Outbound Supply Chain Design Adaptation for Cross Border E-Commerce

IE3100M System Design Project | Group 9
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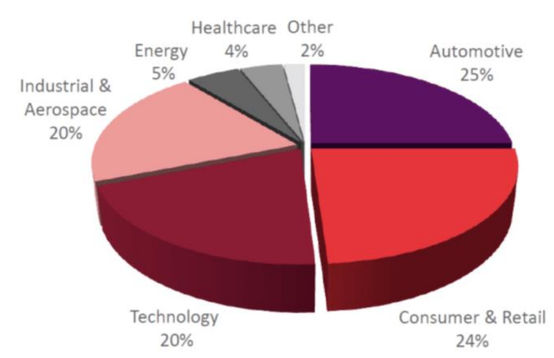
PROJECT OVERVIEW

COMPANY BACKGROUND

CEVA Logistics is one of the world's leading non-asset based logistics companies offering integrated, industry leading solutions across the supply chain in manufacturing support, inbound logistics, warehousing and distribution, outbound logistics, aftermarket services as well as last mile solutions.



- Freight Management and Contract Logistics make up 48% and 52% of CEVA Logistics' total revenue of US$6.6 billion in 2016

PROBLEM DEFINITION

CEVA intends to develop & grow its e-commerce service offerings by making design change and process improvement to its current supply chain operations.

This project aims to design an e-commerce supply chain for CEVA Logistics and provide a suitable algorithm for optimal bin packing which is critical in e-commerce logistics.

OBJECTIVES

- Design an e-commerce specific supply chain by suggesting suitable models to be used in each of the different components along the chain:
  - Inbound Logistics
  - Warehouse & Distribution
  - Outbound Logistics & Freight Management
  - Last Mile Logistics
- Identify a suitable heuristic method and implement a program to solve the 3D Bin Packing Problem (BPP). It is a highly relevant issue as logistics companies need to optimally pack various packages of different sizes to minimize unused pallet space. Their profits from transportation are linked to transportation space utilization.

PROJECT METHODOLOGY

- This project has taken a systematic approach when analyzing the problem. Subsequent steps are only taken when venturing into the e-commerce logistics industry is proven to be viable through market research. Both qualitative and quantitative recommendations are provided with actual environment taken into consideration.

01 — Analyze the global ecommerce market and growth opportunity

02 — Examine the business models used by ecommerce players and identify key challenges faced by logistics companies

03 — Design a supply chain based on existing models and fitness of these models when used in the region

04 — Implement a Human Intelligent-Based Heuristic Approach using programming which automatically generates solution when inputs are given

05 — Evaluate the performance of the proposed algorithm by percentage of completion and time taken to generate solution

SKILLSET APPLIED

System Thinking — Exercise system thinking and manage the project from a macro perspective

Supply Chain Modeling — Design e-commerce supply chain that takes into account of the CEVA context

Communication — Communicate with key stakeholders of the project to obtain relevant information

Optimization — Using knowledge from operation research to solve the 3D Bin Packing Problem

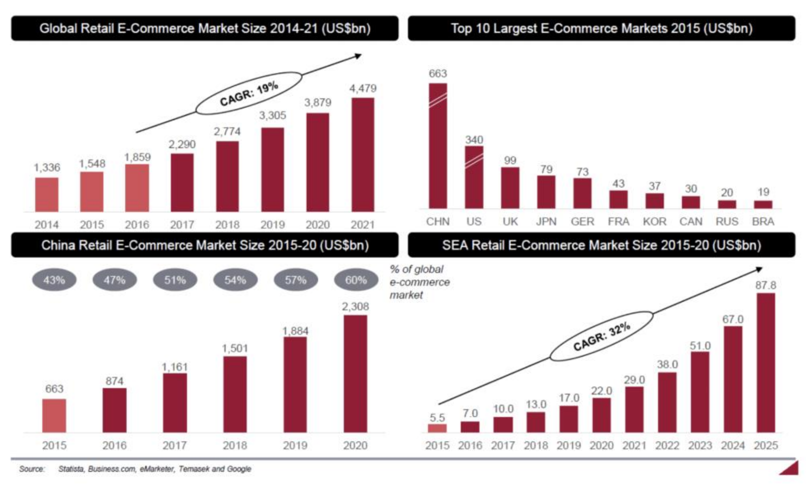
Simulation — Apply simulation skill in solving the optimization problem

Decision Analysis — Make rational decision based on numbers and information when making new designs

RESEARCH FINDINGS

E-COMMERCE MARKET OVERVIEW

- Global e-commerce is a fast and growing market, with a Compounded Annual Growth Rate (CAGR) of ~19%
- China is the largest in terms of market value and expanding fast
- Southeast Asia 's e-commerce market is projected to experience fast growth moving forward (CAGR of 32% vs global CAGR of 19%)



GROWTH DRIVER

- Growing in middle income population
- China and the middle class in both SEA and China are expected to take up 55% and 71% of the population in 2020 respectively
- Internet penetration in SEA and China is expected to increase towards the developed countries' average of ~80%. Smartphone penetration is expected to reach ~70% as well in 2020.

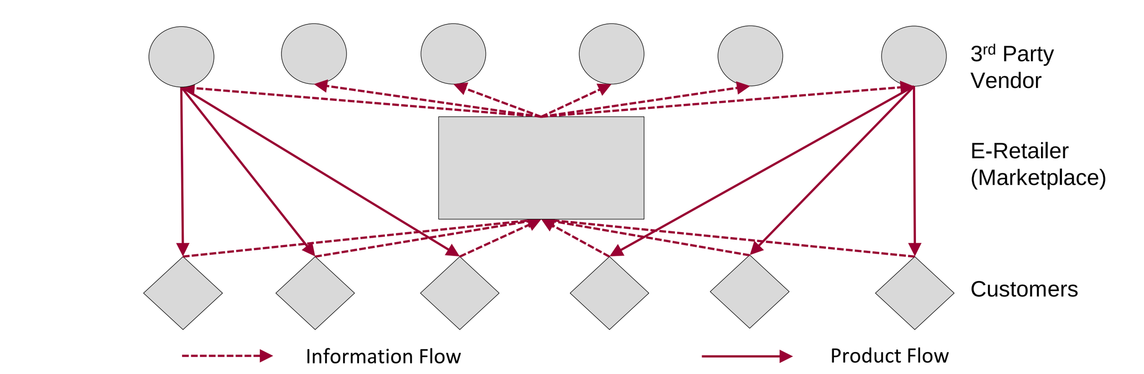
REGIONAL PLAYER AND BUSINESS MODELS

- China e-commerce market is dominated by JD and Alibaba, and they have together with other companies developed a well structured logistics network. The logistics market is competitive.
- E-commerce market in SEA is more segmented and firms employ different business models (Marketplace, Inventory and Hybrid)
- Logistics companies face more challenges in SEA such as geographical issues (Indonesia and Philippines are archipelagos), poor infrastructure affecting last mile delivery, regulatory issues as well as dependence on cash (vs online payments).

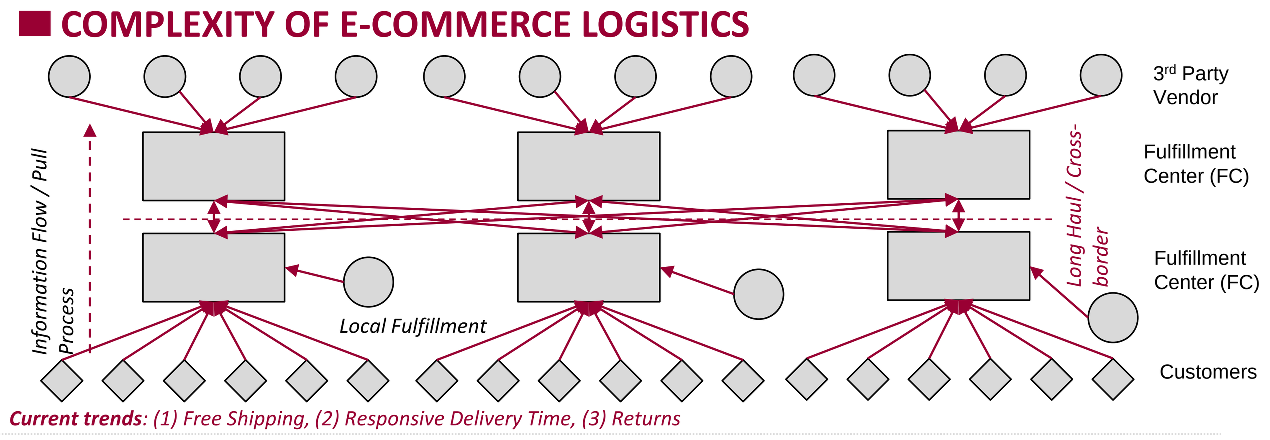
Business Model		Marketplace	Inventory	Hybrid
Description		Product / inventory provided by 3rd parties; transactions processed by marketplace operator	Product / inventory is sourced from 3rd parties and held by e-commerce operator	Mix between Marketplace and Inventory models
Players	Horizontal	Qoo10, Bukalapak, blibli, Lelong, 11st, tokopedia, TARAD, Vatgia.com, elevenia, MetroDeal, Sendo	Tiki.vn	Lazada Group
	Vertical		FashionValet, HipVan, thegioididong, redmart	Zalora, Reebonz

E-COMMERCE SUPPLY CHAIN DESIGN

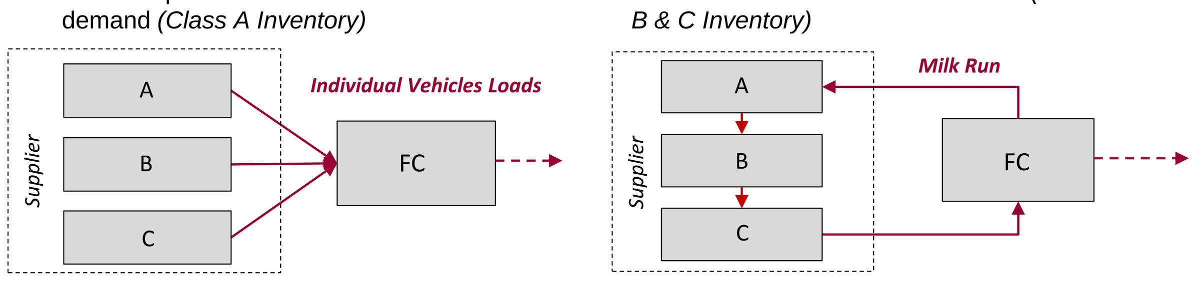
CEVA LOGISTICS' OBJECTIVE



COMPLEXITY OF E-COMMERCE LOGISTICS



- **Push Process:** *(Class A Inventory)*
  - Utilize push process for inventory with sufficient product volume and more certain demand (Class A Inventory)
- **Pull Process:** *(Class B/C Inventory)*
  - Utilize pull process for inventory with lower volume and more uncertain demand (Class B & C Inventory)



	Cost	Responsiveness
Inventory	High	High
Transport	Low	Low

	Cost	Responsiveness
Inventory	Low	Low
Transport	High	High

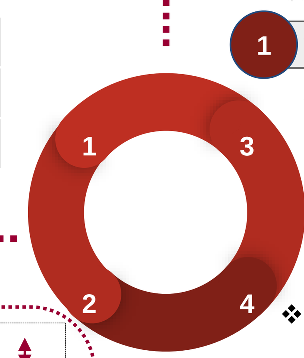
Physical Transport Process

Landside	Unload truck from DC	Incoming checks & administration	Sort goods and documents	Outgoing checks & administration	Build ULD's
Airside	Ramp transport & security check	Load aircraft	Flight	Unload aircraft	Ramp transport
Landside	Breakdown ULD's	Incoming checks & administration	Sort goods and documents	Outgoing checks & administration	Load truck

- **Difficulty** in harnessing this process for e-commerce delivery lies in **optimally building the ULDs from e-commerce packages of various sizes**

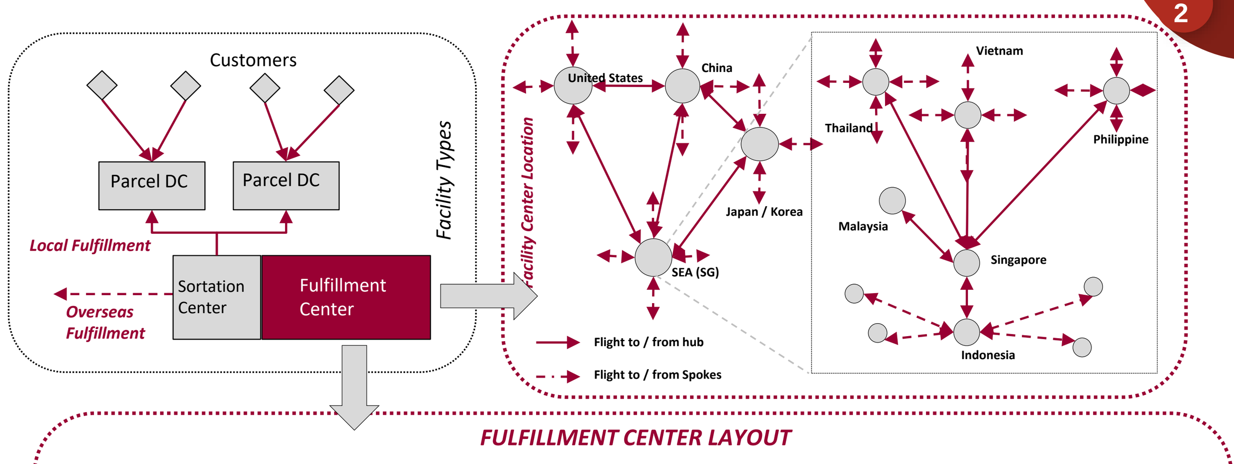
1 With insufficient e-commerce package numbers: Allocate some space / utilize leftover space on its existing flights booked for global traditional logistics freight forwarding

2 With increasing e-commerce package numbers: Flights / flight space can increasingly be entirely booked for e-commerce packages

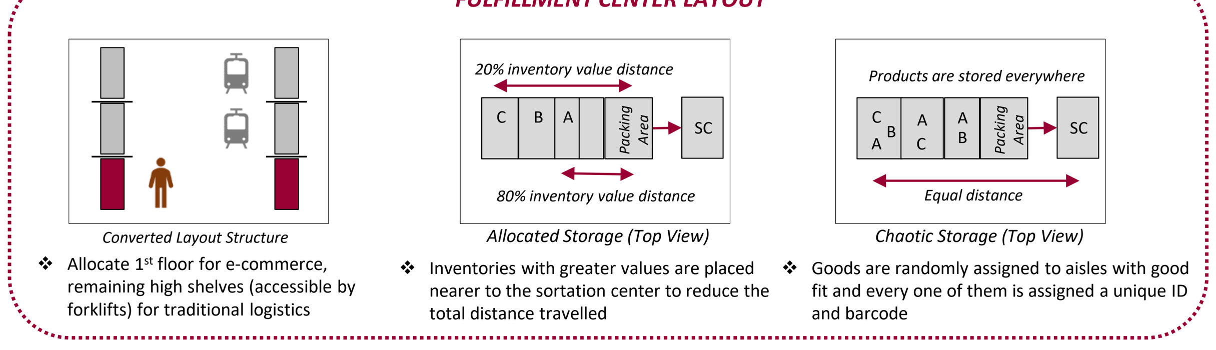


INBOUND LOGISTICS

WAREHOUSING & DISTRIBUTION



FULFILLMENT CENTER LAYOUT



Converted Layout Structure — Allocate 1st floor for e-commerce, remaining high shelves (accessible by forklifts) for traditional logistics

Allocated Storage (Top View) — Inventories with greater values are placed nearer to the sortation center to reduce the total distance travelled

Chaotic Storage (Top View) — Goods are randomly assigned to aisles with good fit and every one of them is assigned a unique ID and barcode

OUTBOUND LOGISTICS / FREIGHT MANAGEMENT

LAST MILE LOGISTICS

- **Challenges:** (1) Last mile delivery takes up >50% of total logistics costs (2) Markets like Indonesia & Philippines are island archipelagos & have problematic traffic

SUPPLY CHAIN MODELS

Traditional	Today's Model (Road Transport)
	Crowdsourcing
	Bike Couriers
High Technology	Drones
	Autonomous Vehicles with Lockers
	Semi-autonomous vehicles

MODEL COMPARISON & SELECTION (PRESENT / *FUTURE*)

	Rural Areas	Suburban Areas	Urban Areas
Regular Parcel (D+1~D+4)	Conventional last mile delivery (Autonomous vehicles with parcel lockers)		
High Responsiveness	Fulfillment cost levels not economical (Drones)	Conventional last mile delivery (Autonomous vehicles with parcel lockers)	
Same Day	Fulfillment cost levels not economical (Drones)		Crowdsourcing/ Bike Couriers
Instant	Fulfillment cost levels not economical		Crowdsourcing/ Bike Couriers

- **Recommendations:** (1) Outsource last mile delivery to local / regional companies like Ninja Van (2) Consolidate deliveries to reduce cost

3D BIN PACKING

MIXED INTEGER PROGRAMMING FORMULATION

$l_i * w_i * h_i$: Length * Width * Height of box i

$L * W * H$: Length * Width * Height of the pallet

v_i: volume of box i

V_j: volume of pallet j

C: cost of using a pallet

m: number of pallet available

n: number of box to be packed

p_i: profit generated by item i when accomodated into a bin

$$u_j = \begin{cases} 1 & \text{if pallet } j \text{ is used} \\ 0 & \text{if pallet } j \text{ is not usedj} \end{cases}$$

$$z_{ij} = \begin{cases} 1 & \text{if box } i \text{ is in pallet } j \\ 0 & \text{if box } i \text{ is not in pallet } j \end{cases}$$

(x_i, y_i, z_i): location of the front left bottom corner of box i

(x_i', y_i', z_i'): location of the rear right top corner of box i

$$x_{ki}^b = \begin{cases} 1 & \text{if } x_i' < x_i \\ 0 & \text{otherwise} \end{cases} \quad \text{(same applied for } y \text{ and } z\text{)}$$

$$x_{ki}^a = \begin{cases} 1 & \text{if } x_i' > x_i \\ 0 & \text{otherwise} \end{cases}$$

r_{pq}^i: binary variable used to describe the orientation of box i into a container

$\forall i, k \in \{1, \dots, n\}, \forall j \in \{1, \dots, m\}, \forall p, q \in \{1,2,3\}.$

$$\min \sum_{j=1}^{m} C * u_j - \sum_{j=1}^{m}\sum_{i=1}^{n} p_i * z_{ij}$$

s.t

$$\sum_{i=1}^{n} v_i z_{ij} \le V_j u_j, \quad \forall j$$

$$\sum_{j=1}^{m} z_{ij} = 1, \quad \forall i$$

$$z_{ij} \le u_j, \quad \forall i, j$$

$$x_i' \le L, \quad \forall i$$

$$y_i' \le H, \quad \forall i$$

$$z_i' \le W, \quad \forall i$$

$$x_i' - x_i = r_{11}^i l_i + r_{12}^i w_i + r_{13}^i h_i, \quad \forall i$$

$$y_i' - y_i = r_{21}^i l_i + r_{22}^i w_i + r_{23}^i h_i, \quad \forall i$$

$$z_i' - z_i = r_{31}^i l_i + r_{32}^i w_i + r_{33}^i h_i, \quad \forall i$$

$$\sum_{p=1}^{3} r_{pq}^i = 1, \quad \forall i, q$$

$$\sum_{q=1}^{3} r_{pq}^i = 1, \quad \forall i, q$$

$$x_i - x_k' + (1 - x_{ki}^b)M + \left(2 - (p_{ij} + p_{kj})\right)M \ge 0, \quad \forall i, j, k$$

$$x_k - x_i' + (1 - x_{ki}^a)M + \left(2 - (p_{ij} + p_{kj})\right)M \ge 0, \quad \forall i, j, k$$

$$y_i - y_k' + (1 - y_{ki}^b)M + \left(2 - (p_{ij} + p_{kj})\right)M \ge 0, \quad \forall i, j, k$$

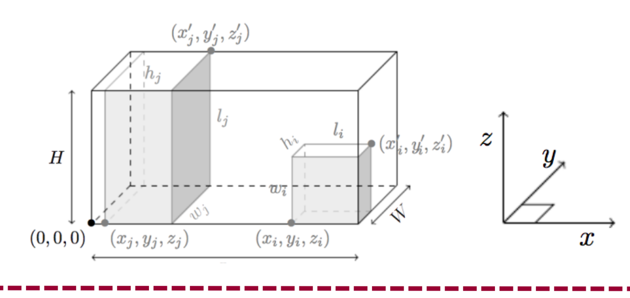
$$y_k - y_i' + (1 - y_{ki}^a)M + \left(2 - (p_{ij} + p_{kj})\right)M \ge 0, \quad \forall i, j, k$$

$$z_i - z_k' + (1 - z_{ki}^b)M + \left(2 - (p_{ij} + p_{kj})\right)M \ge 0, \quad \forall i, j, k$$

$$z_k - z_i' + (1 - z_{ki}^a)M + \left(2 - (p_{ij} + p_{kj})\right)M \ge 0, \quad \forall i, j, k$$

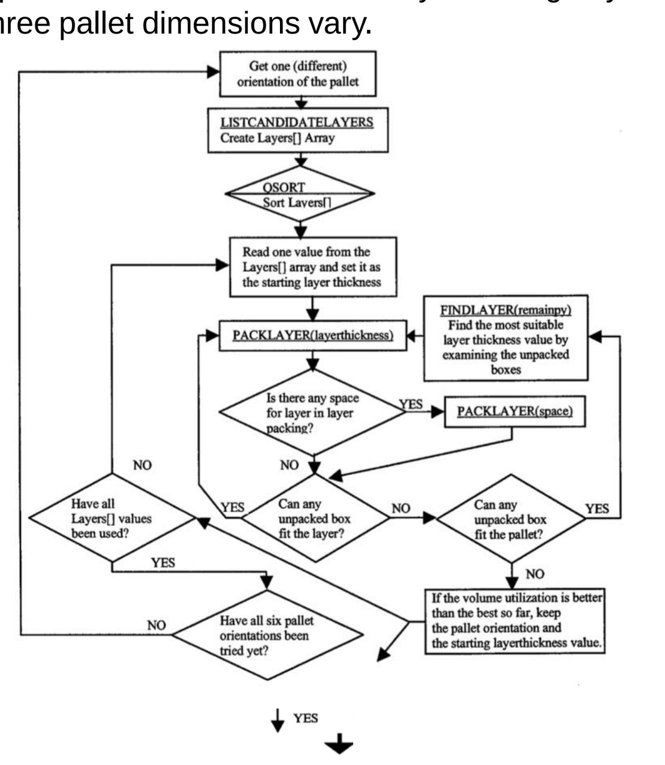
$$x_{ki}^b + x_{ki}^a + y_{ki}^b + y_{ki}^a + z_{ki}^b + z_{ki}^a > 0, \quad \forall i, j, k$$

$$\begin{pmatrix} x_i' - x_i \\ y_i' - y_i \\ z_i' - z_i \end{pmatrix} = \begin{pmatrix} r_{11}^i & r_{11}^i & r_{11}^i \\ r_{11}^i & r_{11}^i & r_{11}^i \\ r_{11}^i & r_{11}^i & r_{11}^i \end{pmatrix} \cdot \begin{pmatrix} l_i \\ w_i \\ h_i \end{pmatrix}$$



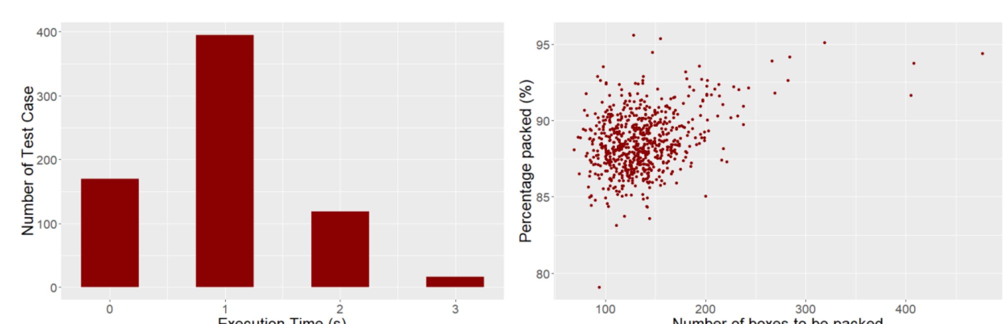
HEURISTIC

- A Layer Packing and Wall Building approach which builds walls or layers along any of the six faces of the given pallet if all three pallet dimensions vary.
- Simultaneously it employs a layer-in-layer packing approach that packs a sublayer into any of the available unused space in the last packed layer.
- The approach attempts to retain a flat forward packing face and reduce surface irregularities.
- In each step, the dimensions of the boxes to be filled are determined before analyzing all eligible boxes and their orientations.
- The most suitable layer thickness is then picked to reduce wasted volume before packing.
- It is an approach that imitates human behavior and intelligence in box packing.



ALGORITHM PERFORMANCE ANALYSIS

Total Number of Test Case: **700**			
Average Box Volume Packed (%)	**88.587%**	Average Pallet Volume Packed (%)	**88.097%**
Standard Deviation (%)	**1.910**	Standard Deviation (%)	**1.901**



- **Observations:**
  - The heuristic is able to fill around 90% of the whole pallet with the given boxes, and standard deviation of such performance is only 1.9. Besides, this method is also able to uphold the performance regardless of the number of boxes to be packed.
  - The results are produced in less than two seconds in most of the tests.