösung 3:

2	1	1	2	2	1

Zufällige Auswahl des Crossover-Points

Elternteil 1:

1	1	1	1	2	2

Elternteil 2:

2	1	1	1	2	1

Kind 1:

1	1	2	1	1	2

Kind 2:

2	1	1	1	1	2

Nach CP → auffüllen nach Index des 2 Elternteils

Mutation: Bestimme Mutationspunkt (MP) und verändere die Nachkommen

Mutationsrate: 10%

Mutationspunktstellen

Kind 1: $Z^1=40$

1	1	2	1	1	2

Kind 1a: $ZF^{1a}=38$

1	1	2	1	2	1

Erstellung Nachbarschaftsliste:
→Unterscheidung der Elemente

Elternteil 1:

1‘	**1“**	**1“‘**	**1““**	**2‘**	**2“**

Elternteil 2:

2‘	**1‘**	**1“**	**1“‘**	**2“**	**1““**

Nachbarschaftsliste:

1‘	1“	2“	2‘	
1“	1‘	1“‘		
1“‘	1“	1““	2“	
1““	1“‘	2‘	2“	
2‘	1““	2“	1‘	
2“	2‘	1‘	1“‘	1““

Egde recombination crossover (ERX):

- Starte mit dem Anfangswert eines zufälligen Elternteils
- Lösche gewählten Knoten aus allen Nachbarschaften

1‘					

~~**1‘**~~	~~1“~~	~~2“~~	~~2‘~~	
1“	~~1‘~~	1“‘		
1“‘	1“	1““	2“	
1““	1“‘	2‘	2“	
2‘	1““	2“	~~1‘~~	
2“	2‘	~~1‘~~	1“‘	1““

Egde recombination crossover(ERX):

Solange das Kind nicht fertig ist:

- Wähle als Nachfolger den Nachbar mit der kürzesten Nachbarliste (zufällige Wahl falls mehrere solche existieren)

1'	**1''**				

~~**1'**~~	~~1''~~	~~2''~~	~~2'~~	
1''	~~1'~~	1'''		
1'''	1''	1''''	2''	
1''''	1'''	2'	2''	
2'	1''''	2''	~~1'~~	
2''	2'	~~1'~~	1'''	1''''

Egde recombination crossover(ERX):

Solange das Kind nicht fertig ist:

- Wähle als Nachfolger den Nachbar mit der kürzesten Nachbarliste (zufällige Wahl falls mehrere solche existieren)

1‘	1“				

~~**1‘**~~	~~1“~~	~~2“~~	~~2‘~~	
~~**1“**~~	~~1‘~~	~~1‘‘‘~~		
1‘‘‘	~~1“~~	1‘‘‘‘	2“	
1‘‘‘‘	1‘‘‘	2‘	2“	
2‘	1‘‘‘‘	2“	~~1‘~~	
2“	2‘	~~1‘~~	1‘‘‘	1‘‘‘‘

Egde recombination crossover(ERX):

Solange das Kind nicht fertig ist:

- Wähle als Nachfolger den Nachbar mit der kürzesten Nachbarliste (zufällige Wahl falls mehrere solche existieren)

1‘	**1“**	**2‘**			

~~**1‘**~~	~~1“~~	~~2“~~	~~2‘~~	
~~**1“**~~	~~1‘~~	~~1“‘~~		
1“‘	~~1“~~	1““	2“	
1““	1“‘	~~2‘~~	2“	
~~**2‘**~~	~~1““~~	~~2“~~	~~1‘~~	
2“	~~2‘~~	~~1‘~~	1“‘	1““

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Egde recombination crossover(ERX):

Solange das Kind nicht fertig ist:

- Wähle als Nachfolger den Nachbar mit der kürzesten Nachbarliste (zufällige Wahl falls mehrere solche existieren)

1'	1''	2'	1''''		

~~1'~~	~~1''~~	~~2''~~	~~2'~~	
~~1''~~	~~1'~~	~~1'''~~		
1'''	~~1''~~	~~1''''~~	2''	
~~1''''~~	~~1'''~~	~~2'~~	~~2''~~	
~~2'~~	~~1''''~~	~~2''~~	~~1'~~	
2''	~~2'~~	~~1'~~	1'''	~~1''''~~

Egde recombination crossover(ERX):

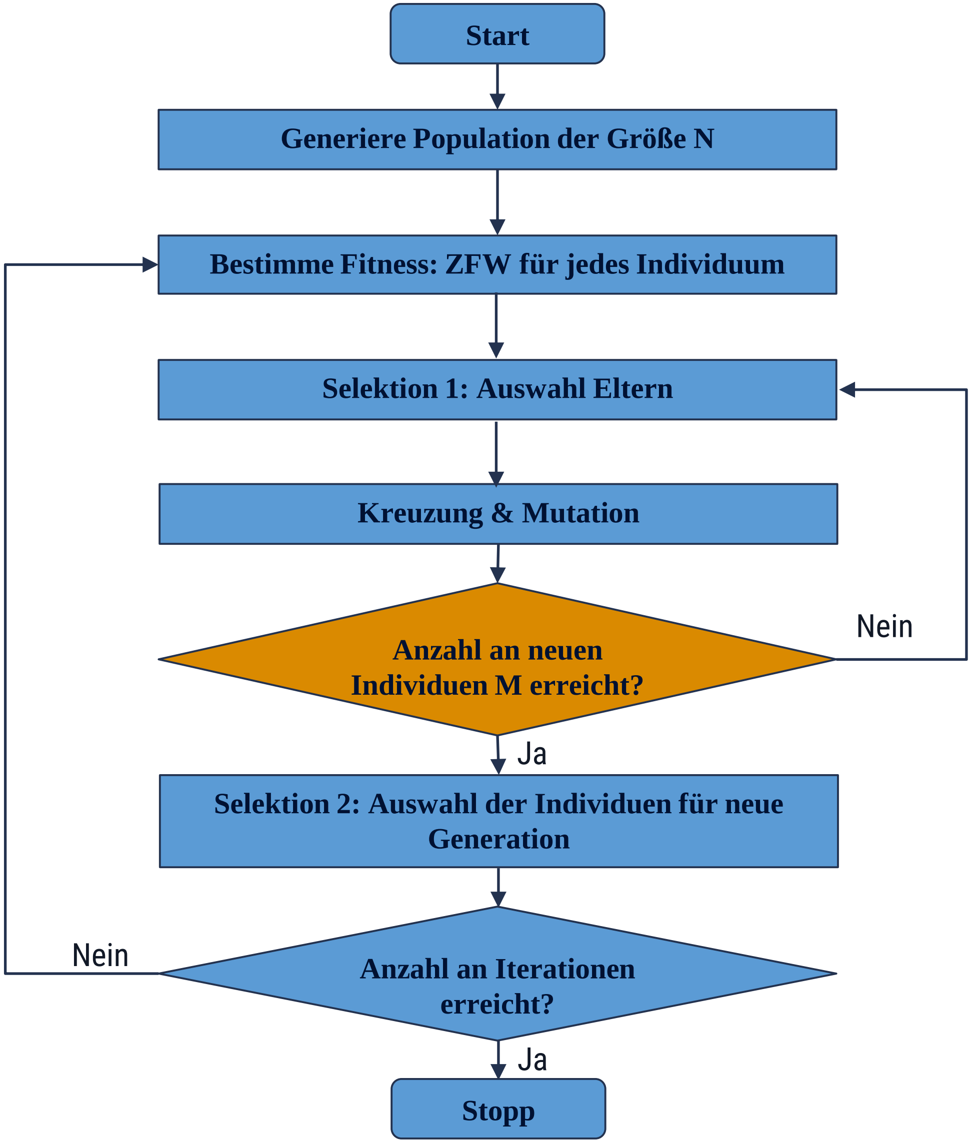
Solange das Kind nicht fertig ist:

- Wähle als Nachfolger den Nachbar mit der kürzesten Nachbarliste (zufällige Wahl falls mehrere solche existieren)

1'	1''	2'	1''''	1'''	2''

~~1'~~	~~1''~~	~~2''~~	~~2'~~	
~~1''~~	~~1'~~	~~1'''~~		
~~1'''~~	~~1''~~	~~1''''~~	~~2''~~	
~~1''''~~	~~1'''~~	~~2'~~	~~2''~~	
~~2'~~	~~1''''~~	~~2''~~	~~1'~~	
2''	~~2'~~	~~1'~~	~~1'''~~	~~1''''~~

Ablaufdiagramm



Neue Individuen

Kind 1a:

1	1	2	1	2	1

Kind 2:

2	1	1	1	1	2

crossover

Kind 3:

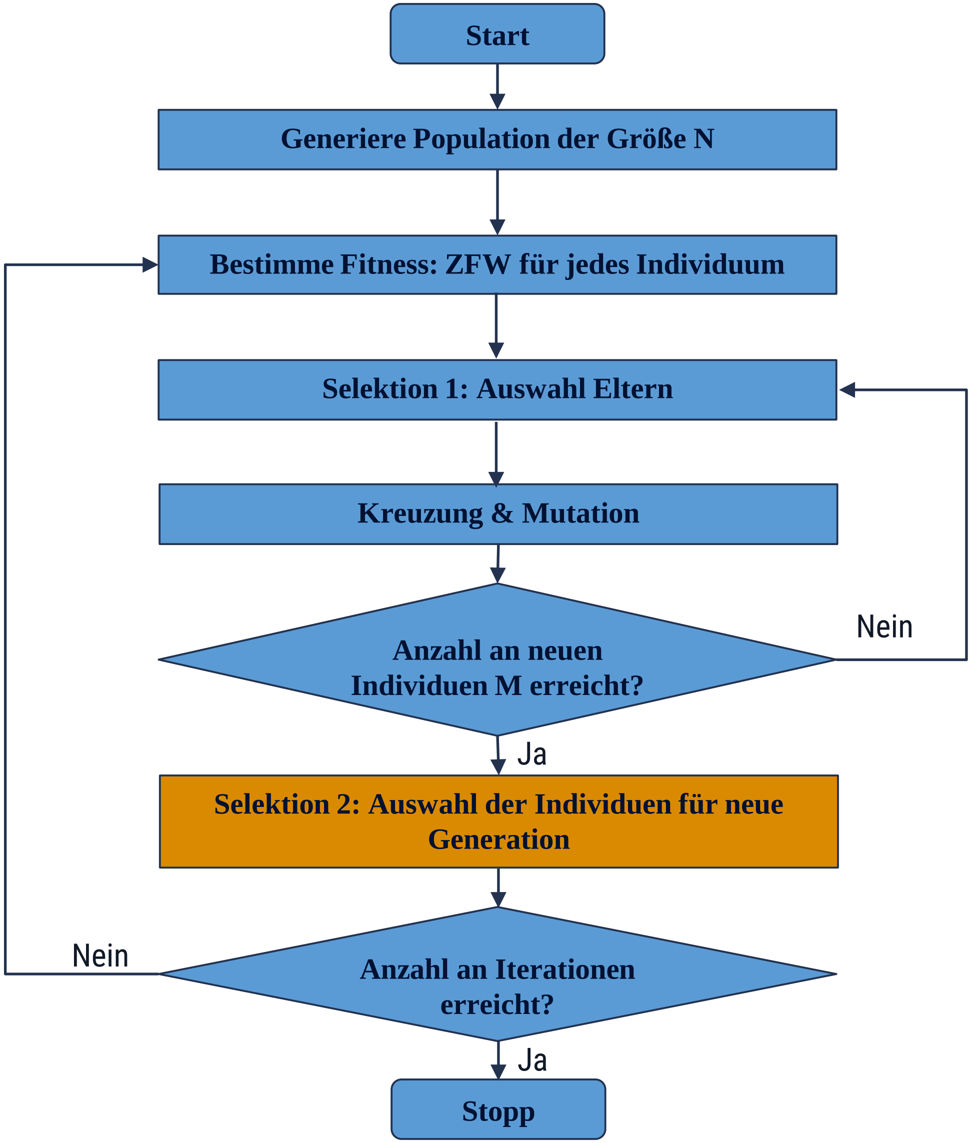
1	1	2	1	1	2

edge recombination crossover

$M \leq N$

$$Z^{1a} = 38$$
$$Z^{2} = 42$$
$$Z^{3} = 40$$

Ablaufdiagramm



Selektion 2

- Nur neue Individuen (M=4)

Kind 1a:

1	1	2	1	2	1

Kind 2:

2	1	1	1	1	2

Kind 3:

1	1	2	1	1	2

Kind 4:

2. edge recombination crossover

- Neue Individuen (M=3) & Individuen aus vorheriger Generation (fittestes Individuum)

Kind 1a:

1	1	2	1	2	1

Kind 2:

2	1	1	1	1	2

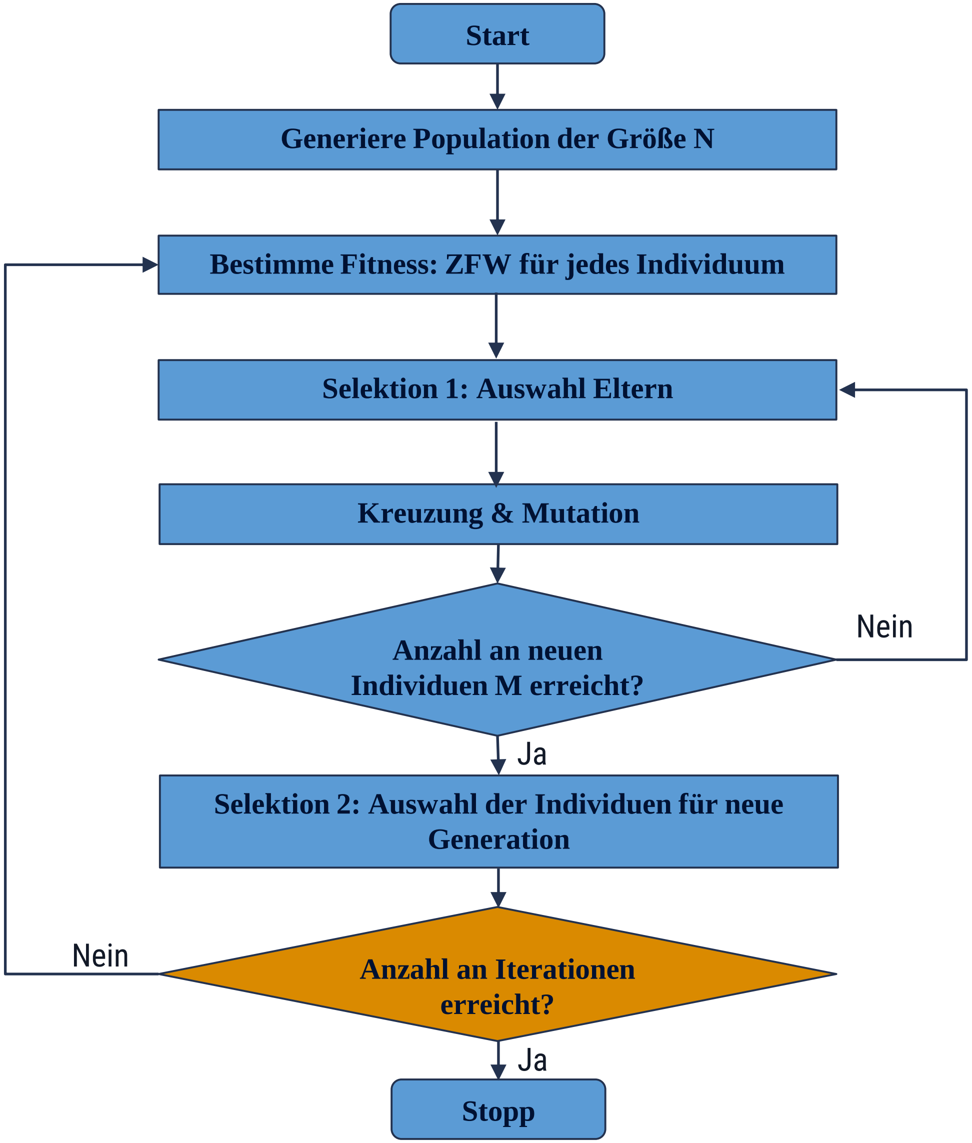
Kind 3:

1	1	2	1	1	2

Lösung 1:

1	1	1	1	2	2

Ablaufdiagramm




GESCHAFFT!
DANKE FÜR EURE AUFMERKSAMKEIT.
NOCH FRAGEN?