IE3100R Systems Design Project. Department of Industrial Systems Engineering and Management. AY2016/2017

A collaboration between NUS and FairPrice Online

OPTIMISING GROCERY E-COMMERCE WAREHOUSE OPERATIONS

Introduction

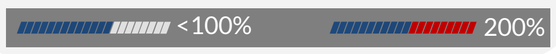
FairPrice Online is the official online shopping portal of NTUC FairPrice Co-operative Ltd, the largest grocery retailer in Singapore. It allows customers to shop online and have their groceries delivered to their doorstep. A recent shift to a new dedicated e-commerce fulfilment centre at Benoi has resulted in several operational issues for the company, which primarily involves limited manpower and sub-optimal warehouse operations. The warehouse is managed by Grocery Logistics Singapore (GLS) and these issues hinder their ability to meet the expected growth of FairPrice online. To improve the overall efficiency of the warehouse operations, an automated system known as the AutoStore has been implemented. In the context of a warehouse with both automated and manual processes, the goal of this project is to reduce average order picking time and hence, improve the overall warehouse capability.

Background

Motivation

Warehouse processes not sufficiently lean and efficient

Management aims to double current sales



Current Process

01 3 delivery time slots
10am – 2pm; 2pm – 6pm; 6pm – 10pm

02 Order picked & packed two delivery slots in advance

VS

Ideal Process

01 Shorter length of delivery time slot
2-hr slots vs 4-hr slots

02 Orders picked & packed one slot in advance

Just-In-Time Picking Methodology

AutoStore

EFFICIENT SYSTEM
Storage & Picking

ROBOTS
Put-away & Picking

PLASTIC BINS
Storage of SKUs

Methodology

Problem Definition

- Understand problems faced and the need for automation
- Analyse current warehouse operations: Process flow, manual picking etc.

Project Objective

"Reduce Average cycle time of Picking Process through effective integration of AutoStore"

Approach

- Lean Startup Model – Iterative Approach
- SKU Assignment based on product velocity
- SKU assignment based on optimization algorithm

Analysis & Results

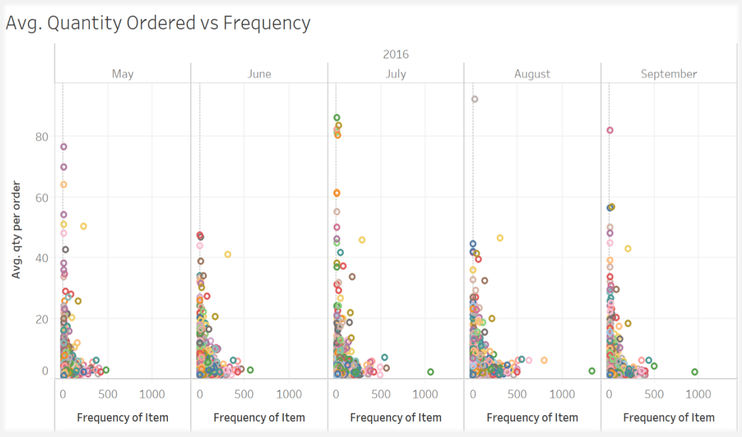
- Analysis of order data to determine optimal SKU assignment
- Sensitivity analysis to test robustness of our model
- Correlation analysis between different SKUs using C#

Recommendations

- Optimal SKU assignment for AutoStore
- SKU correlation results for future assignment
- Identify lanes for pick & pass

Analysis & Results

Studying Demand (May–Sep 2016)



Analysis of FairPrice Online's historic order data suggests that the **demand pattern is similar** across months.

Hence, it is assumed that there are no major changes in demand patterns for the duration of this project.

Iteration 1: Assignment Using Product Velocity

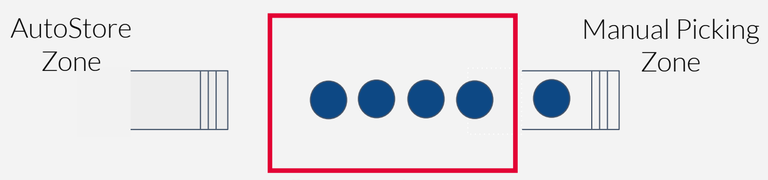
Weight and Volume Constraint

Product Velocity

- Volume of Bin 72,000 cm^3
- Weight Capacity 25 KG
- Recommended Qty Each SKU ≥ 6 per bin
- Filter 10% fastest moving SKUs

SKUs 4000+

Bottleneck formed



AutoStore picking is significantly faster than Manual Zone picking

Iteration 2: Improved Assignment – Optimisation Model (MATLAB)

- Based on our objective, we built a **minimisation model** and solved it using **Genetic Algorithm**.
- A **time study** was conducted in the warehouse to determine values for variables (a), (b) and (c) below.

Variables	Minutes
(a) Time to pick SKU from AutoStore	0.08333
(b) Time to pick SKU from Manual area	0.6
(c) Split Order Processing Time	5
Variables	**No. of SKUs**
(d) Maximum SKUs in AutoStore	4770
(e) SKUs infeasible for AutoStore	8507

- With the variables set in the MATLAB model, we ran the algorithm for **Maximum 4770 SKUs** in **AutoStore** (value based on **Iteration 1**)

Minimisation Objective

Manual Picking + AutoStore Picking + Split Order Processing = Total Picking Time

Iteration 3: Improved Model - Incorporate Bulk Quantity Orders

- The recommended SKU Assignment from Iteration 2 assumes that each SKU would only have one location.
- **GLS concern**: It is not practical to pick bulk quantity orders from AutoStore
- **Our Solution**: Identify SKUs with frequent bulk quantity orders, assign these SKUs to **both AutoStore** (single items) and **manual area** (cartons)

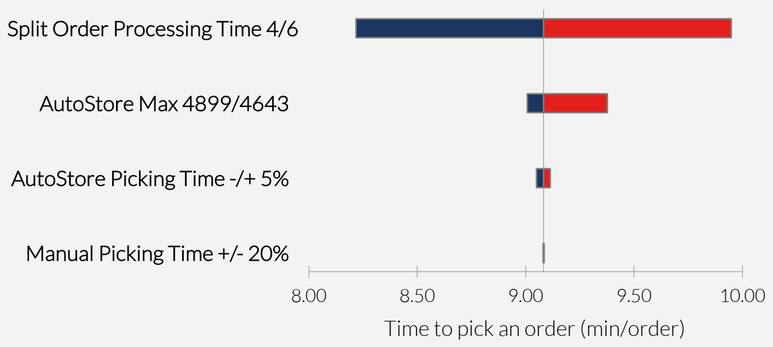
Carton picks from Manual

High Occurrence of Bulk Orders

Single picks from AutoStore

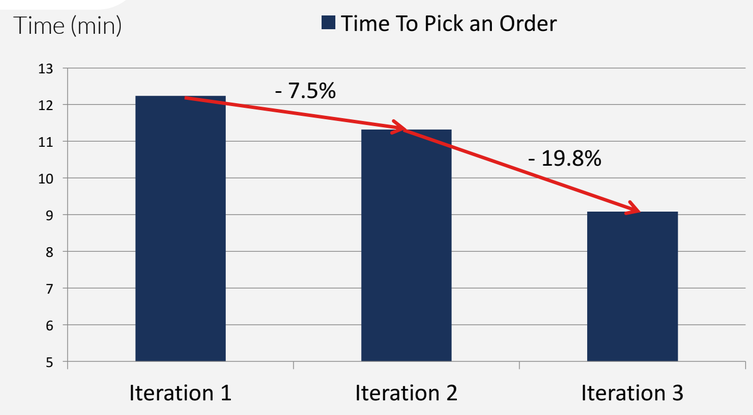
- SKUs with order quantity >1 carton size AND order frequency >1 are identified as bulk quantity ordered
- For these SKUs, new carton-size SKU ids were created (i.e. same product with 2 SKUs to differentiate single and carton)
- Ran optimisation model with carton SKUs fixed as infeasible for AutoStore

Sensitivity Analysis



From the Tornado chart, we see that the **split order processing time** and **the maximum number of SKUs allowed in AutoStore** have the **most impact** on the time to pick an order. Hence, both these factors should be given the most attention.

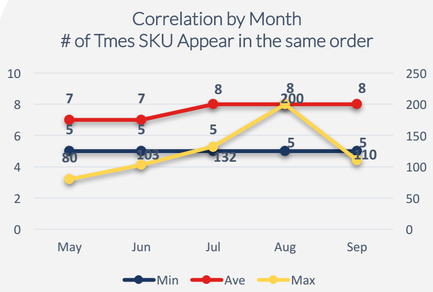
Policy Comparison



- Compared to Iteration 1, Iteration 2 is able to **reduce the average time taken to pick an order** by **7.5%**
- Compared to Iteration 2, Iteration 3 is able to **reduce the average time taken to pick an order** by **19.8%**
- Overall, our SKU assignment policy is able to **reduce the average time taken to pick an order** by **34.8%**

Further Improvements

Correlation Analysis of SKUs

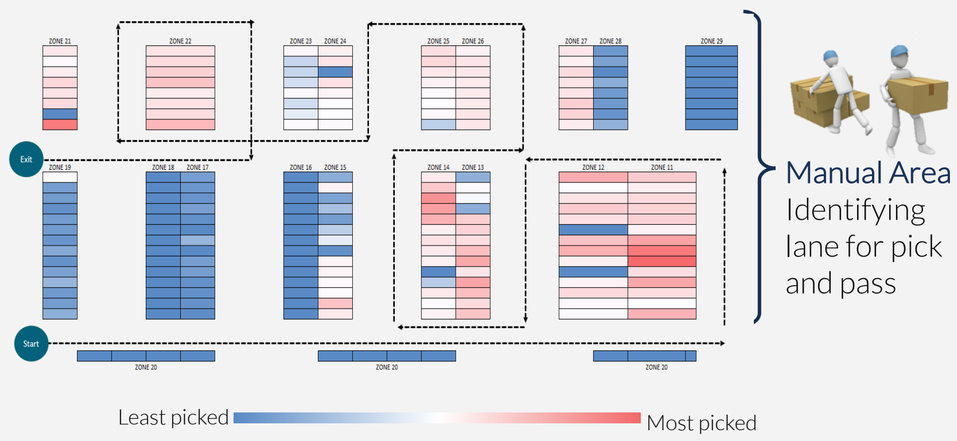


Through correlation analysis, we identified **SKU pairs** that could be placed in the **same** AutoStore bin. We incorporated this in the optimisation algorithm and obtained the corresponding SKU assignment.

Avg. time to pick an order = 10.94s

Month	Max Pairs	#
May	HomeProud Disposable Forks & HomeProud Disposable Spoons	80
June	Julie's Sandwich – Cheese & FairPrice Fine Sugar	103
July	Julie's Sandwich Cheese & Julie's Sandwich Peanut	132
August	Pagoda Fine Salt & FairPrice Fine Sugar	200
September	FairPrice Facial Tissue & Budget Kitchen Towel	110

Analysis of order data



- **Visualisation** of pick zone frequency within the manual area made using historic order data
- Based on the heat map, a **pick and pass strategy** can be employed for the some of the **"hot"** zones i.e. **zones 11, 12, 13, 14, 22**

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