OPTIMIZATION OF BACK FREIGHT

TRANSPORTATION SYSTEMS

Thomas Smaltschinski, Martin Opferkuch,
Gero Becker

Institute of Forest Utilization and Work Science
University of Freiburg

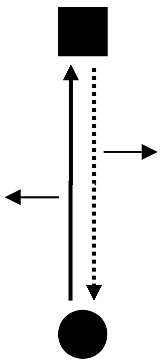
Formec 10/2011
Graz

FobAwi

The Problem: roundwood transport

1-cycle (= normal route)

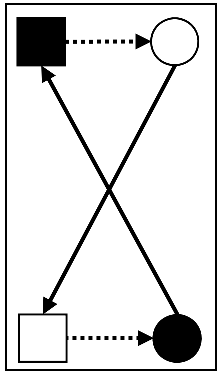
sink (mill)



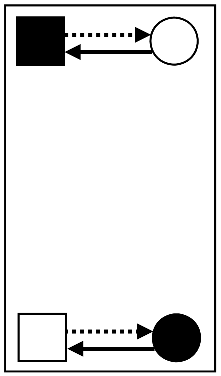
cargo run

empty run

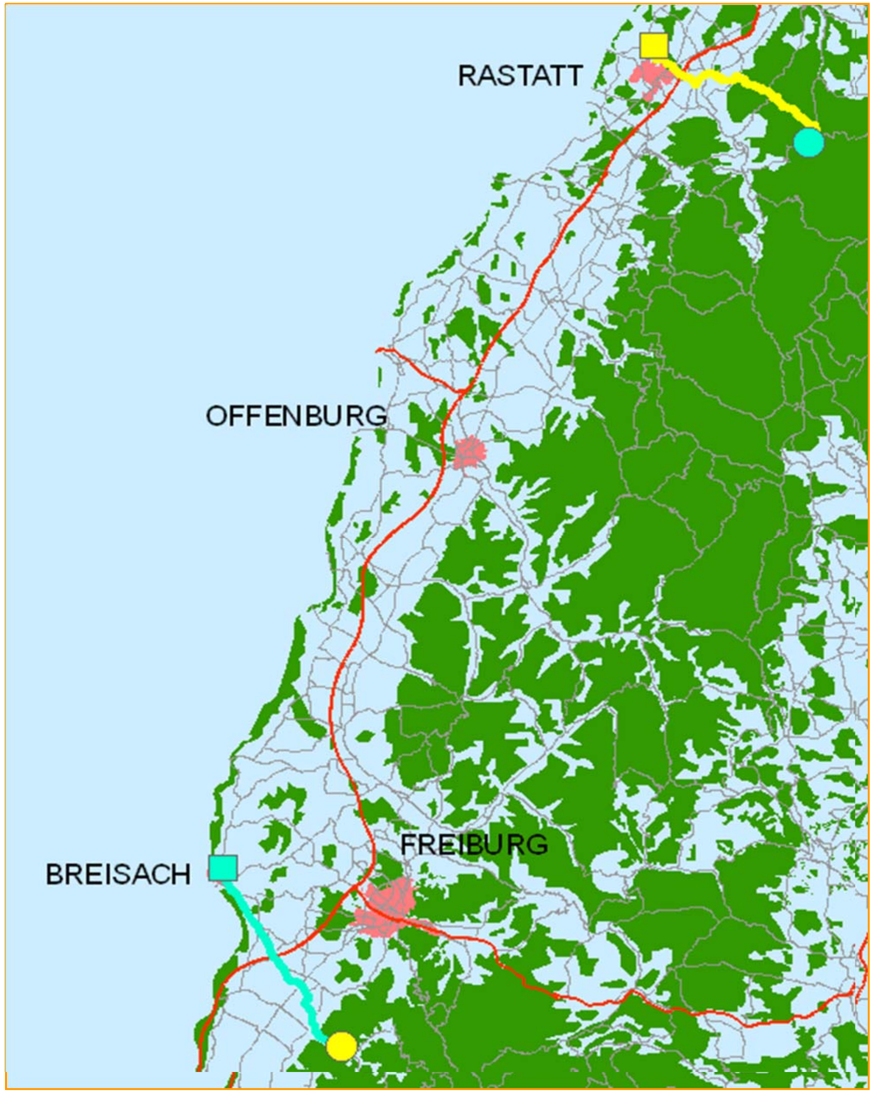
source (pile)



2-cycle, reduction of empty runs

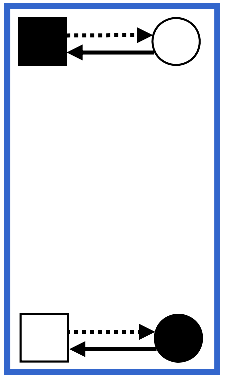


reduction of empty & cargo runs by swap of piles



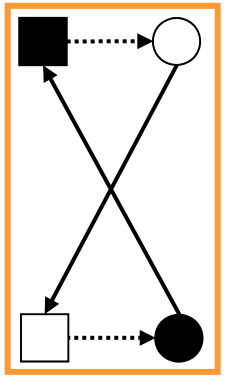
Distinction of products & back freight

Competing products: several mills need the same assortment, where the available quantity is limited



Solution of the Transportation Problem: The quantities of the sources are distributed to the sinks with respect to their needed quantity, whereby the sum of the transport distances is minimal (Hitchcock, 1941).

Non competing products: every mill needs its specific and unique assortment.



Optimization of back freight

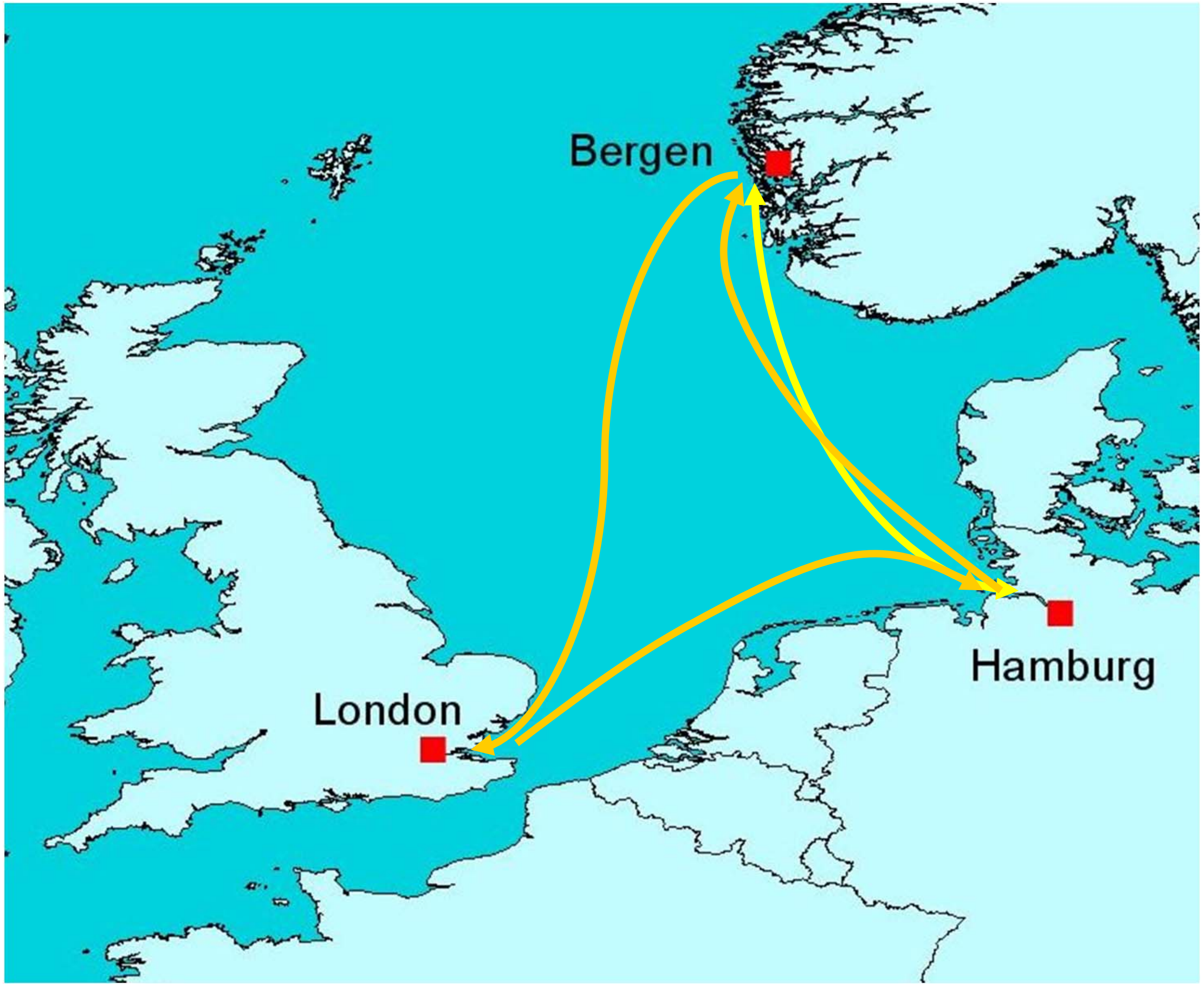
When is back freight possible?

sum of cargo runs > sum of empty runs

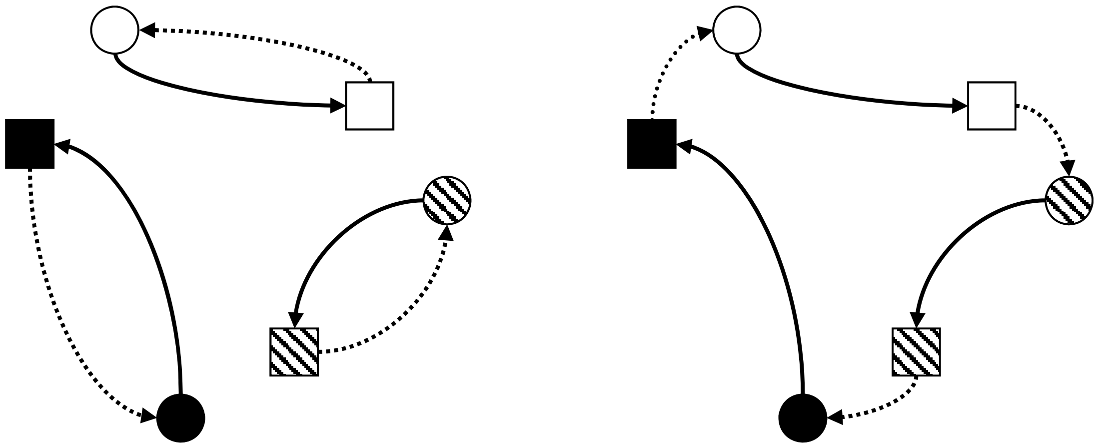
$\binom{n}{2}$ combinations of 2-cycles occur for n sinks.

1. *Examine all combinations of sinks and sources with respect to the inequation.*
2. *Chose the 2-cycle with max. reduction of empty runs.*
3. *Update piles by number of loads.*
4. *Go to 1. until only 1-cycles remain.*

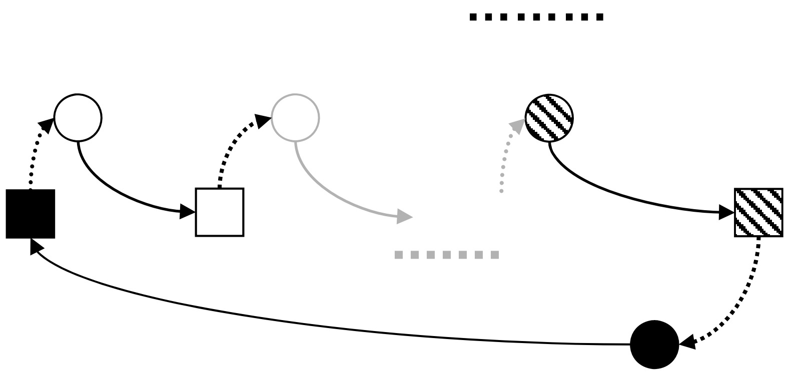
The Hanse in the 14th century



Reduction of empty runs by higher cycles



3-cycle

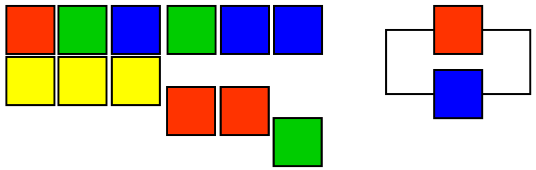


n-cycle

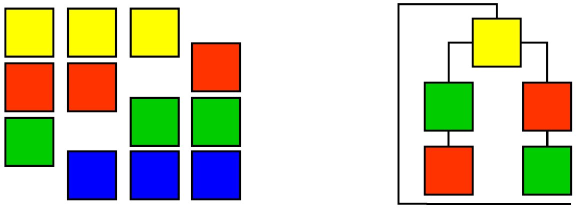
Combinations to visit sinks using higher cycles

4 sinks

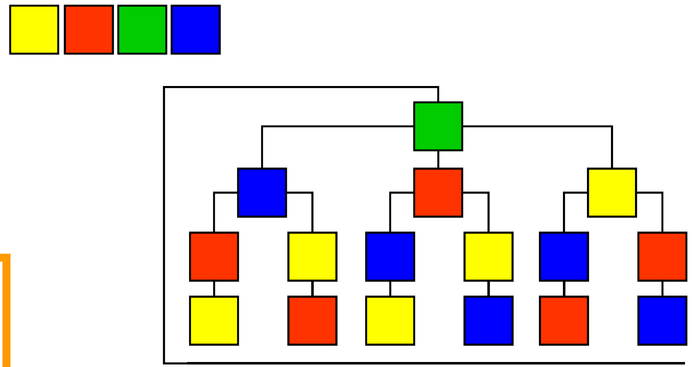
2-cycles $\binom{4}{2} \times (2-1)! = 6$



3-cycles $\binom{4}{3} \times (3-1)! = 4 \times 2 = 8$



4-cycles $\binom{4}{4} \times (4-1)! = 6$



$$\sum_{i=2}^{4} \binom{4}{i} (i-1)!$$

Combinatorial result to visit sinks by higher cycles

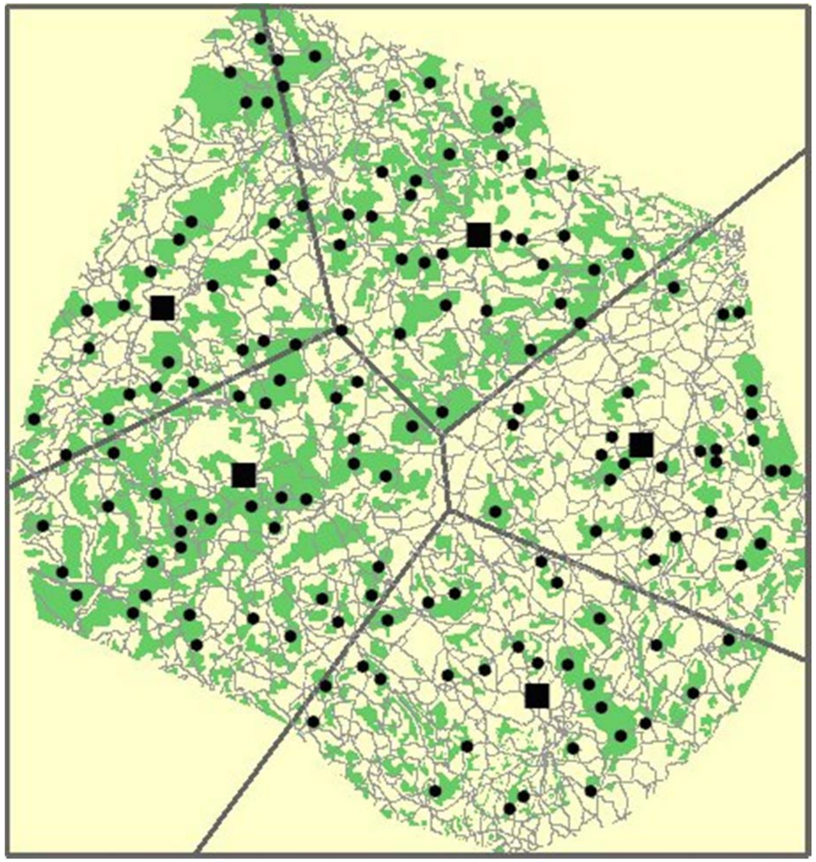
$$Z_{n,k} = \sum_{i=2}^{k} \binom{n}{i} (i-1)! \qquad 2 \le k \le n$$

For n = 20 sinks and k = n the number of possible combinations of cycles amounts 349,096,664,728,623,000.

The combinations grow by **O**((n-1)!). So the problem is NP-hard.

?

Combinatorial experiment



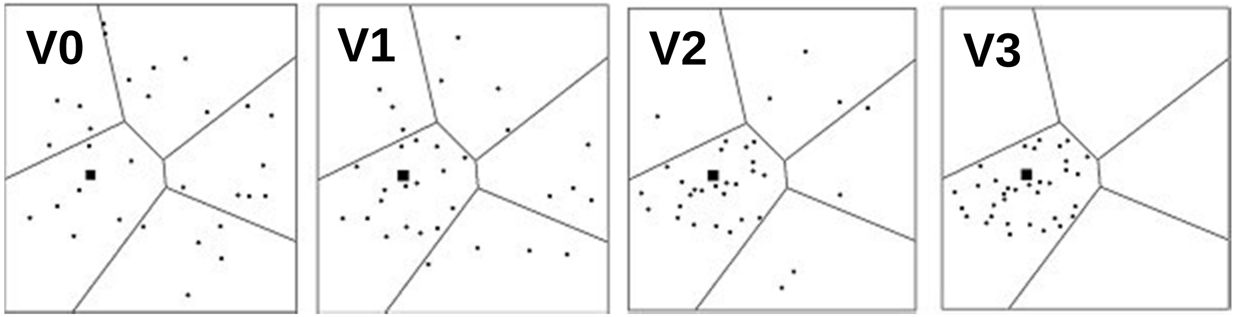
Region ~ 120 x 120 km

5 sinks
150 piles *)
712 cargo runs

Thiessen-polygons define the catchmant areas of the sinks.

***) Each pile contains between 1 and 9 truck loads generated by random numbers.**

Assignment of piles & considered variants



V0 : Random assignment of piles
V1 : 50% of piles in the catchment area
V2 : 75% of piles in the catchment area
V3 :100% of piles in the catchment area

all possible cycles

$$Z_{5,5} = \sum_{i=2}^{5} \binom{5}{i} (i-1)! = 84$$

2- & 3-cycles

$$Z_{5,3} = \sum_{i=2}^{3} \binom{5}{i} (i-1)! = 30$$

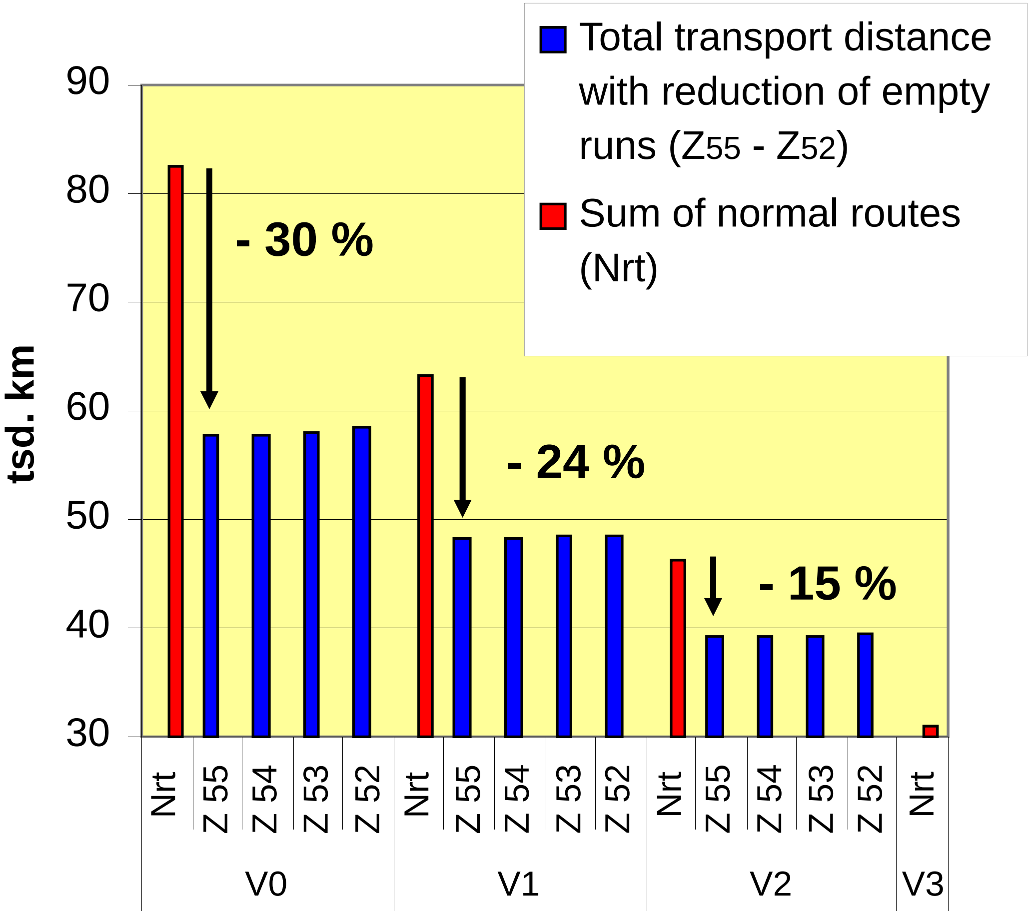
2-, 3- & 4-cycles

$$Z_{5,4} = \sum_{i=2}^{4} \binom{5}{i} (i-1)! = 60$$

only 2-cycles

$$Z_{5,2} = \sum_{i=2}^{2} \binom{5}{i} (i-1)! = 10$$

Results



%-distribution of different cycles

cycle order	V0	V1 %	V2
1	20	51	72
2	48	23	17
3	25	18	7
4	6	5	3
5	1	1	1

Conclusion

- A higher complexity by higher cycle orders does not necessarily result in a higher accuracy by a greater reduction of empty runs.

- With 2- & 3-cycles already > 99 % of the maximum empty run reduction can be achieved.

- Increasing the number of sources within the catchment areas has two effects:

- the total transport distance by normal routes decreases &
- the proportion of possible empty run reduction is lower.

- The total transport distance reaches a total minimum, if all sources assigned to one sink are within its catchment area. Then no more reduction of empty runs is possible nor necessary.

Is big beautiful?

Thank you for your attention

OPTIMIZATION OF BACK FREIGHT TRANSPORTATION SYSTEMS

Thomas Smaltschinski, Martin Opferkuch,
Gero Becker

Institute of Forest Utilization and Work Science
University of Freiburg

Formec, Graz 10/2011