Simulating Railcar Transit Times Under Different Carload Freight Railway Operating Strategies

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Introduction

► Objective: Understand how different operating strategies affect the average railcar transit time from Yard 1 to Yard 2

► Literature review
  – Dong Y. (1997)
    • Simulated how different operating strategies affect the probability of missed train connections at yards and the subsequent impact
  – Dick CT, Mussanov D. (2016)
    • Mainline train delay versus train departure schedule flexibility

► What’s new?
  – Schedule flexibility on the inbound train arrival time
  – Consider outbound train delay and schedule flexibility to calculate mainline travel time between yards
  – Different train departing frequency per day (2 trains vs 1 train)
    • Future single-person crews → short frequent trains
Introduction

- Railcar transit time includes dwell time at Yard 1 and Yard 2 and mainline travel time

- Investigate three operating strategies:
  - Schedule Adherence (SA)
    - Always depart at planned time
  - Hold for Tonnage (HT)
    - Hold train until N railcars accumulate
  - Hold for Tonnage with Time Limit (HTT)
    - Hold train until N railcars accumulate or for T hours maximum
SIGMA Model – Hold for Tonnage

Outputs:
- Average transit time
- Average additional delay time
Experiment Design

- Threshold for Hold for Tonnage is equal to the expected number of cars on the outbound train to Yard 2
- Cutoff time and PMAKE function
- Time limit for Hold for Tonnage with Time Limit
- Schedule flexibility

Yard 1

Inbound trains to Yard 1
- 04:00
- 08:00
- 12:00
- 16:00

Outbound train from Yard 1 to Yard 2
- 24:00

Cut-off time

Expected number of railcars bound for Yard 2
- 15
- 20
- 25
- 40
Result: Different Operating Strategies

Schedule Adherence has the shortest average railcar transit time.

Dwell time at Yard 1 in Hold for Tonnage is longer than Schedule Adherence.
Experimental Factors

- Railcar arrival distribution
- Train arrival interval
- 12-hour departure and 24-hour departure

Factor: Railcar Arrival Distribution

- Expected number of railcars bound for Yard 2 is constant
- Three railcar distributions: increasing (skewed to later trains), uniform, and decreasing (skewed to earlier trains)
- Number of railcars for Yard 2 on an inbound train varies each day (i.e. 15 +/-5)

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Inbound trains to Yard 1

<table>
<thead>
<tr>
<th>Time</th>
<th>Increasing</th>
<th>Uniform</th>
<th>Decreasing</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00</td>
<td>15</td>
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<td>40</td>
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<tr>
<td>04:00</td>
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<td>08:00</td>
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<td>24:00</td>
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</tbody>
</table>
Two conflicting factors

- Dwell time at Yard 1
- Expected number of railcars that miss connection at Yard 1
If the threshold is not reached on Day 1, it is more likely to reach the threshold if the first train arrives on Day 2 carries more railcars bound for Yard 2.
Railcar Arrival Distribution with HTT

Hold for Tonnage with Time Limit

- Low schedule flexibility – similar to Schedule Adherence
- High schedule flexibility – similar to Hold for Tonnage
Factor: Train Arrival Interval

1-hour
- 13:00
- 14:00
- 15:00
- 16:00
- 24:00

4-hour
- 00:00
- 04:00
- 08:00
- 12:00
- 16:00
- 24:00

7-hour
- 00:00
- 02:00
- 09:00
- 16:00
- 19:00
- 24:00

Cutoff Time
The two conflicting factors
- Dwell time at Yard 1
- Expected number of railcars that miss connection at Yard 1
Train Arrival Interval with HT

- Dwell time at Yard 1
- 1-hour case is more sensitive to schedule flexibility
Schedule Adherence has a shorter average railcar transit time than Hold for Tonnage.

Time saving per railcar is 2 to 5 hours for Schedule Adherence.
Conclusion

► As schedule flexibility increases, the average railcar transit time increases

► Schedule Adherence has the shortest average railcar transit time

► The case of bunched train arrivals close to the cutoff time allows a shorter average railcar transit time, but it is more sensitive to schedule flexibility of inbound trains

► Departing two trains per day reduces the average railcar transit time compared to departing one train per day
  - One train/day with low schedule flexibility is almost equivalent to flexible at two trains per day
Future Work

► Extract the dwell time at Yard 1 and Yard 2 and mainline transit time to understand which part is responsible for most of the delay

► For Hold for Tonnage, conduct sensitivity tests on different thresholds

► For Hold for Tonnage with Time Limit, conduct sensitivity tests on different time limits

► Understand the relationship between bunched train arrivals and outbound train departure time

► Extract average number of railcars on the outbound train from Yard 1 and understand its relationship with the average railcar transit time

► Conduct sensitivity test on the distance between two yards
Thank you for your attention!

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