Whirlpool Regional DCs

Investigation of Batching Outbound Shipments to Reduce Labor Hours

Finalist Presentation: December 14, 2011

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Faculty Advisor: Dr. Seong-Hee Kim
Project Site: McDonough, GA Regional DC
Group Members: Michele Bertolino, Ana Herbst, Andy Jones, Adam Liem, Travis Nemes, Melanie O’Gorman, Sam Russell, Eric Sood
Objective: Reduce Labor Hours Through Batch Picking

- Single-Truck Picking
- Batch Picking Shipments
- Multi-Truck Picking

Deliverable: Proof of Concept and Tool for Determining Batching Strategy

Projected Savings: $1,100,000 Annually
Project Background

Batching Tool

Deliverables and Implementation

Value Added
WHIRLPOOL – DC STRUCTURE

Factory

Factory Distribution Center

Regional Distribution Center

Full Truckload

Large Retailer

Local Distribution Center

Less Than Truckload

End Consumer

Whirlpool Corporation Locations

- Regional Distribution Center

DECEMBER 14, 2011

REGIONAL DC BATCH PICKING PROJECT
Batch Picking – Grouping Orders to be Picked at the Same Time to Minimize Repeat Visits to the Same Product Stow Location

*MultiChannel Merchant (Marketing Newsletter)

Non Batched

<table>
<thead>
<tr>
<th>Item (Clamp Capacity)</th>
<th>SKU A (4)</th>
<th>SKU B (8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck X</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Truck Y</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Truck Z</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total Trips</strong></td>
<td><strong>4</strong></td>
<td><strong>3</strong></td>
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<td>1</td>
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<td><strong>1</strong></td>
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</tbody>
</table>
WHIRLPOOL – MCDONOUGH SITE INFORMATION

Scope
1.5M ft² facility
Shipments per Day: 60
SKUs: 2070

Resources
Loading Docks: 80
Clamp Trucks: 68
Drivers: 45

Cost Drivers
Annual Labor Cost: $2.4M
Cycle Time: 4.58 hours
McDonough Regional DC

Shipping Receiving Office
1. Verify Stock
2. Release Shipments to WMS

WMS / Pickers
1. Generate Task List
2. Assign Tasks to Pickers
3. Pick Items to Staging Area

Staging Area
1. Scan Items
2. Load Truck

Outbound Shipments
WHIRLPOOL – CURRENT PROCESS & PROPOSED CHANGES

McDonough Regional DC

Shipping Receiving Office
1. Verify Stock
2. Release Shipments to WMS

WMS / Pickers
1. Generate Task List
2. Assign Tasks to Pickers
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Staging Area
1. Scan Items
2. Load Truck

Outbound Shipments

Proposed Changes

Batch Shipments

Separate Batches into Shipments
Project Background

Batching Tool

Deliverables and Implementation

Value Added
BATCHING TOOL – PROCESS OVERVIEW

1. Input Max Batch Size and Shipments with Similar Due Out Times
2. Generate all Possible Batches and Corresponding Pick Times
3. IP Solver Finds Batching Strategy that Minimizes Pick Time
4. Display Results to the User
**Batching Tool – Calculation Constants**

**Constants**
- Pick Time: 69 sec
- Stage Time: 20 sec
- Sort Time: 24 sec

**Travel Time**
- Travel Time = Distance / Speed
- Travel Distance Varies by SKU
- Travel Speed: 11.7 ft/sec

**Travel Distance Calculation**

**Warehouse**

<table>
<thead>
<tr>
<th>Trip</th>
<th>Warehouse</th>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip 1</td>
<td>110 ft</td>
<td>70 ft</td>
</tr>
<tr>
<td>Trip 2</td>
<td>50 ft</td>
<td>70 ft</td>
</tr>
<tr>
<td>Trip 3</td>
<td>50 ft</td>
<td>70 ft</td>
</tr>
</tbody>
</table>

**Trip 1**
- Warehouse: 110 ft
- Tool: 70 ft

**Trip 2**
- Warehouse: 50 ft
- Tool: 70 ft

**Trip 3**
- Warehouse: 50 ft
- Tool: 70 ft

*Note: The diagram shows the travel routes for each trip.*
### Step 1: Generate All Possible Batches

- Example:
  - 4 Shipments: A, B, C, D

<table>
<thead>
<tr>
<th>Max Batch Size</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feasible Batches</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of Batches</td>
<td>4</td>
<td>10</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

### Step 2: Calculate Total Quantity of Items Per SKU Per Batch

### Step 3: Calculate Total Pick Time for Each Batch
**Objective**
Minimize the Sum of the Time for the Picked Batches

**Constraint**
All Shipments Must be Picked Exactly Once in the Batching Strategy

**Formulation**

\[
\begin{align*}
\text{min} & \quad C^T x \\
\text{s.t.} & \quad \sum_{j=1}^{n} a_{ij} x_j = 1 \quad \forall i \in \{1, \ldots, k\} \\
& \quad x_j \text{ binary} \quad \forall j \in \{1, \ldots, n\}
\end{align*}
\]

- \( i \) – truck number
- \( j \) – batch number
- \( C^T \) – row vector of total pick times for each batch \( i \)
- \( x_j \) – 1 if batch \( j \) is in final batching strategy 0 otherwise
- \( a_{ij} \) – 1 if truck \( i \) is in batch \( j \) 0 otherwise
### Verification

- **Generate Mock Shipments**
  - Solve by Hand
  - Solve with Tool
  - Same Batching Results

### Validation

- **Input Individual Tasks**
- **Run Tool**
  - Same Results as Historical Task Time Data
## Batching Tool – Output

### Max Batch Size
- **Status:** Done

### Input Time Metrics (minutes)
- **Stage Time:** 0.3324
- **Sort Time:** 0.3989
- **Pick Time:** 1.1567
- **Travel Time Between Dock Doors:** 0.04817

### Total Labor Time Savings
- **Total:** (cell circled)

### Percent Savings
- **9.46%** (cell circled)

### Batching Strategy

<table>
<thead>
<tr>
<th>Shipment #</th>
<th>Batch 1</th>
<th>Batch 2</th>
<th>Batch 3</th>
<th>Batch 4</th>
<th>Batch 5</th>
<th>Batch 6</th>
<th>Batch 7</th>
<th>Batch 8</th>
<th>Batch 9</th>
<th>Batch 10</th>
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<tbody>
<tr>
<td>1</td>
<td>30703428</td>
<td>9715746</td>
<td>9715754</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>9716043</td>
<td>9715854</td>
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<td></td>
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<tr>
<td>3</td>
<td>9716050</td>
<td>9716158</td>
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<tr>
<td>4</td>
<td>9716048</td>
<td>30703425</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>9715747</td>
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This project has been created in the framework of a Senior design project. The Georgia Institute of Technology does not officially sanction its content.
Project Background

Batching Tool

Deliverables and Implementation

Value Added
DELIVERABLES – OVERVIEW

**Excel Package**
- **Batching Tool**
  - Excel File
  - OpenSolver Add-in
- **Distance Updater**
  - SQL Query

**Why Excel?**
- Free Implementation
- Simple Data Transfer
- Integer Program Solver
- Fast Run Time

**Project Proposal**
- **Written Report**
  - Proof of Concept
  - Project Methodology and Conclusions
- **Recommendation**
  - One Page Analysis Summary
- **Instructions**
  - Daily Use
  - Updating Tool
IMPLEMENTATION – OVERVIEW

Initial Implementation
- WMS Batching Upgrade
- Batching Tool and OpenSolver Installation

Daily Operation
- Only Impacts Shipping and Receiving Office
- Run Tool 8-10 Times Daily

Periodic Tool Updates
- Warehouse Layout Changes
- Constants Used in Tool
**Intended Effects:**

- Increase Units per Pick
- Decrease Average Pick Time
- Decrease Labor Hours

**Potential Adverse Effects:**
- Increase Congestion
- Increase Mis-Picks
Project Background

Batching Tool

Deliverables and Implementation

Value Added
VALUE ADDED – SEASONALITY ANALYSIS

MONTHLY THROUGHPUT

NUMBER OF UNITS

MONTH OF YEAR

McDonough, GA
Average RDC

25 DECEMBER 2011
## VALUE ADDED – PERCENT SAVINGS

### Batch Picking Savings

<table>
<thead>
<tr>
<th>Max Batch Size</th>
<th>September</th>
<th>November</th>
<th>Interpolated</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>3.35%</td>
<td>3.78%</td>
<td>3.44%</td>
</tr>
<tr>
<td>3</td>
<td>4.48%</td>
<td>4.98%</td>
<td>4.59%</td>
</tr>
<tr>
<td>4</td>
<td>5.06%</td>
<td>5.56%</td>
<td>5.17%</td>
</tr>
<tr>
<td><strong>5</strong></td>
<td><strong>5.39%</strong></td>
<td><strong>5.88%</strong></td>
<td><strong>5.49%</strong></td>
</tr>
<tr>
<td>6</td>
<td>5.61%</td>
<td>6.05%</td>
<td>5.71%</td>
</tr>
<tr>
<td>7</td>
<td>5.74%</td>
<td>6.18%</td>
<td>5.84%</td>
</tr>
</tbody>
</table>
### VALUE ADDED – RDC MONETARY SAVINGS

Savings ($ per Unit) = \( \frac{5.49\% \text{ Savings} \times \text{McDonough Annual Labor Costs ($)}}{\text{McDonough Annual Throughput (Units)}} \) \approx 0.10 per Unit

<table>
<thead>
<tr>
<th>RDC Location</th>
<th>Throughput (Units)</th>
<th>Savings ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carlisle, PA</td>
<td>X,XXX,XXX</td>
<td>$XXX,XXX</td>
</tr>
<tr>
<td>Columbus, OH</td>
<td>X,XXX,XXX</td>
<td>$XXX,XXX</td>
</tr>
<tr>
<td>Denver, CO</td>
<td>X,XXX,XXX</td>
<td>$XXX,XXX</td>
</tr>
<tr>
<td>Fort Worth, TX</td>
<td>X,XXX,XXX</td>
<td>$XXX,XXX</td>
</tr>
<tr>
<td>McDonough, GA</td>
<td>X,XXX,XXX</td>
<td>$XXX,XXX</td>
</tr>
<tr>
<td>Orlando, FL</td>
<td>X,XXX,XXX</td>
<td>$XXX,XXX</td>
</tr>
<tr>
<td>Perris, CA</td>
<td>X,XXX,XXX</td>
<td>$XXX,XXX</td>
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<tr>
<td>Spanaway, WA</td>
<td>X,XXX,XXX</td>
<td>$XXX,XXX</td>
</tr>
<tr>
<td>St. Louis, MO</td>
<td>X,XXX,XXX</td>
<td>$XXX,XXX</td>
</tr>
<tr>
<td>Stockton, CA</td>
<td>X,XXX,XXX</td>
<td>$XXX,XXX</td>
</tr>
</tbody>
</table>
VALUE ADDED – ANNUAL MONETARY SAVINGS

Initial Investment

$50,000
WMS Upgrade

Annual Savings

$1,100,000
RDC Network
PROJECT SUMMARY

Proposed Change

Implement Batch Picking

Methodology

Data Analysis Optimization

Deliverables

Batching Tool
User Guide
Proof of Concept

Value Added

$1,100,000 Annually
APPENDIX
DATA ANALYSIS – TRUCK FREQUENCY

TRUCKS PER DAY

TRUCKS BY HOUR

MAX

AVERAGE
• Including 0’s model is capable 95.47% of the time
• Not including 0’s model is capable 91.04% of the time

• Including 0’s model is capable 99.14% of the time
• Not including 0’s model is capable 97.69% of the time
### Batching Tool – Integer Program

| Integer Program | R | C | D | E | F | G | H | I | J | K | L | M | N | O |
|-----------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Decision Variables | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Objective Coefficients | 42.06101 | 101.3469 | 250.023 | 92.35573 | 50.59488 | 295.4445 | 69.11077 | 48.41944 | 172.6376 | 24.85051 | 143.4079 | 292.086 | 194.6167 | 95.53308 |
| Constraints | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
|               | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
|               | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
|               | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
|               | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
|               | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|               | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|               | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
|               | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

**Input Time Metrics (minutes)**

- Stage Time: 0.333
- Sort Time: 0.398
- Pick Time: 1.156
- Travel Time: 1.156
- Between Dock Doors: 0.048

**Total Labor Time Savings:**

**Batching Strategy**

**Shipment #** | **Batch**
---|----
1 | Batch 1
2
3
4
5
6
7
8
9
10
11
12
13
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35
36
37
38
39
40

**Instructions** | **Main** | **Truckloads** | **MoveTimes** | **IP**
# Batching Tool – Travel Time

## Whirlpool Corporation
Batch Picking Tool
12/14/11

### Input Time Metrics (minutes)
- Stage Time: 0.3324
- Sort Time: 0.3989
- Pick Time: 1.1567
- Travel Time: 0.04817

### Total Labor Time Savings

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<thead>
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<th>Total Minutes</th>
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### Time Table

<table>
<thead>
<tr>
<th>SKU</th>
<th>Time</th>
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<tbody>
<tr>
<td>1CWED5200VQ</td>
<td>1.875298</td>
</tr>
<tr>
<td>1CG65790VQ</td>
<td>1.298485</td>
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<tr>
<td>1CW75100VQ</td>
<td>0.931476</td>
</tr>
<tr>
<td>1CW75755VW</td>
<td>1.364782</td>
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<tr>
<td>7EWE1510YX</td>
<td>1.444471</td>
</tr>
<tr>
<td>7ETW1300YQ</td>
<td>0.926281</td>
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<tr>
<td>7ETW1409YM</td>
<td>0.76057</td>
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<td>7ETW1509YM</td>
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<td>7ETW1515YX</td>
<td>1.432225</td>
</tr>
<tr>
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<tr>
<td>7ETW1715YX</td>
<td>1.226426</td>
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<tr>
<td>7MWGD1730YX</td>
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<tr>
<td>177WD5070YQ</td>
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<td>A9RXNGFYX</td>
<td>1.691225</td>
</tr>
</tbody>
</table>
VALIDATION – CALCULATION

Pick Time for Batch n:
\[ \sum_{\text{trucks in batch n}} \text{nonbatched picking} + \sum_{\text{skus in batch n}} \text{batched picking per sku} \]

Non-Batched Pick Time: \[ \left( \frac{\text{SKU i in truck T}}{\text{carrying capacity SKU i}} \right) \cdot (\text{RoundtripTravel} + \text{PICK} + \text{STAGE}) \]

Round Trip Travel: \[ \frac{\text{AvgDistanceTraveled} \cdot 2}{\text{AVGSPEED}} \]

Batched Pick per SKU: \# trips for SKU \cdot (\text{RoundtripTravel} + \text{PICK} + \text{STAGE}) + \# Dropoffs \cdot (\text{STAGE} + \text{SORT} + \text{IntradockdoorTravel})

Trips per SKU: \[ \left( \sum_{\text{trucks in batch n}} \frac{\text{SKU i}}{\text{CarryingCapacity of sku i}} \right) \]

Dropoffs: \# trucks containing SKU i – 1

IntraDockDoorTravel: \[ \frac{\text{AvgDistanceBtwnBatchedDockDoors}}{\text{AVGSPEED}} \]

Constants

- Average Speed = 11.7 ft/sec (8 mph)
- Pick Time = 69 sec
- Stage Time = 20 sec
- Sort Time= 24 sec
(1) I noticed that you suggested limiting to 15 or fewer orders optimized together. Is the bottleneck the number of possible batches, or the solution time required by OpenSolver? Whichever it is, could you give me a ballpark solution time for different numbers of orders between, say, 10 and 20?

The reason for limiting the number of inputted shipments was to control the run time of the OpenSolver. Specifically, the bottleneck occurs while the constraint matrix is being loaded into the IP (a problem acknowledged and currently being worked on by the OpenSolver developers). The run time was a function of how many shipments were inputted into the model and the specified maximum batch size. For examples of run times, please see the table below. In the two months that we analyzed and ran through the tool, only once did we encounter 15 shipments being due out within the same time period ( < 0.25% of runs). Because this was the maximum observed value and an outlier, we did not deem it necessary modify the tool to reduce run time for such a high shipment number (such as 20).

<table>
<thead>
<tr>
<th>Max Batch Size/# Shipments</th>
<th>10</th>
<th>15</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4.8 seconds</td>
<td>50 seconds</td>
<td>3:40*</td>
</tr>
<tr>
<td>7</td>
<td>7.5 seconds</td>
<td>4:10</td>
<td>34:50*</td>
</tr>
</tbody>
</table>

Note: Starred values have been estimated based on the size of the constraint matrix.
(2) It wasn't clear to me how the data gets inputted to your tool. Given a set of, say, 15 orders, how long would it take someone to convert those orders (amount of each SKU required by each order) into a format readable by your tool, and how much would that effort cost Whirlpool annually?

Data will be pulled by the Shipping and Receiving Office associate (SRO) via a database query and then copy/pasted into the tool. When performed by team members running data through the tool, this process took only 30-45 seconds per run. However, it is understandable that this process may take longer for the SRO, considering Microsoft Excel and Access load times and that the SRO is not running data back to back. If we are to assume that the process takes the SRO a conservative 5 minutes per run, the annual cost is approximately $3950 as detailed in the equation below.

\[
\left[ \frac{5 \text{ minutes per run}}{60 \text{ minutes per hour}} \right] \times \left[ \frac{8 \text{ runs}}{\text{day}} \times 5 \text{ weekdays} + 2 \text{ weekend runs} \right] \times \frac{50 \text{ weeks}}{\text{year}} \times \frac{\$22.50}{\text{labor hour}} \approx \$3950
\]

If Whirlpool were to implement batch picking with a strict set of batch picking rules, the tool could be altered such that larger data sets could be pulled into the tool directly from the database. Batch picking rules would automatically be applied, eliminating this as a requirement of the SRO and significantly reducing the time required for this step.