Car Scheduling-Based Hump Sequencing

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Car Scheduling Integration

ABSTRACT

In a car-scheduling driven approach to hump sequencing, the goal is not to make all connections, but to ensure that at least the most important ones are protected. Yard management can use the tool to decide whether to hold outbound train departures for a short time, or else drop the connection if the delay would be too long.
TABLE 1: Connection Matrix for Scoring Example

<table>
<thead>
<tr>
<th>Inbound Trains</th>
<th>Outbound Trains Avail Time</th>
<th>X Due 11 A.M.</th>
<th>Y Due 11 A.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8:00 A.M.</td>
<td>3 cars</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>8:30 A.M.</td>
<td>5 cars</td>
<td>6 cars</td>
</tr>
<tr>
<td>C</td>
<td>10:00 A.M.</td>
<td></td>
<td>4 cars</td>
</tr>
</tbody>
</table>

*Processing Time of Each Inbound = 1 Hour*

Based on projected train availability times, first-in-first-out for the example in Table 1 would be sequence A-B-C. Train A starts processing at 8:00 A.M. and requires one hour to complete, so Train B cannot begin until 9:00 A.M. Since train X has connections from both trains A and B, it cannot be completed until train B has finished processing at 10:00 A.M. Likewise, train Y has connections from both trains B and C, so its earliest completion time is 11:00 A.M. By comparison with the target “set” times for outbounds X and Y, train X is ready one hour early (slack -1.0 hours), while Y is exactly on time (slack 0.0 hours.)

Both B-A-C and B-C-A score worse than FIFO sequence A-B-C. Therefore, the optimality of sequence A-B-C has been proven with respect to the objective function.

**TABLE 3. Hump Sequence Example, Fix Trains 2 & 3**

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Best Outbound Trims</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-A-C</td>
<td>Train “X” @ 10:30 A.M.</td>
<td>2.2553</td>
</tr>
<tr>
<td></td>
<td>Train “Y” @ 11:30 A.M.</td>
<td></td>
</tr>
<tr>
<td>B-C-A</td>
<td>Train “X” @ 12:00 noon</td>
<td>3.7183</td>
</tr>
<tr>
<td></td>
<td>Train “Y” @ 11:00 A.M.</td>
<td></td>
</tr>
</tbody>
</table>

Any Hump Sequence other than A-B-C sets one of the outbound trains late; then a outbound train must either hold unnecessarily, or “run away” from its connection.
Problem Statement

• Given a connection matrix that has been generated by the Car Scheduling system, optimize the Hump Sequence to minimize weighted lateness of outbound trains.

• The objective is to get all the cars into the bowl in time to make their scheduled connections without delaying outbound trains. Some other sequencing approaches do not consider the ability to hold outbound trains at a relatively low cost for a short time to make all scheduled connections.

• A mixed integer, non-linear formulation reflects an exponentially increasing cost of late train departures. Short holds cost little; long holds cost a lot. Thus the cost of late train “sets” rises rapidly in this formulation.

• Scheduled connections are never left behind . . . unless those connections are explicitly “dropped” by explicit management decision. Therefore, it is an iterative process. This is the point of Car Scheduling trip plan integration.

FIGURE 2: The Exponential Function, e^x
The Rescheduling Process

- A report is produced showing how the cars in the bowl build up as each cut is processed over the hump. In this example inbound train PCHK 17 is seriously late and would result in making the outbound train HKCP 20 more than 7 hours late.
- The system is suggesting that a very late 5-car connection be dropped, and that those cars should be rescheduled to another train.
- If this were done, the HKCP 20 would be ready with its scheduled cars 4½ hours early.
- No cars miss their connections due to late arrival, without an active review.

**FIGURE 7: Late Connection Exception Screen**

<table>
<thead>
<tr>
<th>Car Numbers to be Dropped:</th>
</tr>
</thead>
<tbody>
<tr>
<td>GACX005268 CPRR Resch HKCP 20 @ 04/20 09:30 -&gt; HKCP 21 @ 04/21 12:00</td>
</tr>
<tr>
<td>CP 387242 CPRR Resch HKCP 20 @ 04/20 09:30 -&gt; HKCP 21 @ 04/21 12:00</td>
</tr>
<tr>
<td>NAH455571 CPRR Resch HKCP 20 @ 04/20 09:30 -&gt; HKCP 21 @ 04/21 12:00</td>
</tr>
<tr>
<td>PROK075021 CPRR Resch HKCP 20 @ 04/20 09:30 -&gt; HKCP 21 @ 04/21 12:00</td>
</tr>
<tr>
<td>USLX020238 CPRR Resch HKCP 20 @ 04/20 09:30 -&gt; HKCP 21 @ 04/21 12:00</td>
</tr>
</tbody>
</table>
Three Step Process for Car Scheduling Integration

1. Reschedule any cars which cannot possibly be processed in time.

   - Realistic projections of start hump, processing, and end hump times for each cut of cars to be processed is needed for this purpose.
   - If classification tracks are approaching capacity or under adverse weather conditions, hump processing tends to be delayed and slows down.
   - Determination and resolution of likely missed connections because of late arrivals is accomplished during the hump sequencing phase.
Three Step Process for Car Scheduling Integration

2. Based on the planned hump sequence, advance any cars expected to be processed in time to make an earlier connection.

• Given conservative or padded connection times often now planned, often a significant number of cars may be advanced ahead of their original schedule.

• Padding in connection times results in underestimating tonnage that is truly available for any given departure: the car scheduling system may indicate space still remains on the train, but in fact the train has actually exceeded its capacity due to cars that will make connections earlier than scheduled.

• Advancing connections that have excessive slack provides a more accurate tonnage forecast for locomotive distribution, and reveals any outbound trains that may in fact exceed their capacities.
Three Step Process for Car Scheduling Integration

3. If after advancing planned connections, any outbound train has more cars scheduled than it can carry, determine which cars to reschedule to later trains.

- Often, some cars advanced in Step 2 must simply be returned to their originally scheduled trip plans, but sometimes it is more desirable to advance those cars anyway, and delay other cars instead.
- Planning hump sequencing and reconciling trip plans while trains are on “final approach” into the terminals will result in better management awareness of incoming volumes, critical connections and would trigger better planning of the resources needed to handle the traffic.
Observations and Conclusions

1. Hump Sequencing is the Yard analogy to Meet-Pass Planning for Line-of-Road.
   - Traditionally, it has been viewed as an operational decision, but as the level of schedule adherence improves, there is value in developing a planned hump sequence as well as in meet/pass planning as part of the Service Design process.
   - Once this is done then day-to-day modifications can be identified as deviations from a base plan.
   - By comparison with an unscheduled railroad, trains may be spaced out, but no specific meet-pass or hump sequencing plans have been developed by Service Design.
Observations and Conclusions

2. The process also helps keep the Trip Plan database current.
   - The Yard System should have its own database which is fed from the Train Consisting, Trip Planning and Train Dispatching systems.
   - This local data can be used for “What If” scenario development.
   - The system should reschedule cars once it is known for sure what the terminal handling plan will be.
   - Interim updates should not as a rule be made to the main trip planning database to avoid “churning” the main database. A decision has to be made as to the most appropriate time to “lock in” the decision on how individual cars will be handled by reporting it to the main database.
3. **Much can be accomplished by integrating yard systems with current trip planning databases.**

   - There are many possibilities for using current trip planning data to improve yard operations.
   - This integration will improve the quality of trip planning as well, and make it much more realistic.
   - Even more can be done in the future with the implementation of Dynamic Car Scheduling processes that support flexible routing and take train capacities into account.
   - A Dynamic Car Scheduling system may subsume some of the required functionalities of Yard Planning since it can make those decisions with a more global rather than local perspective.
References


Thank You