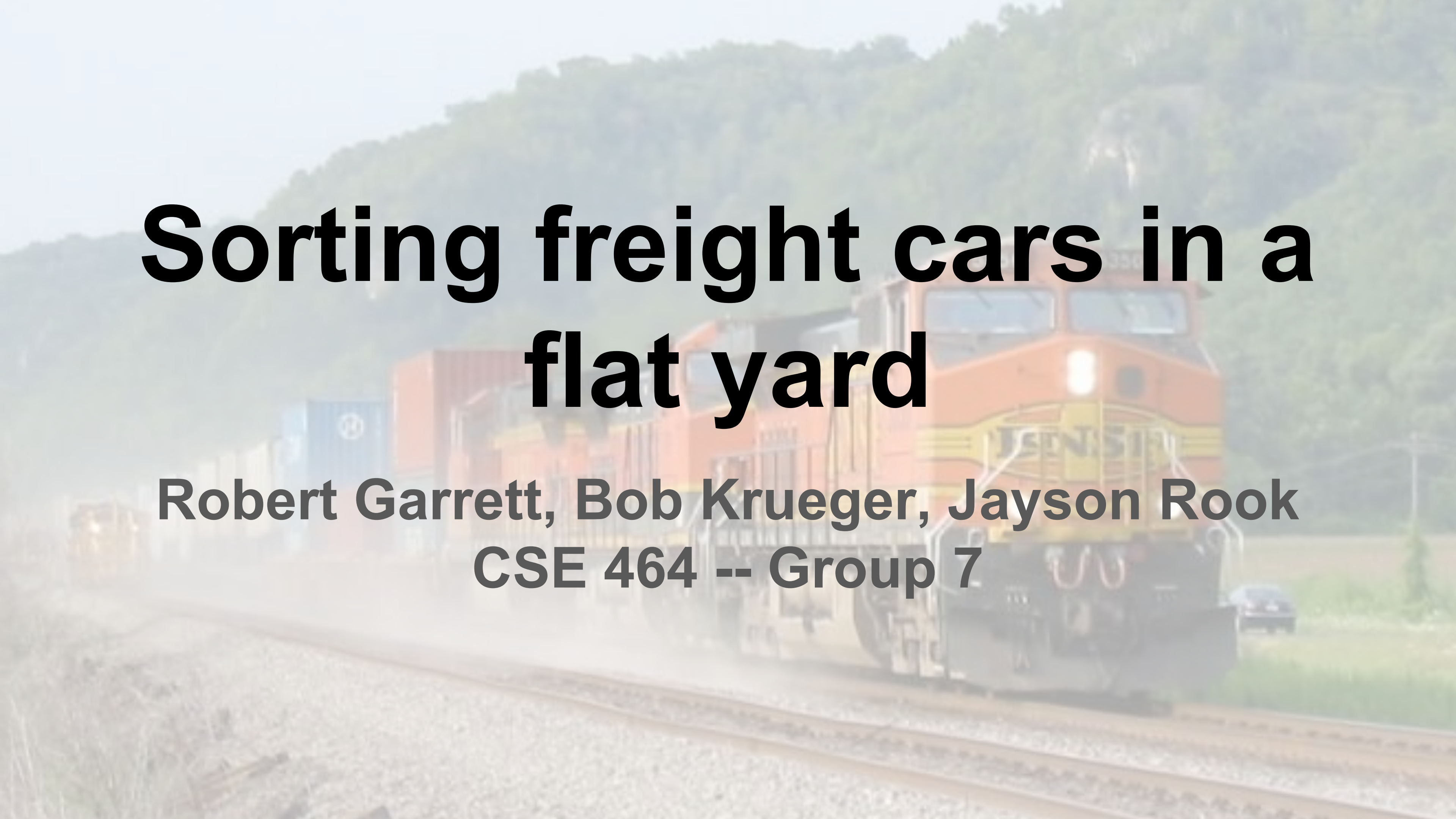

Sorting freight cars in a flat yard

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CSE 464 -- Group 7

Introduction

- Rail yards full of freight cars
- Cars dropped off randomly
- Cargo headed to multiple destinations
- Takes time, gas and manual labor to sort

Motivation

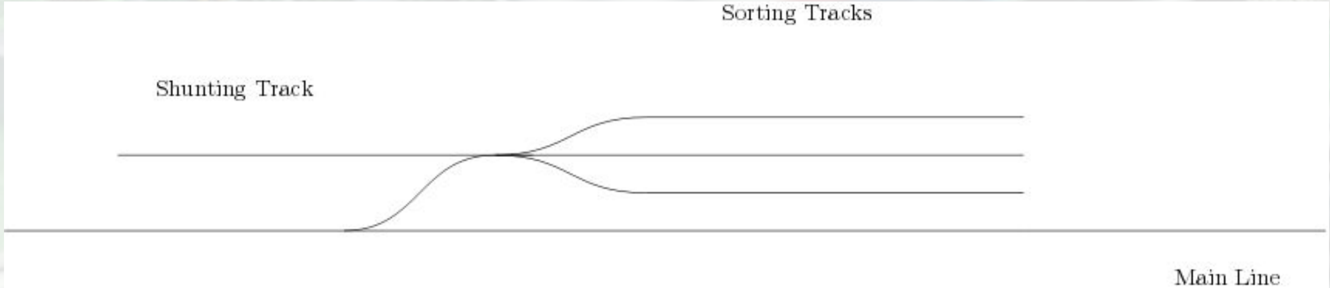
- How can we make sorting these cheaper and quicker?
- Algorithm that gives us a sorting procedure
- Then, we can either:
    - Provide instructions to engine operator
    - Completely automate the process with self driving engine

Key Contributions

- Previous works deal with “hump yard” problem
- Our work is more general:
  - No need for building hump yard
  - Works with existing/old infrastructure
- Saves time and money with no downside
- Executable by automated vehicles or humans
- We account for using a smaller/more efficient engine, and a limited-space yard

Problem Definition

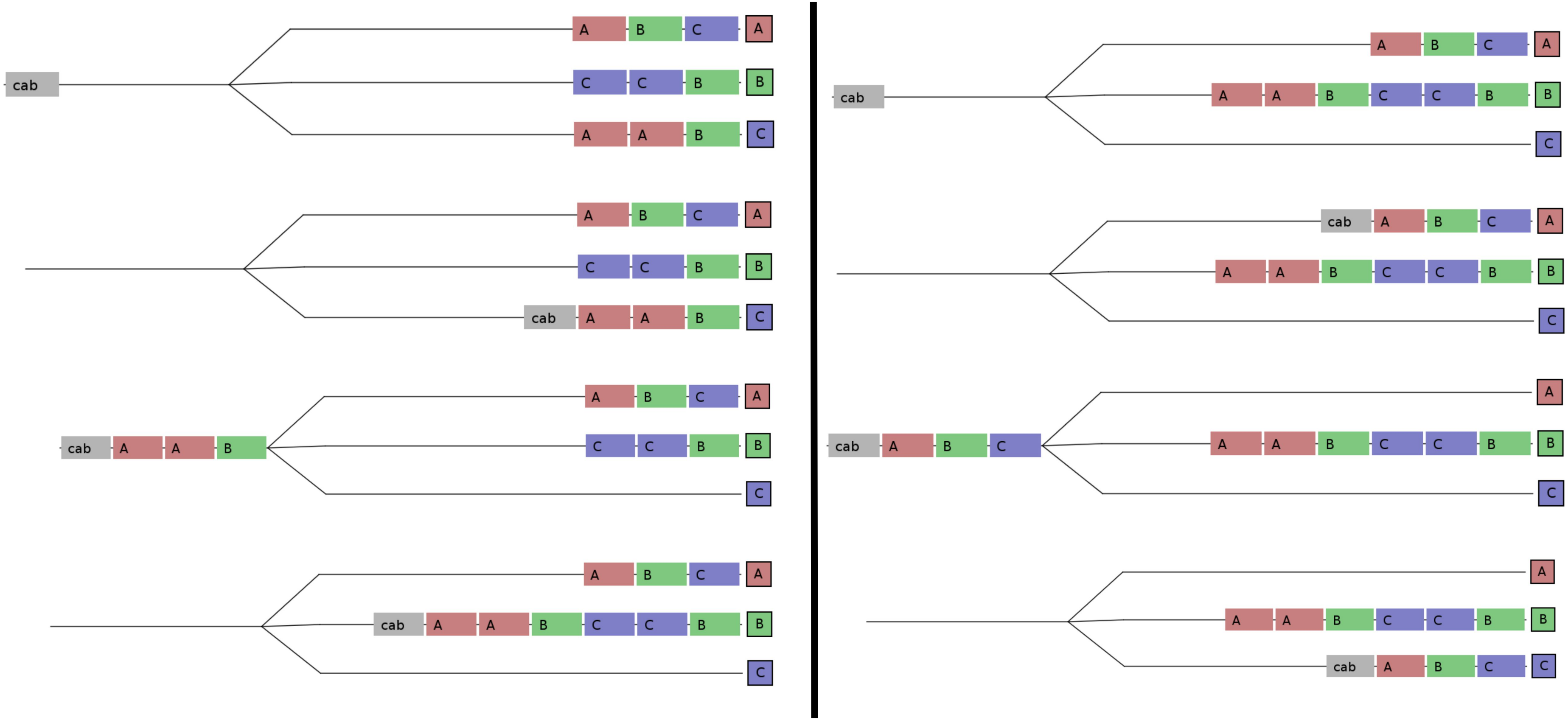
- Want to ensure problem is solvable and interesting
- Model: (k,l,w,m)
  - k parallel tracks connected by one shunting track
  - each track has length $l \geq 2m + w * \mathrm{ceiling}(m/(w(k-1)))$
  - engine can carry w cars
  - m cars on the tracks headed to $d \leq k$ destinations



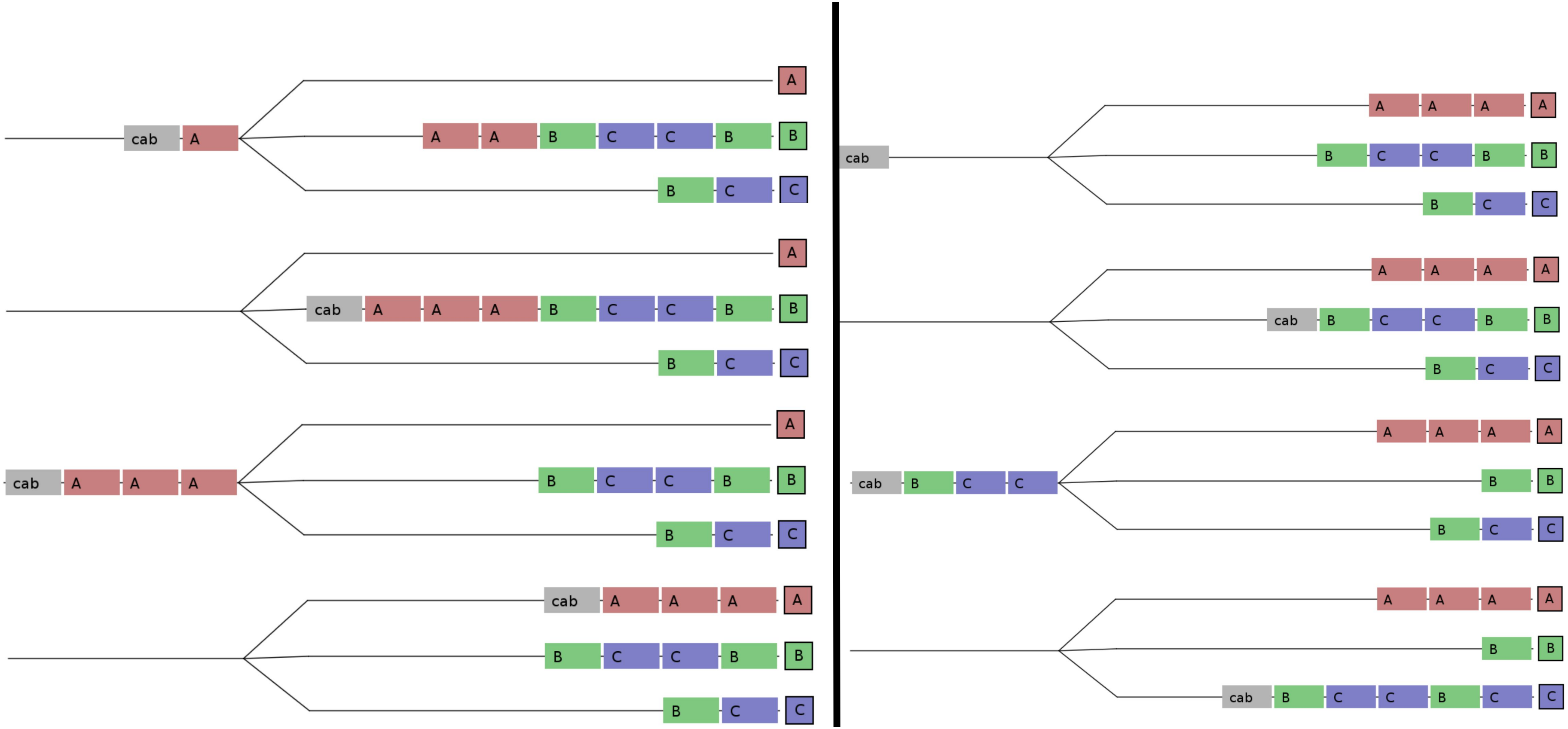
Solution

- Clear off last track (track k)
- Start at track i=1:
  - look at all cars d on the track
    - if $d < k$, place on track $d + 1$
    - otherwise if $d = k$ place on track k
- Increase i by 1
  - repeat the process, but if $d<i$, place on track d
- Once $i=k$, all tracks but k and $k-1$ are sorted
  - Sort these like a simple 2 track case, we are done!

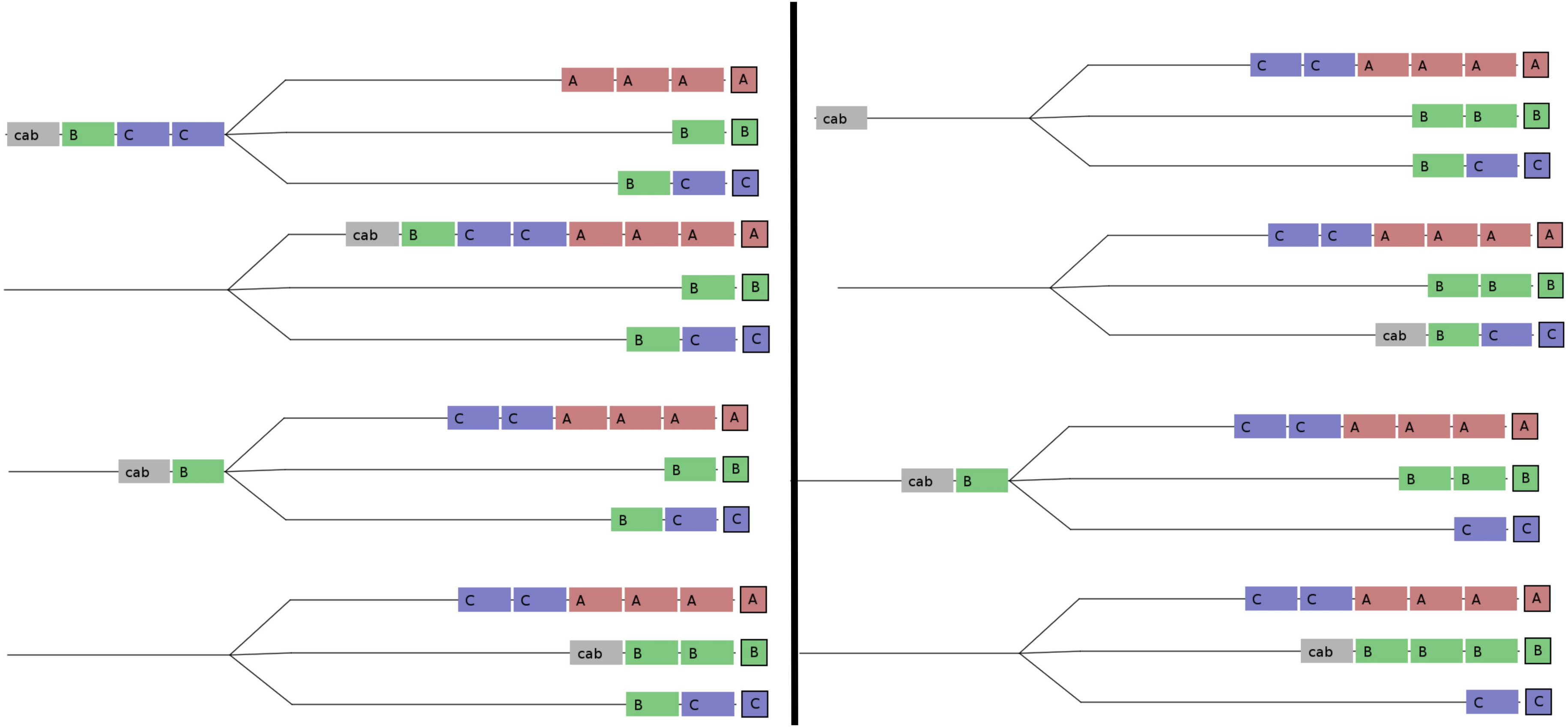
Solution (example)



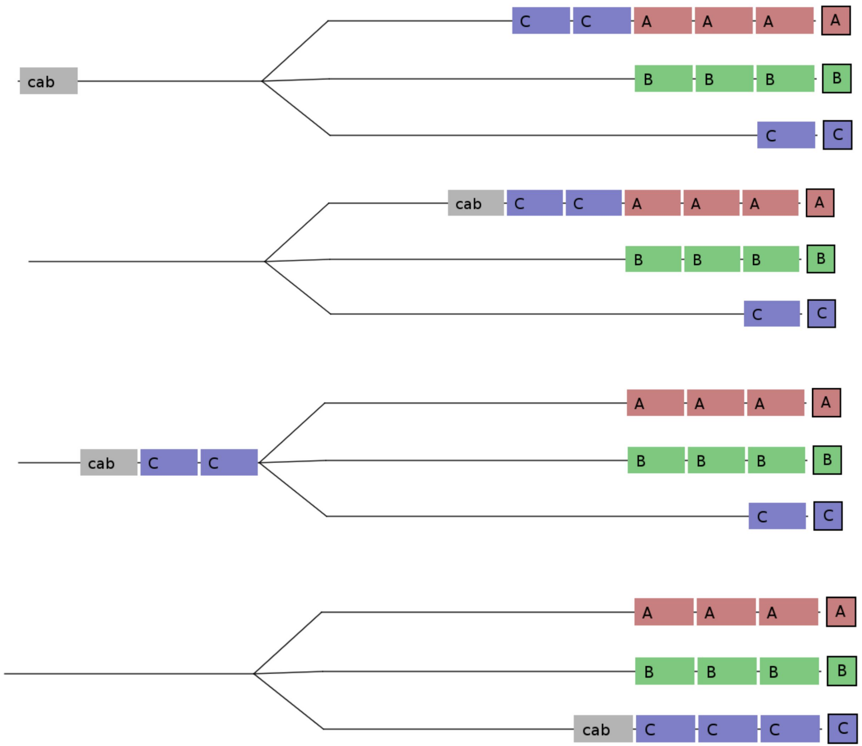
Solution (example)

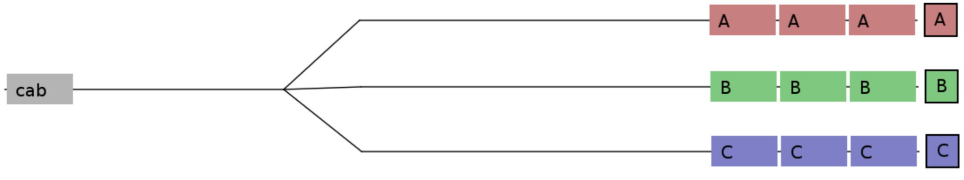


Solution (example)



Solution (example)





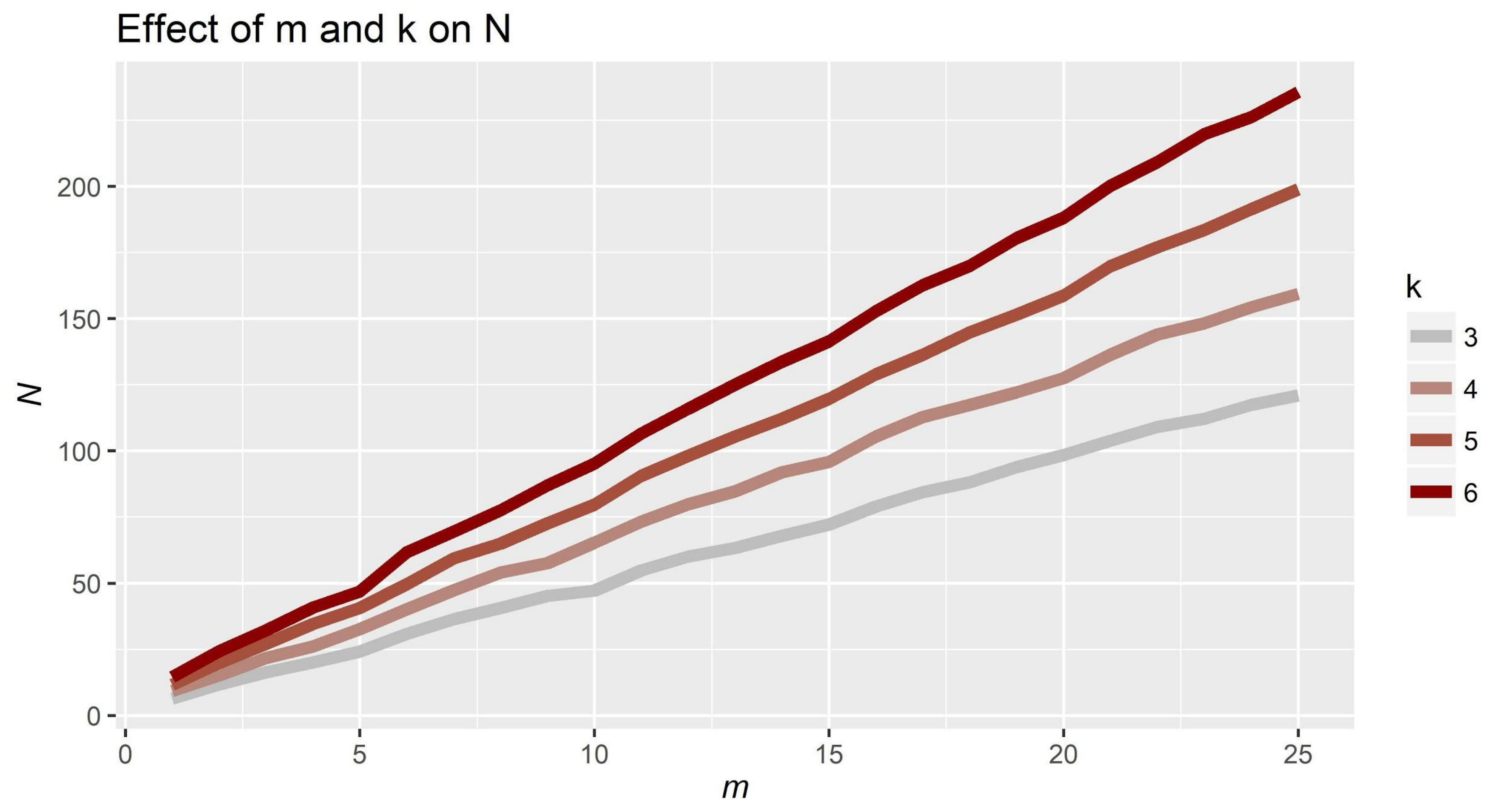
http://ceclnx01.cec.miamioh.edu/~rookjc/trains2/

Cost Analysis

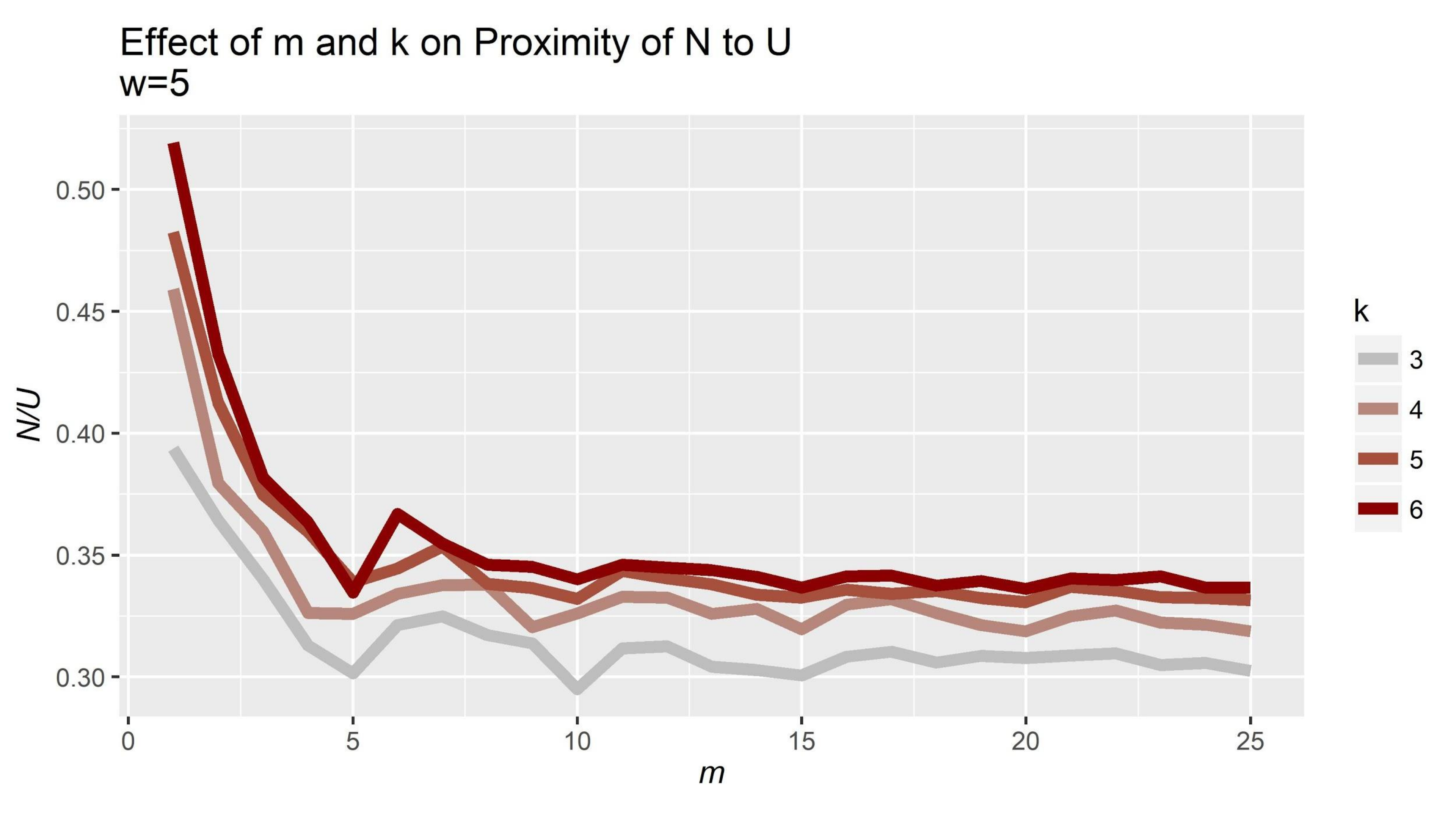
- **Variables of interest:**
  - ***N* - Runtime/length of solution**
  - ***m* - maximum number of cars starting / ending on each track**
  - ***k* - number of sorting tracks**
  - ***w* - weight capacity of engine**
  - ***n* - total number of cars, at most *mk***
  - ***U* - upper bound on *N*, equal to *4m(k+1)***

Cost Analysis

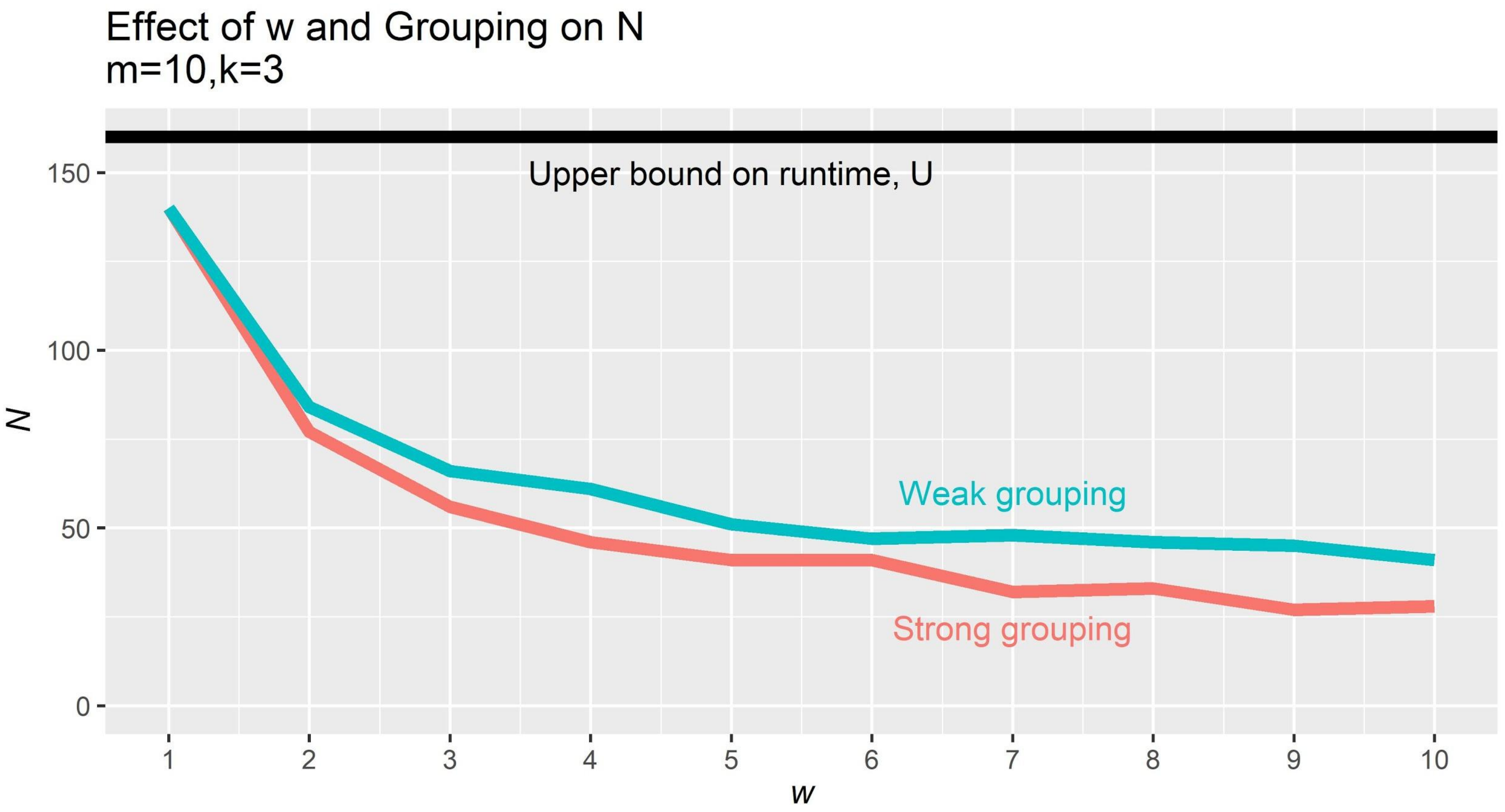
- **Metric: what is a move?**
- **Complexity of algorithm: *O(mk)* or *O(n)***
- **Our Upper bound is $U = 4m(k+1)$**
  - **Move most cars twice**
  - **Move cars on final track an extra two times**
- **Other questions to look into:**
  - **How does w affect N?**
  - **How does the car grouping affect N?**
  - **Are there cases when U is much higher than N?**



Effect of m and k on N
N
200
150
100
50
0
0
5
10
15
20
25
m
k
3
4
5
6



Effect of m and k on Proximity of N to U
w=5
N/U
0.30
0.35
0.40
0.45
0.50
0
5
10
15
20
25
m
k
3
4
5
6



Effect of w and Grouping on N
m=10,k=3
Upper bound on runtime, U
Weak grouping
Strong grouping
150
100
50
0
N
1
2
3
4
5
6
7
8
9
10
w

Applications

- Financial:
  - Humans can finish their job faster
  - Works with existing infrastructure
- Automation:
  - Give procedure to self driving engine
- Environmental:
  - Less utilization of engine = less fuel used
  - Can use a more efficient engine

Conclusion

- Our algorithm executes quickly
- We strike a favorable balance
  - Finds a reasonably good solution
  - Do not achieve the optimal running time or fewest possible steps
- More computational power would lead to better procedure
- Multiple applications

References

First Related Work
Title: Trains of Thought
Author: Brian Hayes
Source: *Computing Science,* originally published in *American Scientist*
Link: http://bit-player.org/wp-content/extras/bph-publications/AmSci-2007-03-Hayes-trains.pdf

Second Related Work
Title: Sorting Using Networks of Queues and Stacks
Author: Robert Tarjan
Source: Journal of the ACM (JACM) JACM Homepage archive. Volume 19 Issue 2, April 1972. Pages 341-346
Link: https://dl.acm.org/citation.cfm?id=321704

Third Related Work
Title: Train Marshalling Problem -Algorithms and Bounds-
Author: Beygang, Florian; Dahms, Krumke
Source: Wirtschaftsmathematik (WIMA Report)
Link: http://fdahms.com/documents/publications/2010_train_marshalling_problem.pdf
Summary of Relevant Information:

References

Fourth Related Work

Title: A Graph Theoretical Approach To The Shunting Problem
Author: Gabriele Di Stefano and Magnus Love Koˇci
Source: Electronic Notes in Theoretical Computer Science
Link: https://www.sciencedirect.com/science/article/pii/S1571066104000052

Title: Railroad Yards, Keeping Freight Moving
Source: American Rails
Link: https://www.american-rails.com/railroad-yards.html

Title: Priority car sorting in railroad classification yards using a continuous multi-stage method
Inventor: Edwin R. Kraft
Source: Google Patents
Link: https://patents.google.com/patent/US6418854

Title: Robust Algorithms for Sorting Railway Cars
Author: Christina Büsing and Jens Maue
Source: Lecture Notes in Computer Science, vol 6346
Link: ftp://ftp.math.tu-berlin.de/pub/Preprints/combi/Report-014-2010.pdf

References

Title: Current Methods for Optimizing Rail Marshalling Yard Operations
Author: Donald H. Timian
Source: Master's Thesis, Kansas State University (1994)
Link: http://www.dtic.mil/get-tr-doc/pdf?AD=ADA289371

Title: Analysis of rail yard and terminal performances
Author: Marin Marinov et al
Source: Journal of Transport Literature
Link: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S2238-10312014000200008

If you want to try out some rail sorting problems yourself, visit http://www.transum.org/Software/Shunting/Puzzles.asp.