Machine Reasoning and Reasoning System Project

Intelligent E-commerce Shipping Option Generator and Packing Optimizer

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1. Executive Summary

In the past few years, e-commerce and online shopping have become more and more popular. In some markets, it even becomes an essential part of daily lives. A lot of small and medium size merchants have emerged to capture the business opportunities. While setting up an online store is easier now because of the mature platforms like Woocommerce and Shopify, there are still many challenges for small and medium sized online merchants. One of them is pack and shipping.

Packing and shipping is particularly hard to handle because different merchants will have different types, sizes and combinations of products. Packing problem refers to how to pack the ordered goods in the basket in order to minimize volume, which in turns minimizes shipping cost. Shipping problem refers how to find the cheapest available option for customer to minimize their shipping cost and thus induces more sales.

In this project we interviewed several online merchants who sell internationally. We understand their current challenges and designed this smart shipping options generator and cost calculator.

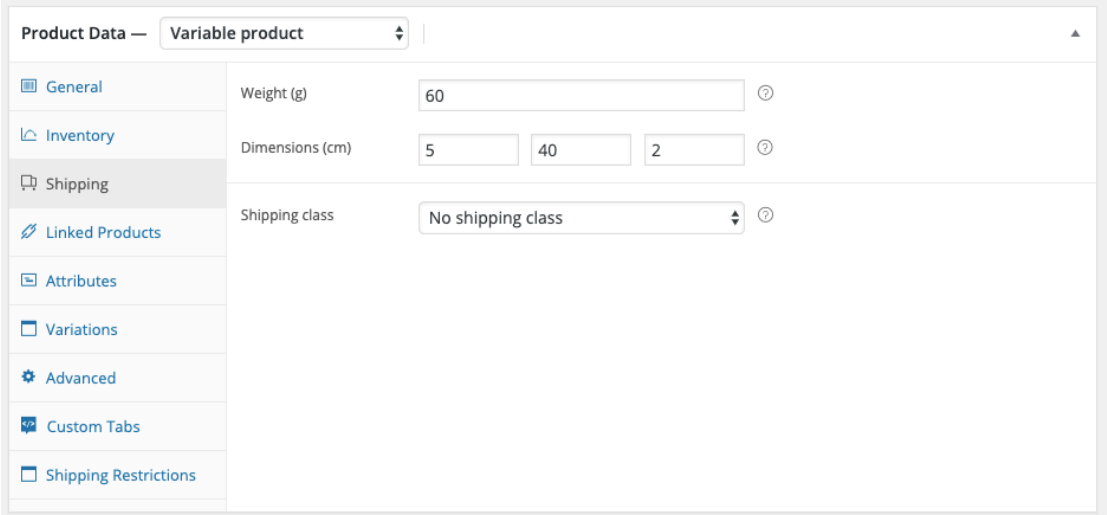
We will use DHL, UPS, Fedex and SF Express as example. We will configure their shipping rates into the system, where our rules-engine will find the optimal shipping rates based on the weight and destinations. We also leverage third party library for the packing optimization problem in order to minimize shipping cost.

2. Case Study - Online Smart Watch Merchant

To understand the business needs and collect the knowledge from real life online merchants, we interviewed an online smart watch merchant that sells smart watches to over 30 countries online.

Their current process to calculate shipping cost is documented below:

1. Setting up of product details in online store powered by Woocommerce.
Details of product include:
- Product Name
- Weight
- Dimensions
- Countries to ship (some products only ship to certain countries)



2. Determining the Shipping Countries
The company selected 30 countries (Singapore, USA, UK, Russia etc.) to ship to. The countries were then configured into the online store.

3. Reviewing Shipping options
Based on the countries selected, the company then reviews the shipping rates table from different couriers, for example DHL, UPS and SF Express. In shipping rate table, countries that are nearby and thus have similar shipping rates are grouped together as zone. Different couriers have different zone grouping and rate weight tiers. Examples below:

DHL Shipping rates

Export rates by zone and product

DHL EXPRESS WORLDWIDE

Weight in kg	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
Documents only up to 2kg								
0.5	23.64	33.43	43.43	61.41	62.66	63.61	106.42	127.39
1	35.78	50.70	67.98	89.14	90.91	93.77	154.44	194.83
1.5	44.24	64.97	90.23	115.45	117.70	123.83	201.21	274.95
2	52.70	79.24	112.48	141.76	144.49	153.89	247.98	355.07
Documents from 2.5kg and non-documents from 0.5kg								
0.5	41.00	51.07	53.63	76.65	80.46	82.48	131.41	209.42
1	44.61	61.84	72.84	98.22	103.07	106.97	171.57	279.40
1.5	51.95	72.75	92.79	120.18	126.08	131.46	211.51	349.12
2	59.29	83.66	112.74	142.14	149.09	155.95	251.45	418.84
2.5	67.36	96.25	132.94	172.15	180.53	184.53	313.25	499.22
3	78.43	108.16	155.63	193.23	202.64	207.57	363.85	567.90
3.5	89.50	120.07	178.32	214.31	224.75	230.61	414.45	636.58

SingPost Airmail rates

▸ Overseas Postage Rates - Airmail Rates

There will be an additional S$2.50 applicable for international registered article.

AIRMAIL RATES[1]					
Destination	Letters and Printed Papers[2]		(NEW) Small Packets[3]		Postcards[4] (per piece)
	Weight Step Up To (max weight: 2kg)	Postage Rate	Weight Step Up To (max weight: 2kg)	Postage Rate	
Zone 1 Malaysia & Brunei	20g	$0.50	100g	$2.50	$0.40
	50g	$0.70	250g	$3.90	
	100g	$1.10	500g	$5.20	
	Per additional 100g	$1.10	Per additional 100g	$1.10	
Zone 2 Countries in Asia & the Pacific (except Australia, Japan & New Zealand)	1st 20g	$0.70	100g	$3.20	$0.60
			250g	$6.80	
	Per additional 10g	$0.25	500g	$12.00	
			Per additional 100g	$2.50	

4. Setting up shipping rules

The company's policy is to give 2 shipping options for each online checkout:
Standard Shipping is offered for cheaper shipping cost but slower delivery time.
Express Shipping is offered for expedite delivery time but more expensive.

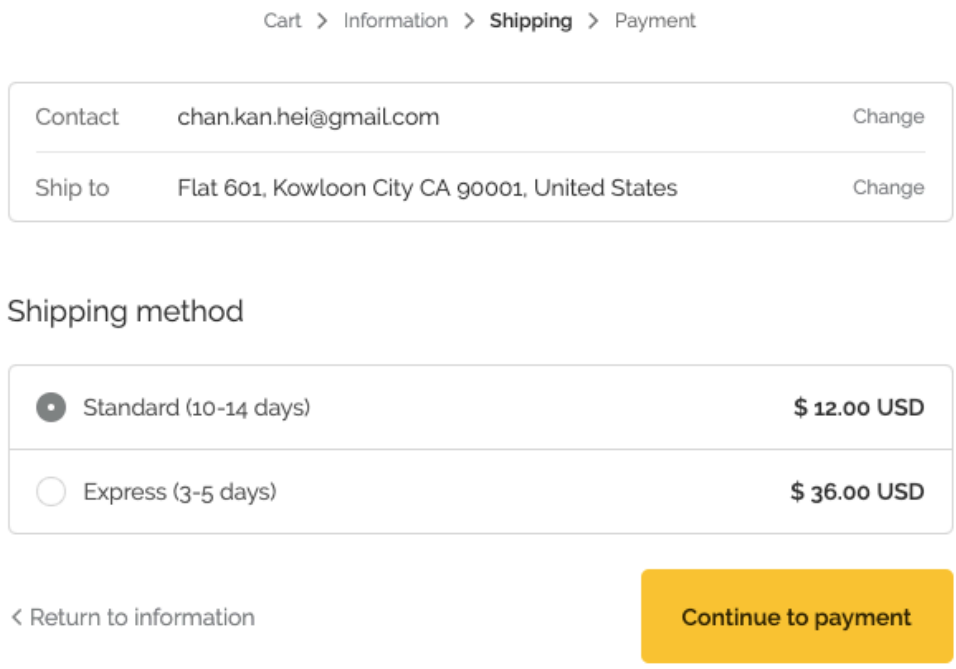
Online platform like Woocommerce (wordpress online store engine) and Shopify supports weight based shipping cost calculations. For example, the merchant can set

up a shipping rule for USA with base cost at 10 SGD, then for each additionally 0.5 kg, charge 3 SGD on top. Each country can only be set to one zone. Each zone can have multiple shipping rules (standard shipping and express shipping rule). Then for each rule, a courier is chosen.

As a result, a shipping rule table is created manually like below.

	Country	Express option	Watch and More Shipping Rule on Woocommerce	Charm and Cable Shipping Rule on Woocommerce	Express Delivery Time	One watch cost	Each extra watch cost	Charm and Cable only	Standard option
Austria	AT	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Australia	AU	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	DPEX
Belgium	BE	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Bulgaria	BG	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Switzerland	CH	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Germany	DE	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Denmark	DK	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Spain	ES	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Finland	FI	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
France	FR	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
United Kingdom	GB	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Hong Kong	HK	-	-	-	-	-	-	-	HKPost Packet (Local)
Hungary	HU	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Indonesia	ID	DHL Express	X-WnM-35+7	X-CnC-35	3-5	35	7	35	SingPostRAM
Israel	IL	DHL Express	X-WnM-65+13	X-CnC-65	3-5	65	13	65	SingPostRAM
India	IN	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Italy	IT	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Japan	JP	DHL Express	X-WnM-30+6	X-CnC-30	3-5	30	6	30	SingPostRAM
Cambodia	KH	DHL Express	X-WnM-35+7	X-CnC-35	3-5	35	7	35	SingPostRAM
Korea	KR	DHL Express	X-WnM-30+6	X-CnC-30	3-5	30	6	30	SingPostRAM
Macao	MO	DHL Express	X-WnM-30+6	X-CnC-30	3-5	30	6	30	-
Malaysia	MY	DHL Express	X-WnM-30+6	X-CnC-30	3-5	30	6	30	DPEX
Netherlands	NL	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Norway	NO	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Poland	PL	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM
Portugal	PT	DHL Express	X-WnM-40+8	X-CnC-40	3-5	40	8	40	SingPostRAM

5. Displaying the Shipping Options on check out page
While there could be more than 2 viable shipping options for customer, to simplify operation workflow, only two are selected as Standard and Express and displayed to the customer to choose from.



3. As-Is Process Pain Points and How To Improve

1. Manual settings of shipping rule and choice of courier.
The current process requires manual comparison of shipping rates tables of couriers, which is time consuming and not scalable.

How we can improve: The shipping rates table of courier can be converted to a decision table. The logic of picking the cheapest courier can be entered into a rules-engine like drools. The shipping cost can then be directly calculated real time according to the total weights of the basket.

2. Volumetric weight is not considered
SF express provides a great definition of Volumetric Weight.

"The chargeable weight(kg) of a shipment is determined by the actual gross weight or the volumetric weight(L×W×H(cm)÷5,000), whichever is greater"

Physical Weight is not the only factor couriers consider when charging shipping cost. They also look at the volume. For example if you have something that is very light like cotton but takes up a huge amount of space. Courier will charge you the cost based on the volumetric weight not the physical weight.

How we can improve: How we pack the products will affect the final volume of the package and thus affect the volumetric weight. Bin packing to minimize volume is an optimization problem that can be solved with an optimizer.

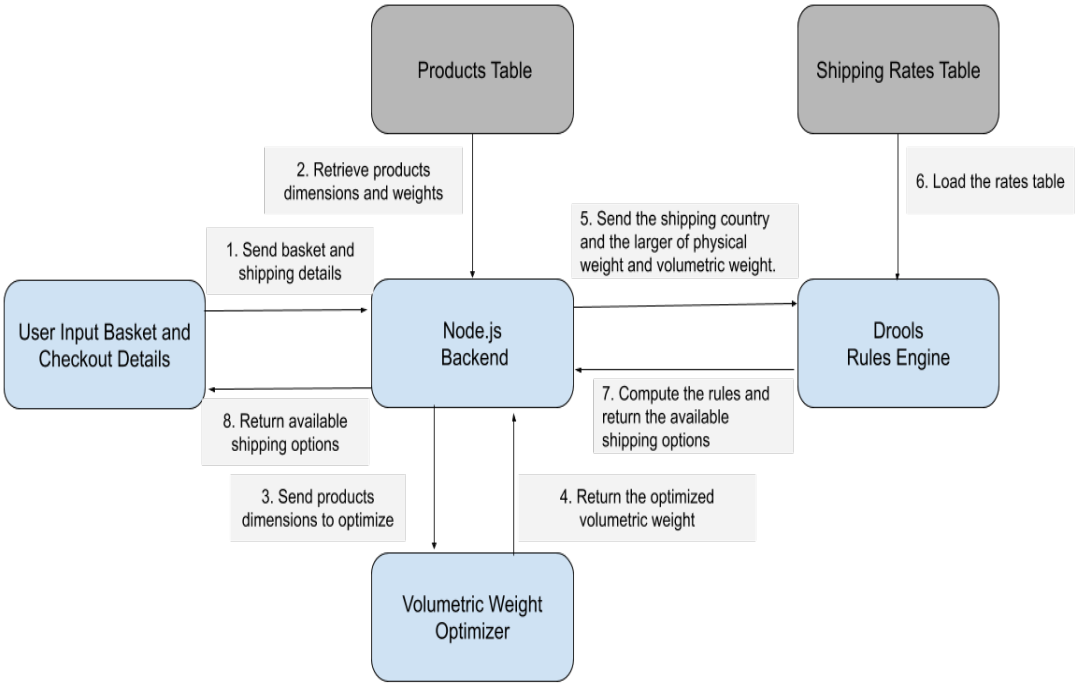
4. Business Objectives and Values

After understanding the business needs, the objective of the below proposed system is to replace the manual settings and maintenance of shipping rules with our machine-intelligent real time shipping cost calculator and packing optimizer (considering the volumetric weight as well).

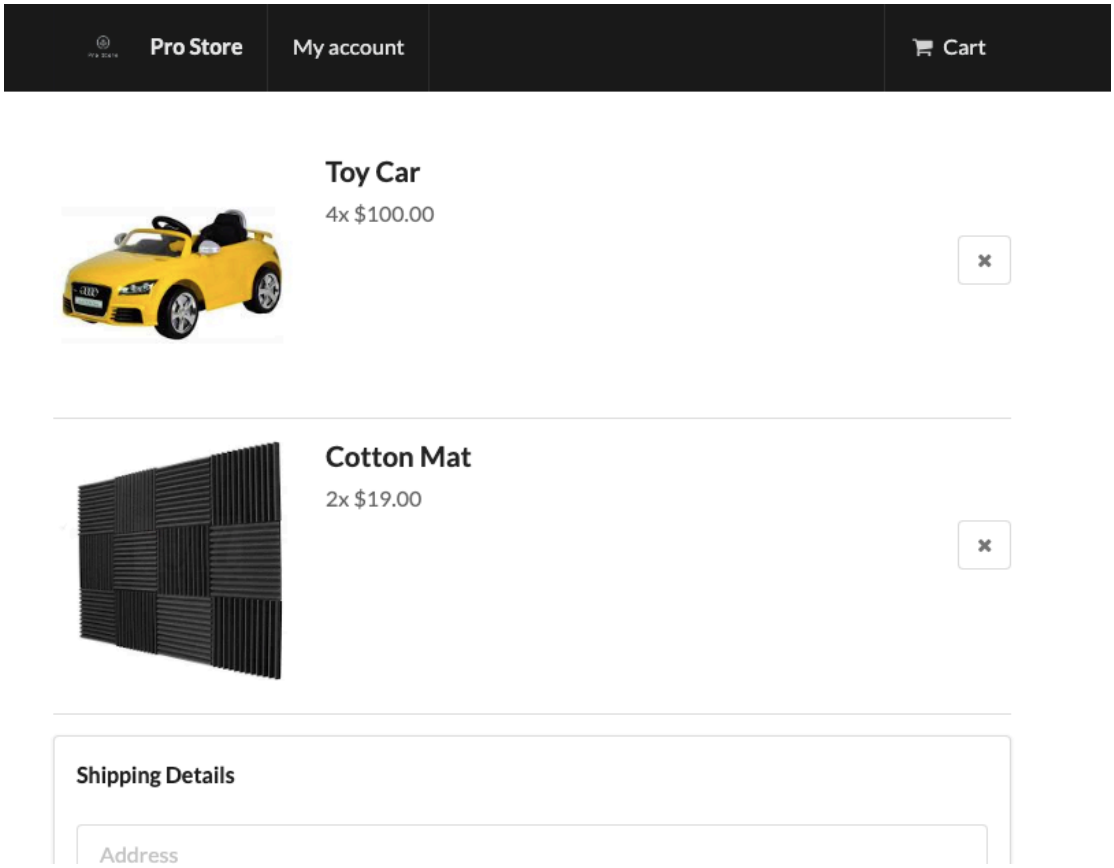
To the online merchants, it saves the time and effort to compare shipping options themselves and the time and effort in setting up the rules in the online store. This also helps them automate choice of courier; provides better services by giving more shipping options and thus attract more business.

To the customer, new system will allow them to have the flexibility to choose the best suitable shipping options to them. Simply having standard and express options are not enough, as there can be middle options between the two that are more appealing to customers.

5. System Process Design



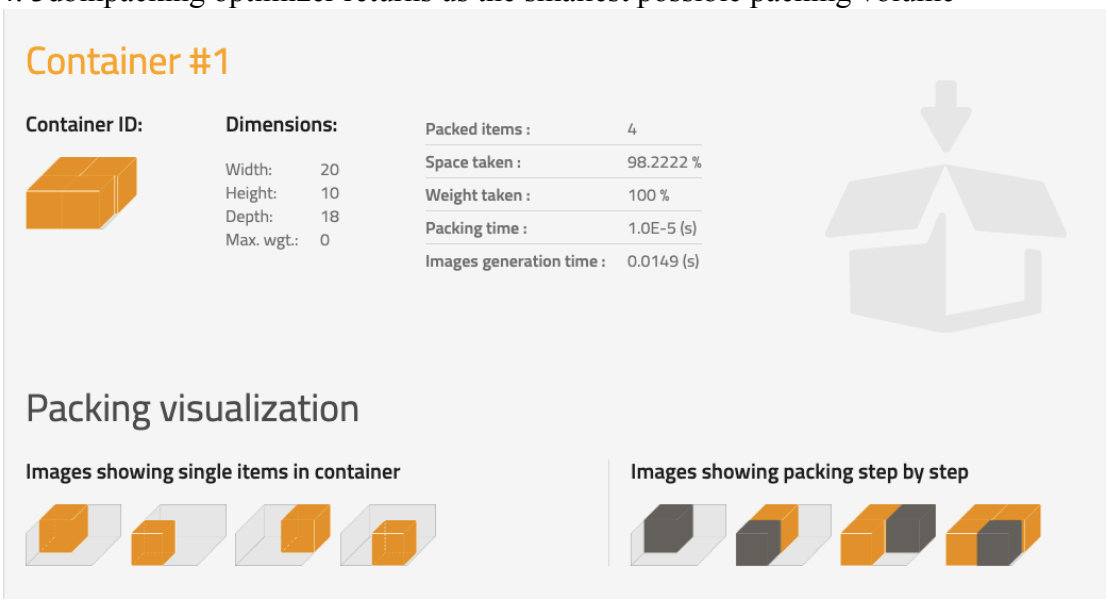
1. Customers add products into the cart on the web store. Upon clicking "Get Shipping Prices", the web store will then send the basket details, including the quantity of each product and the shipping destinations to our system backend.



2. Our system backend will retrieve the product weights and dimensions from database.

3. Our system will send the dimensions to 3Dbinpacking optimizer to get the smallest packing volume.

4. 3dbinpacking optimizer returns us the smallest possible packing volume

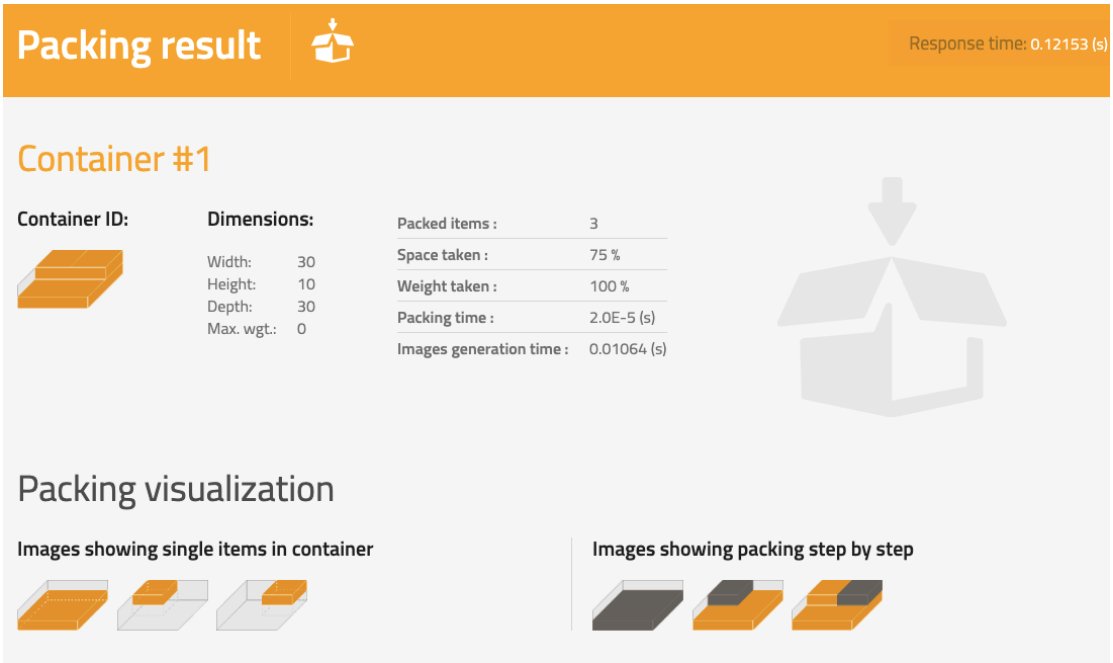


5. The rule of courier is to use larger of physical weight and volumetric weight for shipping cost calculation. Our system backend will calculate the gross total of weight of the basket and the volumetric weight (20*10*18)/5000 = 0.72 kg. That means if the physical weight of the shipping is smaller than 0.72 kg, the volumetric weight of 0.72kg will be used in shipping cost calculations.

System backend then send the destination and the larger of volumetric weight and physical weight to our drools rules engine.

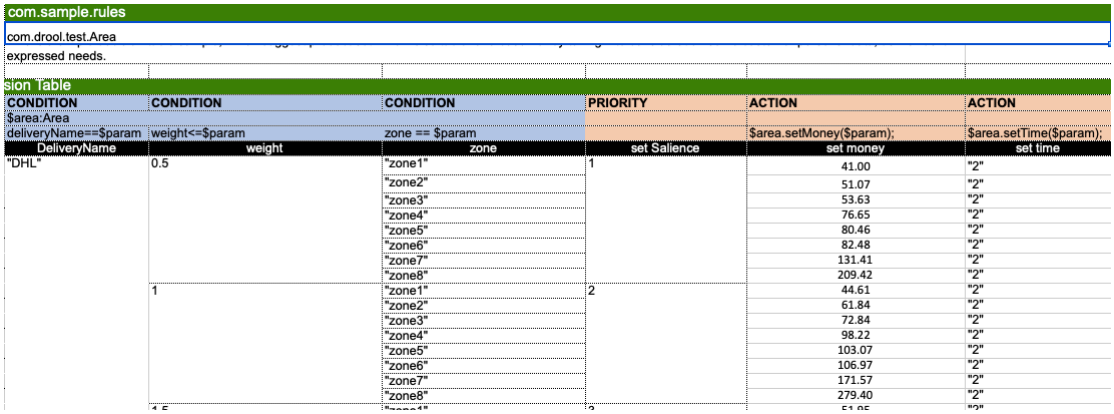
Example where Volumetric Weight > Physical Weight:
Product A: Dimensions: 30 x 5 x 30 Weight: 1 kg
Product B: Dimensions: 15 x 5 x 15 Weight: 0.2 kg

Say a customer ordered 1 product A and 2 product B:
Gross weight: 1*1 + 2*0.2 = 1.4 kg
Volumetric weight:
Using our optimizer, the smallest dimension to pack these 3 boxes is
30 x 10 x 30 = 9000 cubic meter -> volumetric weight = 9000/5000 = 1.8 kg



As volumetric weight is higher than physical weight, the volumetric weight is sent to the drools rules engine.

6. Drools rules engine will import the rules from the decision table defined.



com.sample.rules					
com.drool.test.Area					
expressed needs.					
sion Table					
CONDITION	CONDITION	CONDITION	PRIORITY	ACTION	ACTION
$area:Area					
deliveryName==$param	weight<=$param	zone == $param		$area.setMoney($param);	$area.setTime($param);
DeliveryName	weight	zone	set Salience	set money	set time
"DHL"	0.5	"zone1"	1	41.00	"2"
		"zone2"		51.07	"2"
		"zone3"		53.63	"2"
		"zone4"		76.65	"2"
		"zone5"		80.46	"2"
		"zone6"		82.48	"2"
		"zone7"		131.41	"2"
		"zone8"		209.42	"2"
	1	"zone1"	2	44.61	"2"
		"zone2"		61.84	"2"
		"zone3"		72.84	"2"
		"zone4"		98.22	"2"
		"zone5"		103.07	"2"
		"zone6"		106.97	"2"
		"zone7"		171.57	"2"
		"zone8"		279.40	"2"

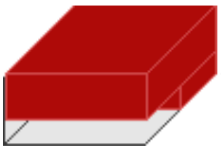
7. According to the weight and destinations, drools rules engine will return the courier options, their respective cost and estimated transit days back to our system backend.

8. Finally, our system backend will send the shipping options to the web store for customer to choose shipping options from.

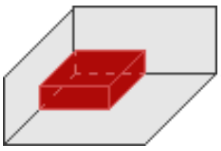
Get Shipping Prices

Delivery Name	Delivery Time (Days)	Shipping Cost	Select
SF	2 to 3	$35.5	○
UPS	3 to 5	$77.4	○
DHL	2	$72.75	◉
FedEX	4	$72.6	○

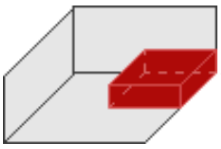
Note Your package will be packed in the following manner to minimize shipping cost!



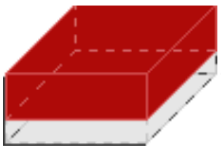
30x15x30 Final Packing



15x5x15 Toy Car



15x5x15 Toy Car

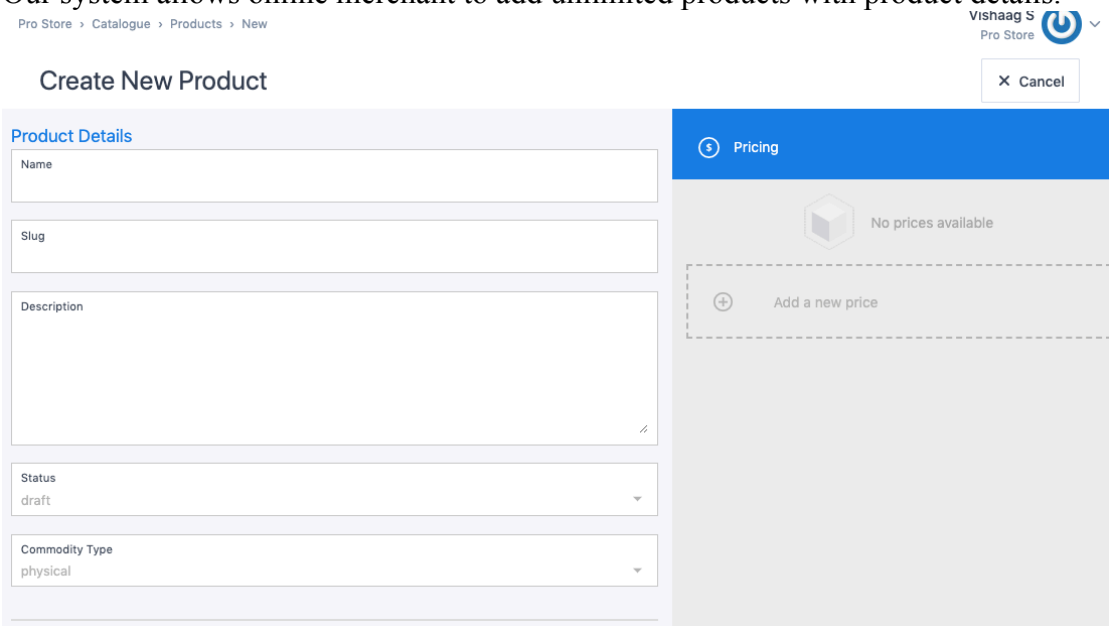


30x10x30 Cotton Mat

6. Customer Journey

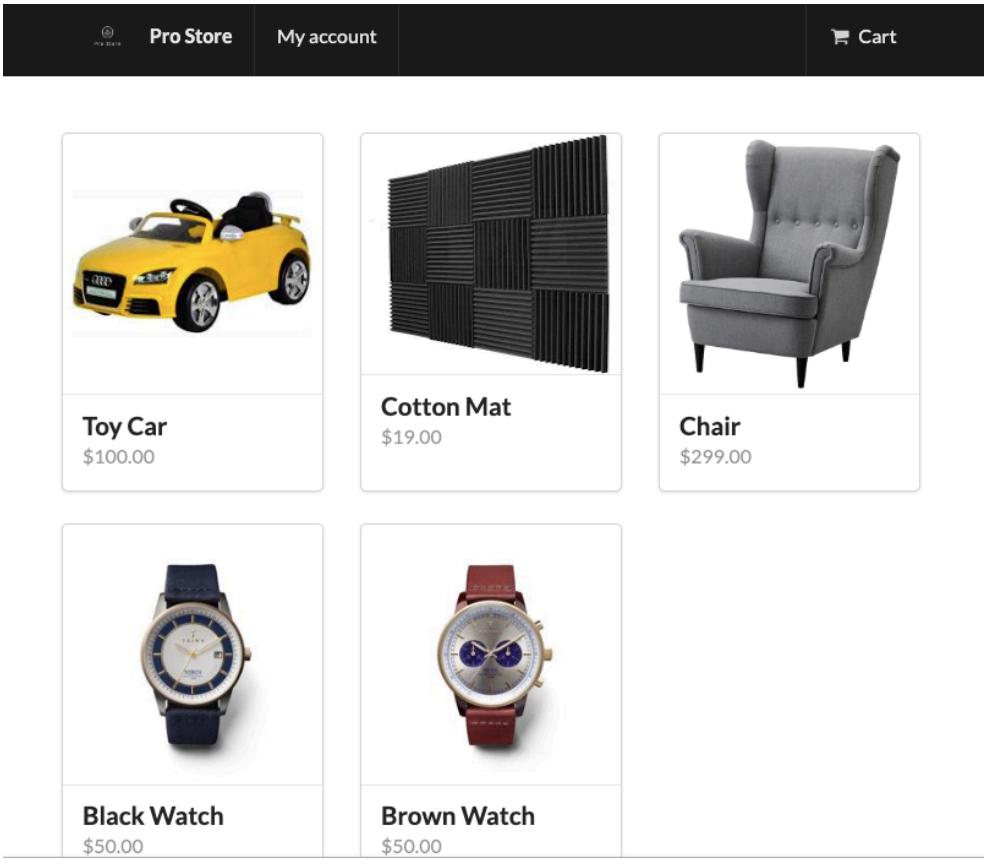
1. Setting up of Products by Merchants

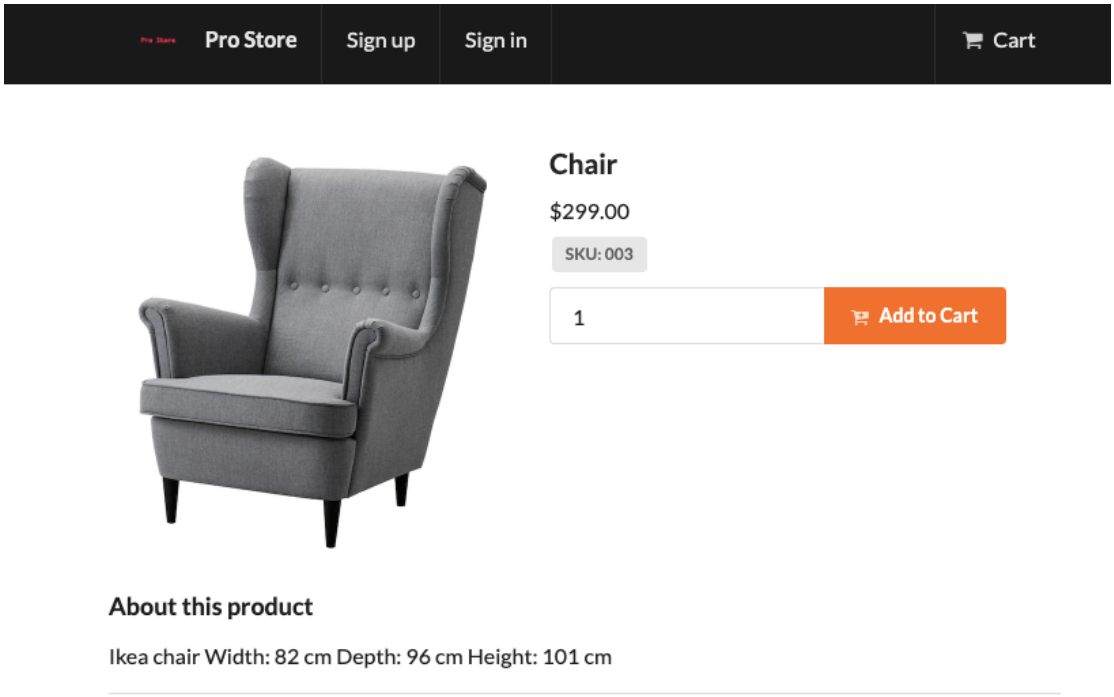
Our system allows online merchant to add unlimited products with product details.



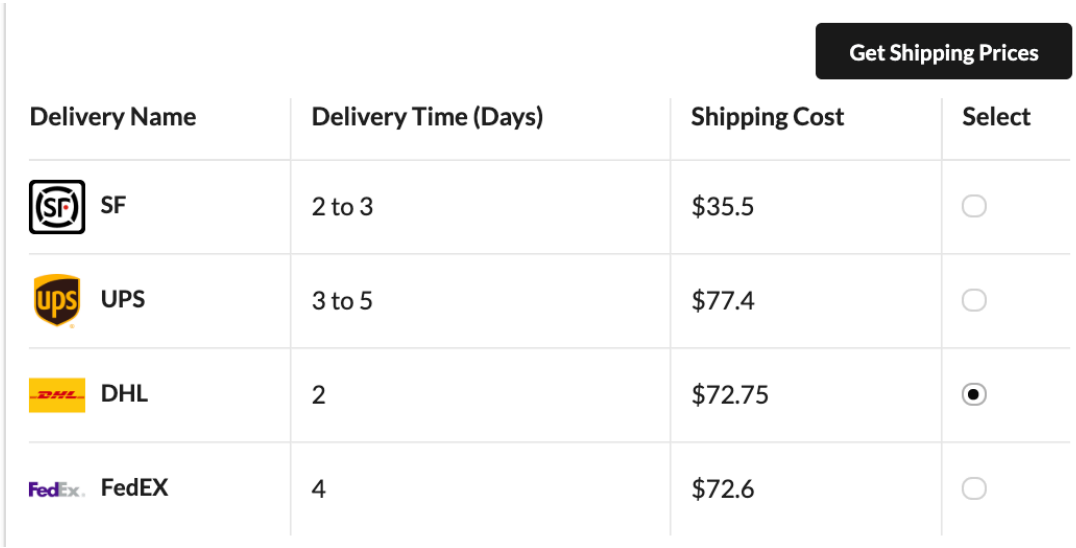
2. Browse Catalogue and Add Products to Cart by Customer

Our system allows user to add product (product set up from above) into a basket. (Different products, different quantities) like below.





3) Allow the Customer to Select from Available Shipping Options
The system allows customer to pick all the available shipping options. They are no longer limited to standard and express options.



7. Limitations

Although the proposed system automates the courier and shipping rates selection process, it still requires manual maintenance of shipping rates. When courier updates their rates, the decision table has to be updated to reflect.
Some couriers charge extra handling fee and fuel charges which are not captured.

In reality, the total weight of final shipping is not simply the sum of weight of products. Different products use different packaging. For example, fragile product requires extra plastic bubble sheet wrapping. Our system doesn't account for the weight of packaging.

Our optimizer can figure out the best way to pack the products such that the total volume is the smallest. However, such packing arrangement may not always be feasible. Packing workers in fulfillment center may not be able to pack the goods to attain the smallest volumetric weight.

8. Improvements

Automatic Scrapping of Shipping Rates
If the URL and structure of courier website is stable, we can further develop a web scrapping tool to automatically update the shipping rates in the decision table.

Integration with Shopify and Fulfillment Centres
As discussed, Shopify system has its own out-of-box flow to manage shipping rules. Unless the merchant has a highly technical team to customize Shopify in order to use it. Fulfillment Centres are also well integrated with Shopify to map the shipping rule with their courier option. To use our system, merchants will have to set the automation themselves via fulfillment center API, which is not feasible for many traditional fulfillment centres. In the future, we can develop the system into a Shopify plugin to allow one click-installation.

9. Conclusions

After we finished the project, we showed the prototype with our case study online merchant again. He is amazed by the performance. He is particularly interested in the shipping rates decision table as it can help him determine the cheapest courier without manually comparing.

We believe the proposed system is useful to all middle size online clients who ship to many countries. If the merchant only ship to few countries, the choice of courier would be obvious and it doesn't worth using many different couriers to save cost.

The team is excited about the potential popularity of the system once it is commercialized and integrated with major ecommerce platform like Shopify and Woocommerce.