



Enhancing DoReMi's Order and Inventory Management process

with **The Sunday Lunatics Consultancy Ltd**

Project Report

Brought to you by:



Tan Jun Khiang
Tan Wei Lian, William
Tang Meng
Leong Jun Hun, Darryl

Table of Contents

Executive Summary / Paper Abstract	3
List of Abbreviations	4
Introduction	5
Business Problem Background	5
Project Objectives & Success Measurements	6
Project Solution	6
Project Scope	6
Process Overview	7
Knowledge Models	9
Approval Check	13
Credit Risk Check	13
Bulk Discount Determination	15
Inventory Restock	17
User Roles	18
Project Implementation	19
System Development	19
System Architecture	19
System Domain Modelling	21
Testing Approach and Test Cases	21
Project Performance & Validation	22
Project Conclusion	23
References	24
Appendices	25
Appendix A: Stakeholders Engagement	25
Appendix B: Rule Bases	28
Appendix C: Test Cases	36
Appendix D: Success Measurements for Enhanced Processes	41

Executive Summary / Paper Abstract

The pervasive shift of retail towards e-commerce is threatening the existence of traditional brick and mortar businesses. DoReMi, a specialized music retailer, faces an uphill challenge in dealing with the forces of change and finds itself in a precarious situation. Several factors, namely its lack of product diversification, limited channels of purchase and its limited adoption of technology exacerbates DoReMi's current situation.

The Sunday Lunatics (TSL) is engaged to provide consultancy services to identify areas of improvements for DoReMi and solutions to help propel DoReMi into the ecommerce space. Through extensive information gathering with the staff of DoReMi, TSL has converted years of tacit knowledge into documented knowledge models. TSL has proposed new business workflows leveraging on the Knowledge Models developed, to enable faster decision making and more timely delivery of orders. The completion of the entire project can help DoReMi achieve cost savings through value creation from process automation and upskilling of workforce as well as value add in productivity from the overall enhanced efficiency and supply chain management.

Due to the diverse nature and complexity of implementation, TSL recommends a phased approach towards the implementation of Harmony. The challenges related to Sales & Pricing and Logistics & Supply Chain Management are assessed to be more critical and TSL recommends prioritizing these challenges. The remaining challenges relating to Point-of-Sale system and detailed Project Management will be addressed in subsequent phases of the consultancy.

The objective of Harmony, the Proof of Concept (POC) solution for the Order Handling and Inventory Restock processes in the initial phase is to demonstrate the implementation of the knowledge models and seek validation from DoReMi management to proceed with the next phase. Through the proposed workflows, TSL is able to execute sophisticated business rules, incorporating a multitude of factors, in automated and efficient manner. Through this, manual intervention is significantly reduced as complex decision making is offloaded to our system. This means that DoReMi staff is able to focus on higher order thinking tasks. The proposed business processes also seek to prepare DoReMi for new Inventory management concepts such as 'Just In Time' inventory, where no or limited inventory is stored, allowing DoReMi to save on warehousing costs.

The technologies used in our POC solution are a combination of Angular, Drools and java Business Process Model (jBPM).

List of Abbreviations

Abbreviation	Abbreviation Description
TSL	The Sunday Lunatics
POC	Proof Of Concept
jBPM	Java Business Process Model
USA	United States of America
CEO	Chief Executive Officer
KIE	Knowledge Is Everything
DBMS	Database Management System
DB	Database
UI	User Interface
COA	Center of Area
ROC	Return on Capital
NPM	Net Profit Margin
CTR	Current Ratio
QKR	Quick Ratio
CHR	Cash Ratio
TAT	Total Assets Turnover
SAR	Security-to-Assets Ratio
DAR	Deposits-to-Assets Ratio
LDR	Loans-to-Deposits Ratio
LTV	Lifetime Value
DSDM	Dynamic Systems Development Method
HR	Human Resource
IT	Information Technology

Introduction

DoReMi Books is a company that specializes in the supply and sale of classical music scores and music books in the United States of America (USA) with subsidiaries in the major cities of each of the 50 states. It started in 1955 and an important line of business for the company is the supply of music books to music schools. These schools buy books in bulk for their students and are given special bulk-package discounts. Sales to music schools constitute 30% of the annual revenue of DoReMi.

Business Problem Background

DoReMi faces numerous external challenges such as fierce competition from larger non-niche online retailers like Amazon or Book Depository. Other physical music retailers have also started to embrace online and internet sales as the new way of interacting and transacting with their customers. The lowered entry barriers to ecommerce and the ease of setting up an online retail store also means that building customer loyalty is becoming increasingly critical - it is DoReMi's interest to ensure that existing customers remain, due to high customer acquisition costs.

In response to the new challenges, the Chief Executive Officer (CEO), Sam Gu, appointed The Sunday Lunatics (TSL) Consultancy Ltd. to conduct a business process improvement exercise to revamp their music books sale transaction and order handling process as well as introduce improved stock and inventory management capabilities.

During the short 2-week visit to DoReMi in USA, TSL has observed and assessed DoReMi's existing process. The lack of automation and technology has also led to high occurrences of erroneous order deliveries. This includes orders not being fulfilled, incorrect orders being delivered and delayed order shipments.

TSL has identified the following key challenges after engaging various key stakeholders in the companies. The detailed concerns of the stakeholders can be found in Appendix A.

- No visibility into internal workings of existing logistics applications.
- No proper task delegation and management.
- Current practice of manual forms has higher risk of human error for erroneous or delayed order processing as compared to digital forms.
- Lack of common process for common tasks such as order handling or supplier liaison.
- Adjustment of prices for seasonal promotions takes too long for IT department to make required changes.
- Cashiers are unable to deal with high volume of orders.

Project Objectives & Success Measurements

TSL has defined the following business objectives and their corresponding measurements of success. The completion of the entire project can help DoReMi achieve cost savings through value creation from process automation and upskilling of workforce as well as value add in productivity from the overall enhanced efficiency and supply chain management.

Objectives	Required Success Measurement
Streamline Order Handling Process for Bulk Purchase	Reduction in time taken to fulfil Bulk Purchase by 20%.
Enhance Inventory Management and Supply Automation	Reduction in time taken to make Supply Order by 20%.

Project Solution

Project Scope

TSL has observed the operational challenges faced by DoReMi span several areas. TSL will introduce a new internal platform, Harmony to address the challenges. Harmony will automate the following processes:

Process	Roles
Order Handling	Sales, Accounts
Inventory Restock	Warehousing

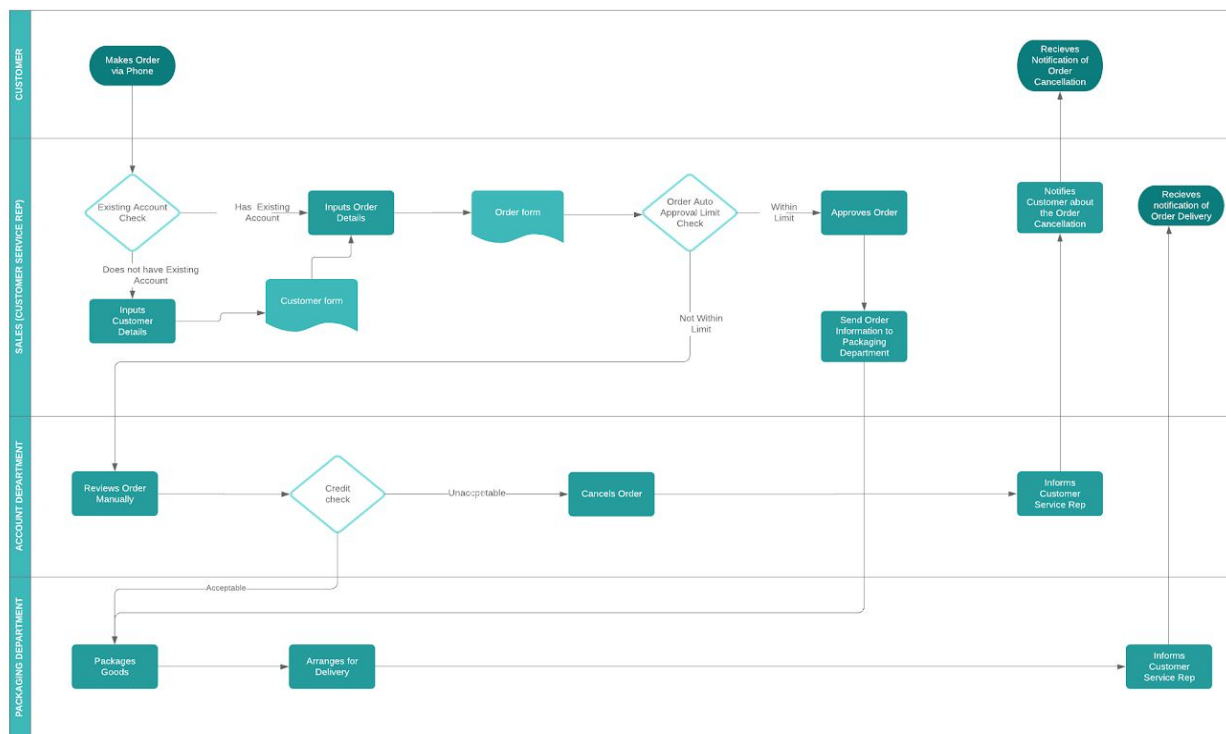
The respective roles are able to perform the following tasks:

Sales	Accounts	Warehouse
Order Handling <ul style="list-style-type: none">Make Order	Order Handling <ul style="list-style-type: none">Evaluate Customer Credit RiskApprove Order	Inventory Restock <ul style="list-style-type: none">Approve Inventory Restock Request

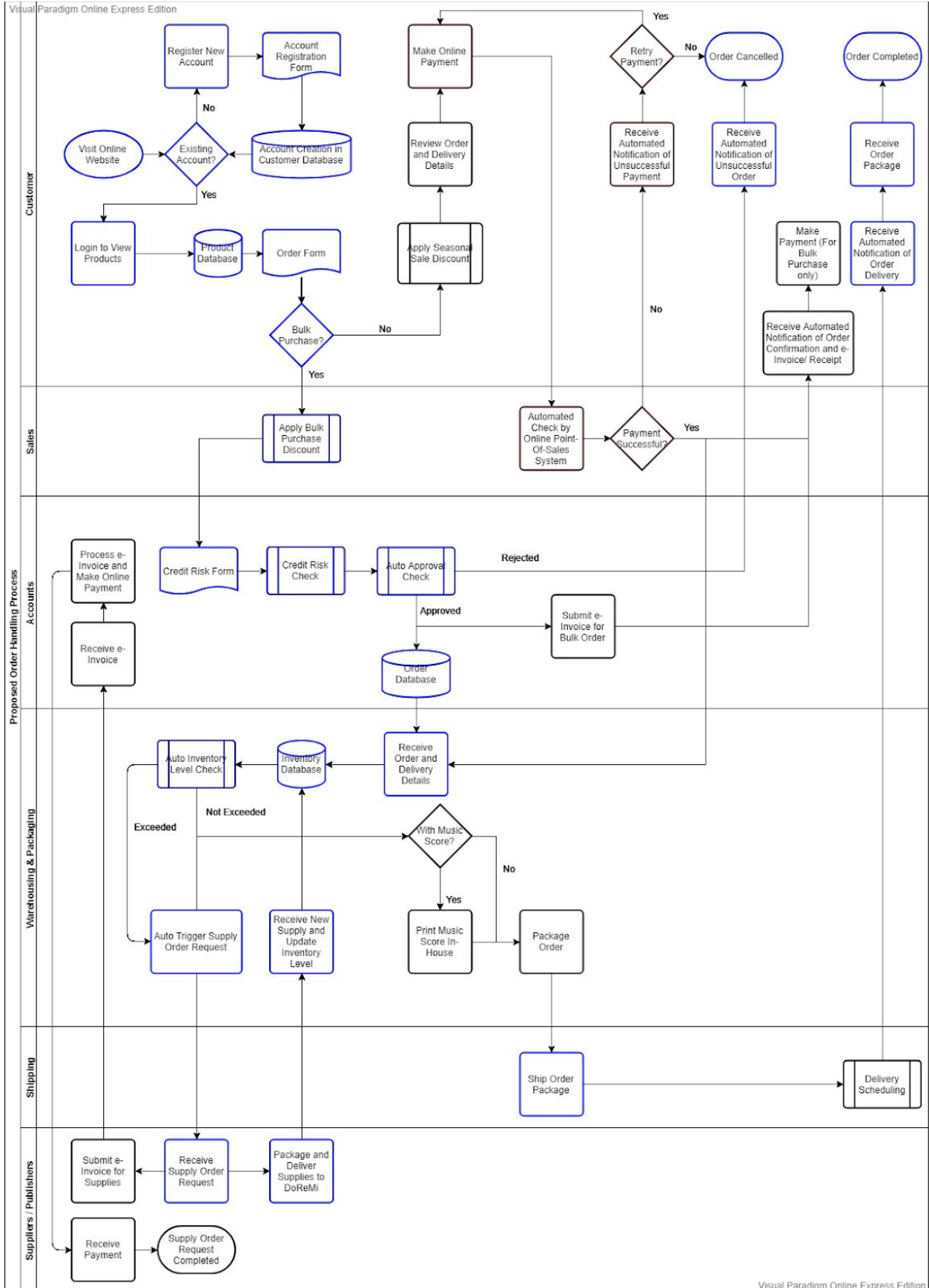
Due to the diverse nature and complexity of implementation, TSL recommends a phased approach towards the implementation of Harmony. The challenges related to Sales & Pricing and Logistics & Supply Chain Management are assessed to be more critical and TSL recommends prioritizing these challenges. The remaining challenges relating to Point-of-Sale system and detailed Project Management will be addressed in subsequent phases of the consultancy.

Process Overview

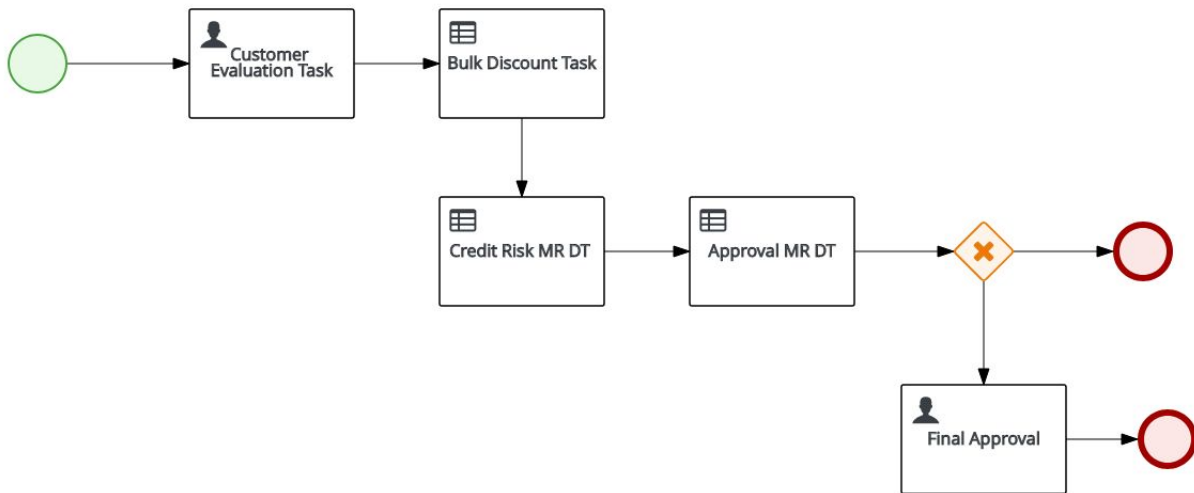
The as-is activity workflow is detailed in the following diagram and is used as the baseline to develop the to-be activity workflow to meet the project objectives and address the concerns of the stakeholders.



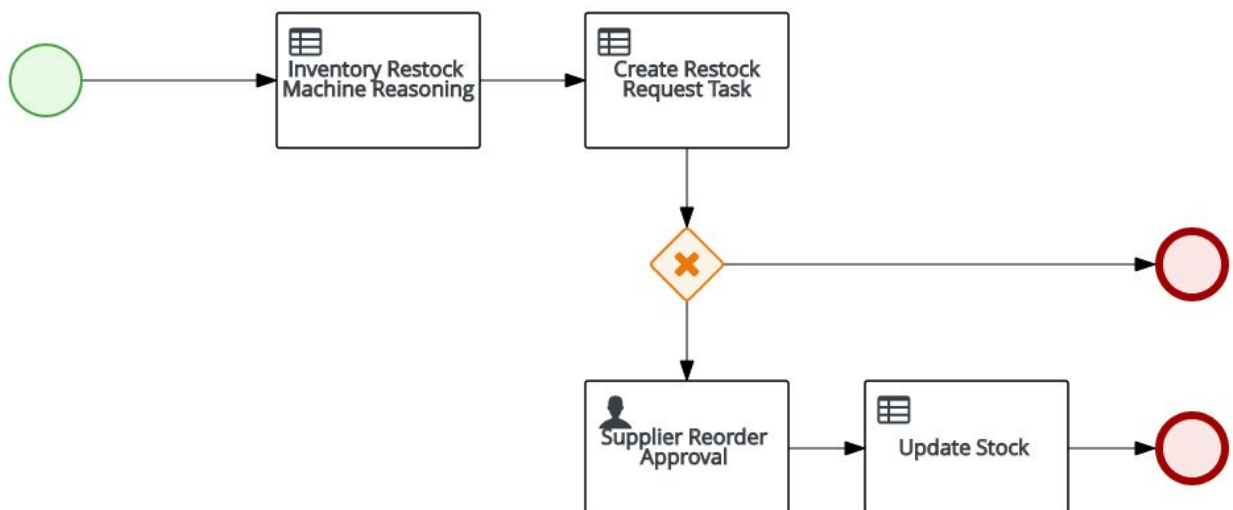
The proposed to-be business process upon completion of all project phases is detailed in the following diagram. The proposed business process leverages on several Knowledge Models to enable the delivery of the key objectives. For the initial phase, TSL has prioritized the processes as outlined in blue.



The following workflow diagram details the Order Handling Process in JBPM :



The following workflow diagram details the Inventory Restock Process in JBPM :



Knowledge Models

Our platform, Harmony relies on the use of Knowledge Models. Knowledge Models are used to facilitate communication between different teams across DoReMi at different levels of

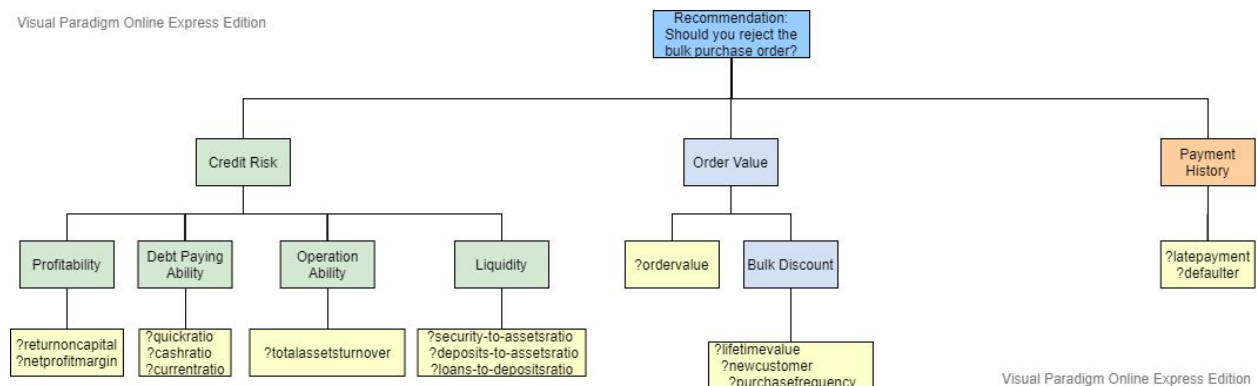
abstraction. Knowledge models can help establish common understanding of processes and tasks.¹

The following Knowledge Models have been developed and integrated into Harmony:

Process	Knowledge Model	Key Stakeholder	Objective	Logic Type
Order Handling Process	Approval Check	Accounts	To determine the types of orders which are eligible for straight thru processing	Deductive
	Credit Risk Check	Accounts	To determine the credit risk for bulk purchase customer (e.g. Music Schools)	Fuzzy
	Bulk Discount	Sales	To determine the optimal bulk discount for large orders	Fuzzy
Inventory Restock	Inventory Optimization	Warehouse	To determine the if a specific product which stock needs to be replenished	Fuzzy
Internet Sales Transaction System	To be addressed in subsequent phases.			

For the order handling process, the following inference diagram is developed to better represent the relationship among the knowledge models.

Visual Paradigm Online Express Edition



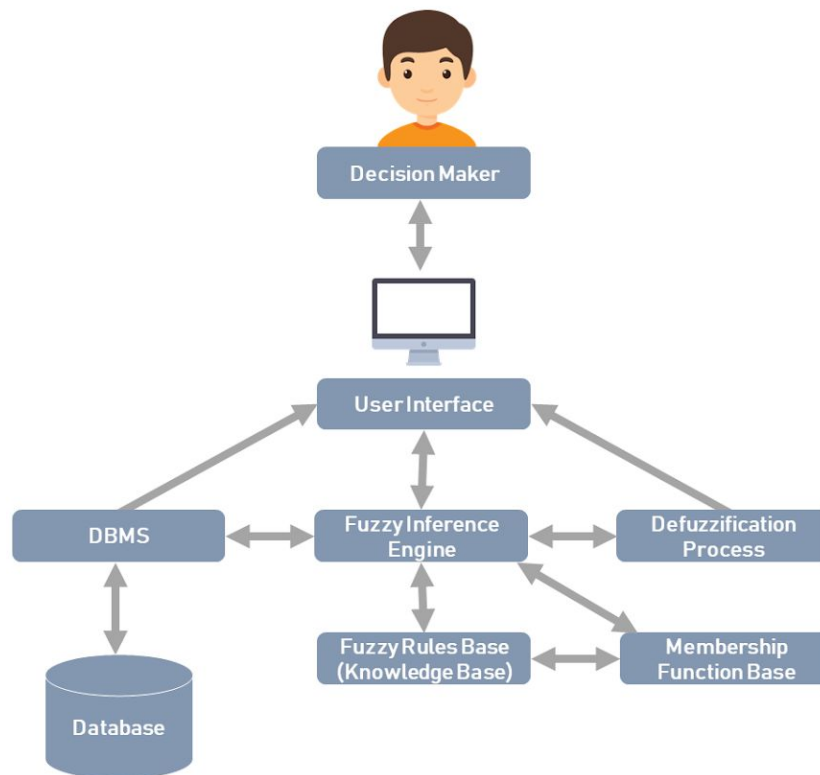
¹ "Knowledge Modelling Techniques for Developing ... - Chris Kimble."

http://www.chris-kimble.com/Publications/Documents/Abdullah_2002.pdf. Accessed 9 Mar. 2019.

Deductive logic is the process of reasoning from one or more statements (facts and rules) to reach a logically certain conclusion. On the other hand, fuzzy logic is a form of multi-valued logic in which the truth values of variables may be any real number between 0 and 1 inclusive. It is employed to handle the concept of partial truth, where the truth value may range between completely true and completely false. For both logic type, business rules are needed and hence, TSL is using Knowledge Is Everything (KIE) Drools, a Business Rules Management System to implement them.

For fuzzy logic, the proposed model consists of the following components.

1. Member function base
2. Fuzzy rule base
3. Fuzzy inference engine
4. Database Management System (DBMS)
5. Database (DB).
6. User interface
7. Defuzzification process



1. Member Function: Fuzzy logic techniques use linguistic variables to evaluate each indicator. Each indicator value is assigned a degree of membership in relation to the linguistic descriptors such as "High", "Medium", and "Low" as well as "Long", "Moderate" and "Short".

2. Fuzzy Rule Base: Fuzzy rules base contains the expert knowledge of indicators relations and the formation of a total judgment as if-then rules. All the fuzzy rules together compose the so called “knowledge base”.
3. Fuzzy inference Engine: The role of fuzzy inference engine is to match the fuzzy rules that are contained in the rules base with the entered values for the indicators data that is stored in the database to identify which rules should be applied and manage the reasoning process. This model is based on Mamdani inference method as the core of the reasoning process. The Mamdani-style fuzzy inference process is performed in four steps:
 - i. Fuzzification of the scalar input variables
 - ii. Rule evaluation
 - iii. Aggregation of the rule outputs
 - iv. Defuzzification
4. DBMS: The customer’s data is managed by the DBMS. DBMS is used by the users to perform model's database managing operations including storing, retrieving, adding, deleting and modifying.
5. DB: DB is used to store the entire customer’s data including the financial indicators data. It is managed by the DBMS that allows the users (decision makers) to add, update and delete the customer's data.
6. User Interface (UI): UI facilitates communication between the user (decision maker) and the implemented system of the model. It is also used to input the customer’s data and show the results.
7. Defuzzification Process: Defuzzification is the process which takes the aggregate output fuzzy set of the inference engine as an input and transform it to a crisp output. In this model, the Center of Area (COA) method is used as a defuzzification strategy.

$$\text{Center of Area, } z_{COA} = \frac{\sum_{j=1}^n \mu_c(z_j)z_j}{\sum_{j=1}^n \mu_c(z_j)}$$

For the initial phase and considering the limitations of KIE Drools, the fuzzification, aggregation of the rule output and defuzzification will have to be manually input by the respective users. This will be addressed in subsequent phases with the integration of another system capable of these processes such as MATLAB & Simulink or equivalent to enhance the platform.

Approval Check

TSL understood that there is a lack of digital forms and the order handling approval process is inefficient and subject to human error. With the requirement of online sales system and anticipated increase in sales volume for bulk purchases, TSL proposes to automate most of the approval and credit risk check process with an option for the Accounts Manager to review and approve the credit risk check and order.

The following guided rule decision table is designed based on deductive logic to reject orders considering the customer's history of payment default, late payment history, evaluated credit risk and the value of their bulk purchase order.

Entity	Attribute	Description
Customer	Defaulter	Identifies whether the customer is a defaulter
	Late Payment	Identified whether the customer has any late payment over the last 3 years
	Credit Risk	Probable risk of loss resulting from a customer's failure to repay a credit or meet contractual obligations
Order	Order Value	The total value of the order being placed.

WHEN	AND	AND	AND	THEN
Defaulter	LatePayment	OrderValue	CreditRisk	Status
Yes	-	-	-	Rejected
No	Yes	>10,000	-	Rejected
No	No	>10,000	High	Rejected
No	No	>200,000	Medium	Rejected
No	No	>500,000	Low	Rejected

Credit Risk Check

TSL proposed a fuzzy logic approach to credit risk check which focuses on quantitative factors to be derived from the customer's financial statement. The objective is to predict credit risk rating for bulk purchase customers with reasonable accuracy. Credit risks are calculated based

on the customer's overall ability to repay². These financial ratios are classified into following four categories of financial indicators³.

Financial Indicators	Description	Financial Ratios
Profitability	Ability to earn profit under normal operation situation reflects the degree of risk	Return on Capital (ROC) = (Net Income - Dividends) / (Total Debt + Total Equity) Net Profit Margin (NPM)= Net Profit / Total Revenue
Debt-paying ability	Ability to repay the due short-term and long-term debts, which is helpful to forecast the potential earnings and reduces the risk.	Current Ratio (CTR) = Current Assets / Current Liabilities Quick Ratio (QKR) = (Current Assets - Inventories) / Current Liabilities Cash Ratio (CHR) = Cash & Cash Equivalents / Current Liabilities
Operation ability	Ability using various assets to gain profits.	Total Assets Turnover (TAT) = Net Sales / Total Assets
Liquidity	Ability to pay off its short-terms debts obligations.	Security-to-Assets Ratio (SAR) = Securities / Total Assets Deposits-to-Assets Ratio (DAR) = Total Deposits / Total Assets Loans-to-Deposits Ratio (LDR) = Total Loans / Total Deposits

The Accounts user needs to derive and input the linguistics description for each financial indicators based on the scalar value of each calculated financial ratios due to the limitations as mentioned earlier in Section Knowledge Models section. Some samples from the fuzzy rule base which are used during the initial phase is shown below. The full set of fuzzy rules can be found in Appendix B.

WHEN	AND	AND	AND	THEN
Profitability	DebtPayingAbility	OperationAbility	Liquidity	CreditRisk

² "Credit Risk - Investopedia." 6 Feb. 2019, <https://www.investopedia.com/terms/c/creditrisk.asp>. Accessed 9 Mar. 2019.

³ "(PDF) A Fuzzy Logic Model for Credit Risk Rating of ... - ResearchGate." 29 Mar. 2016, https://www.researchgate.net/publication/299483791_A_Fuzzy_Logic_Model_for_Credit_Risk_Rating_of_Egyptian_Commercial_Banks. Accessed 9 Mar. 2019.

Medium	Low	High	Medium	Medium
--------	-----	------	--------	--------

WHEN	AND	THEN
ROC	NPM	Profitability
Low	Medium	Low

WHEN	AND	AND	THEN
CTR	QKR	CHR	DebtPayingAbility
Low	Medium	High	Medium

WHEN	THEN
TAT	OperationAbility
High	High

WHEN	AND	AND	THEN
SAR	DAR	LDR	Liquidity
Low	High	Medium	Medium

Bulk Discount Determination

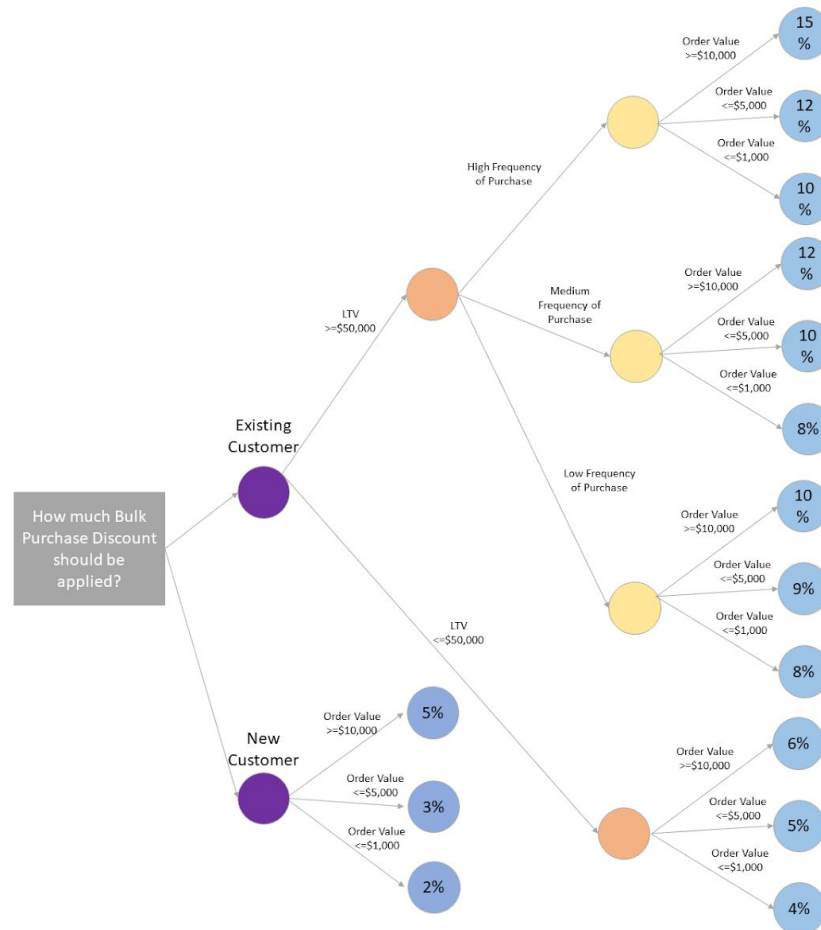
It was observed that the discounts given to the clients were arbitrary in nature, with many Sales Representatives giving generous discounts. TSL proposes a Bulk Purchase Discount Recommendation model, which would provide a more consistent approach towards providing bulk discounts to music schools.

A multi-factor approach is adopted in bulk discount determination, which seeks to incorporate both Customer and Order attributes. The objective of this model is encourage customers to purchase more products in bulk and to increase stickiness with DoReMi, by rewarding loyal customers with more attractive discounted prices.

Entity	Attribute	Description
Customer	New Customer	Identifies whether the customer is a new or existing

		customer
	LTV	Lifetime Value of Customer. This is derived from subtracting the cost of customer acquisition from the total profits from the customer ⁴ .
	Frequency of Purchase	How often a customer has made a purchase over the last 3 months
Order	Order Value	The total value of the order being placed.

TSL proposes the following Decision Tree to enable a consistent approach to bulk purchase discount determination:



Some samples from the rule base are shown below. The remaining rules can be found in Appendix B.

⁴ "Simple CLV Formula | Customer Lifetime Value."

<https://www.clv-calculator.com/customer-lifetime-value-formulas/simple-clv-formula/>. Accessed 9 Mar. 2019.

WHEN	AND	AND	AND	THEN
NewCustomer	OrderValue	LTV	Frequency of Purchase	Discount
Yes	<=1000	-	-	2%
No	<=5000	<=50,000	-	5%

Inventory Restock

TSL observed that existing Inventory Management is a highly manual and inefficient process. There is no defined process for the replenishment of product stock. The arbitrary nature of stock replenishment means that often, there is a tendency for products to go out of stock, especially for bulk orders. This has impact on customer satisfaction.

The Inventory Model which the TSL develop is based on the idea of Safety Stock, which the inventory quantity to maintain before a stock out occurs. ⁵Most Safety stocks consider Demand as well as Supply Lead Time factors ⁶. TSL proposes to add an additional factor, Service Level, which seeks to help DoReMi identify important revenue generating products and expedite the Supply Re-ordering process, such that the probability of stock out is reduced.

The components of the Inventory Restock model are as below:

Entity	Attribute	Description
Product	Stock Level	Existing warehouse inventory level of a particular product
	Product Demand	Anticipated product demand for the next month
	Service level	An indicator to the importance of the product, based on the amount of revenue a product generates. A product with a high service level. Products which generate the top 20% of revenue are considered 'High', the next 20% to 30% to be 'Medium' and last 50% to 60% to be 'Low'.
	Supply Lead Time	Historical latency between the placement of an order from supplier and the actual delivery of the goods.

⁵ "INVENTORY MANAGEMENT, SERVICE LEVEL AND SAFETY STOCK."

http://www.jopafi.com/uploads/issue9/INVENTORY_MANAGEMENT_SERVICE_LEVEL_AND_SAFETY_STOCK.pdf. Accessed 9 Mar. 2019.

⁶ "Understanding safety stock and mastering its equations - MIT."

http://web.mit.edu/2.810/www/files/readings/King_SafetyStock.pdf. Accessed 9 Mar. 2019.

The output of the Inventory Restock model provides a recommendation to the Accounts department for them to increase the Product Inventory by a specific percentage. However, if the product inventory level is below 100, create an Order Request to increase stock to 100. A predefined reorder quantity is maintained for each product. The output of the decision table is as follows:

Available Inventory	Increase Stock By Quantity
<100	100

A sample of the Inventory Restock Decision table is provided below: The remaining rules can be found in Appendix B.

WHEN	AND	AND	AND	THEN
Stock Level	Demand Level	Service Level	Supply Lead Time	Increase Stock By %
Low	High	Medium	Long	70%
Low	Medium	Medium	Short	40%

User Roles

The following RACI matrix details the User Actions and roles of the Harmony platform:

User Action	Roles		
	Sales	Accounts	Warehouse/Packaging
Make Bulk Purchase Order	I	A	C
Package Bulk Purchase Order	I	I	R / A
Ship Bulk Purchase Order	I	I	I
Make Supply Order	I	A	R
Package Supply Order	I	I	C
Receive Supply Order	I	I	R / A

Project Implementation

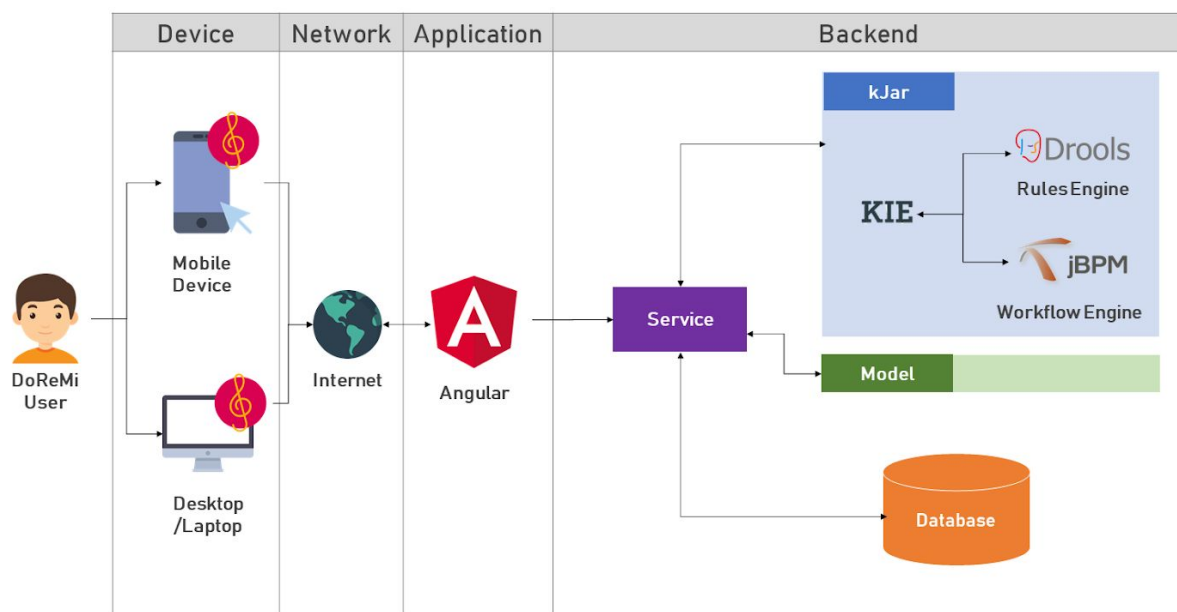
System Development

Systems development is the process of defining, designing, testing, and implementing a new software application or program. It can include the internal development of customized systems, the creation of database systems, or the acquisition of third party developed software.

⁷

System Architecture

The system architecture is based on 3 main principles which are intelligence and robustness, scalability and modularity. The selected KIE suite of engines are intelligent and robust, as they can perform the required machine reasoning based on the specified statements and provide consistent and accurate outputs. The scalability and modularity of the system architecture allows easy deployment to docker and cloud platforms for rapid expansion of operations as well as integration with other backend systems to provide more functionalities.



⁷ "System Development."

<https://www.fca.gov/template-fca/download/ITManual/itsystemsdevelopment.pdf>. Accessed 9 Mar. 2019.

The harmony platform is built with KIE business applications⁸ structure. The key components are:

- KJAR package which contains artifacts generated from KIE components, namely:
 - Drools, the business rule management system with a forward-chaining and backward-chaining inference based rules engine
 - jBPM, the workflow managements system which executes business processes, converting business logic into assets such as cases, processes, decision tables.
- Model: Java package containing Data Objects for persistence storage. Built with Java Persistence API (JPA).
- Service: Backend application to expose REST based API for Frontend application usage. Used maven for dependency management and spring framework for application runtime.
- Angular: Frontend web application framework with material design.
- Database

The choice of this structure

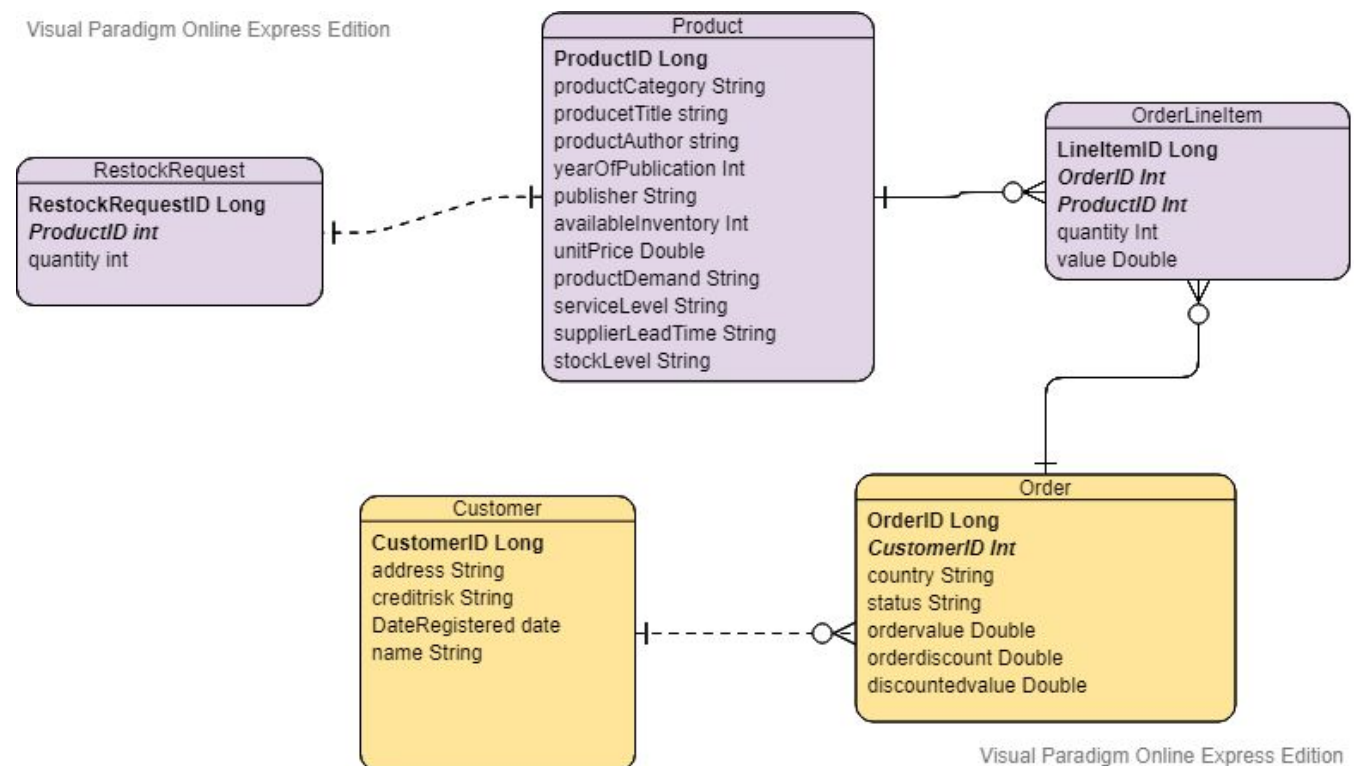
- Business Agility: Separating the KIE components with the main application allow business analysts to work on building the business rules and business process on the KIE workbench, without the need to care about any application development. This greatly speed up the production deployment of any enhancement to business rules or processes and thus give the company a competitive edge in the market.
- High Availability and Scalability: The KIE Business Application supports the deployment to OpenShift and docker container⁹. This allows the customer to scale their business to the global level by moving to the cloud infrastructure.

The entire sales and procurement process is intrinsically complex as there are numerous factors to be considered. Despite the extensive engagement with the various stakeholders and literature review, the relevancy of the current system is subject to changes in product demand and supply trends, any future restructuring of the company and other unforeseen factors. While such factors are not captured yet, it is possible to consider them during future enhancement of the system in subsequent project phases to be more holistic and adaptable.

⁸ "jBPM Documentation - JBoss.org Documentation."
https://docs.jboss.org/jbpm/release/7.17.0.Final/jbpm-docs/html_single/. Accessed 10 Mar. 2019.

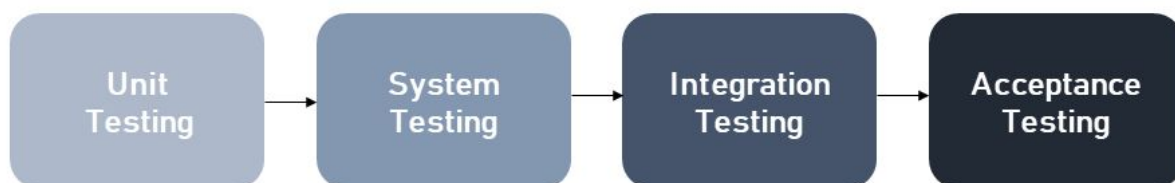
⁹ "jBPM Documentation - JBoss.org Documentation."
https://docs.jboss.org/jbpm/release/7.17.0.Final/jbpm-docs/html_single/. Accessed 10 Mar. 2019.

System Domain Modelling



Testing Approach and Test Cases

In the development of the platform the following testing methodology¹⁰ was developed:



- **Unit Testing:** Validate that each individual component of the workflow jBPM works according to implemented business rules
- **Integration Testing:** Validate that components within the jBPM workflow are working together
- **System Testing:** Validate that the frontend interface and the backend jBPM and Drools engines are working

¹⁰ "Unit Testing Tutorial: What is, Types, Tools, EXAMPLE - Guru99." 8 Feb. 2019, <https://www.guru99.com/unit-testing-guide.html>. Accessed 9 Mar. 2019.

- **Acceptance Testing:** Validate the the platform conforms to DoReMi's business requirements

The following base test cases were developed to demonstrate the functionality of the Harmony platform. The full test case results are available in Appendix C

Test Case	Description	Expected Outcome
A1	Customer is a defaulter	Customer order is rejected.
A2	Customer has low credit risk with no late payment and default payment and has an order with value of \$400,000.	Customer order is approved.
B1	Customer has low profitability, low debt paying ability, medium operation ability and low liquidity.	Customer has a high credit risk.
B2	Customer has high profitability, medium debt paying ability, medium operation ability and high liquidity.	Customer has a low credit risk.
C1	Customer is New, Order Value is less than \$5000	Order Discount is 3%
C2	Customer is not new, Order Value is greater than \$10,000, Customer LTV is greater than \$50,000 and Frequency of Purchase is High	Order Discount is 15%
D1	Inventory Level is High, Demand and Service Level is Low, Supplier Lead Time is Moderate	No prompt generated for Warehouse
D2	Inventory Level is Low, Demand and Service Level is high, Supplier Lead Time is Moderate	Warehouse is prompted to increase product stock sharply

Project Performance & Validation

The following table details the key objectives set out by TSL and how our POC implementation has achieved them. The simplified value stream mapping of the two processes which demonstrate the achievement of success measurements is detailed in Appendix D.

Objectives	Required Success Measurement	Projected Success Measurement
Streamline process	Reduction in time taken to fulfil	Reduction in time taken to fulfil

for Bulk Orders	Bulk Purchase Order by 20%	Bulk Purchase Order by 51%
Enhance Inventory Management and Supply Automation	Reduction in time taken to fulfil Supply Order by 20%	Reduction in time taken to fulfil Supply Order by 35%

Project Conclusion

Findings & Recommendations

The automation of DoReMi's manual processes and the introduction of the rule-based machine reasoning algorithms will enable DoReMi to expedite operational processes for Order Handling and Inventory Restock.

The proposed Order Handling process enables the automatic determination of a discount based on customer attributes which helps increase customer stickiness and loyalty. The automated Credit Risk check incorporates a robust credit mitigation against default risks, allowing undesirable bulk orders to be rejected and maintain healthy finance status. The Auto Approval expedites the Order approval process and allows bulk orders to be fulfilled more quickly.

The Inventory Restock Process reduces the likelihood of stock outs, especially for high revenue generating products. The Inventory Optimization check integrates demand and supply factors, reduce the manual work required by warehouse staff to monitor existing Inventory levels and placing supply orders when stock is low.

The subsequent phases of consultancy target to further enhance Harmony via integrating other Intelligent Reasoning concepts. This includes optimization of delivery schedules, pricing determination for marketing campaigns and fuzzy logic systems, as well as the synergizing of internet point-of-sale systems and Human Resource systems.

References

- 1: "Knowledge Modelling Techniques for Developing ... - Chris Kimble."
http://www.chris-kimble.com/Publications/Documents/Abdullah_2002.pdf. Accessed 9 Mar. 2019.
- 2: "Credit Risk - Investopedia." 6 Feb. 2019, <https://www.investopedia.com/terms/c/creditrisk.asp>. Accessed 9 Mar. 2019.
- 3: "(PDF) A Fuzzy Logic Model for Credit Risk Rating of ... - ResearchGate." 29 Mar. 2016, https://www.researchgate.net/publication/299483791_A_Fuzzy_Logic_Model_for_Credit_Risk_Rating_of_Egyptian_Commercial_Banks. Accessed 9 Mar. 2019.
- 4: "Simple CLV Formula | Customer Lifetime Value."
<https://www.clv-calculator.com/customer-lifetime-value-formulas/simple-clv-formula/>. Accessed 9 Mar. 2019.
- 5: "INVENTORY MANAGEMENT, SERVICE LEVEL AND SAFETY STOCK."
http://www.jopaf1.com/uploads/issue9/INVENTORY_MANAGEMENT_SERVICE_LEVEL_AND_SAFETY_STOCK.pdf. Accessed 9 Mar. 2019.
- 6: "Understanding safety stock and mastering its equations - MIT."
http://web.mit.edu/2.810/www/files/readings/King_SafetyStock.pdf. Accessed 9 Mar. 2019.
- 7: "System Development."
<https://www.fca.gov/template-fca/download/ITManual/itsystemsdevelopment.pdf>. Accessed 9 Mar. 2019.
- 8: "JBPM Documentation - JBoss.org Documentation."
https://docs.jboss.org/jbpm/release/7.17.0.Final/jbpm-docs/html_single/. Accessed 10 Mar. 2019.
- 9: "JBPM Documentation - JBoss.org Documentation."
https://docs.jboss.org/jbpm/release/7.17.0.Final/jbpm-docs/html_single/. Accessed 10 Mar. 2019.
- 10: "Unit Testing Tutorial: What is, Types, Tools, EXAMPLE - Guru99." 8 Feb. 2019, <https://www.guru99.com/unit-testing-guide.html>. Accessed 9 Mar. 2019.

Appendices

Appendix A: Stakeholders Engagement

Stakeholder	Concerns	Inferred solution
Human Resource (HR)	I am sensing some discomfort among the staff. The union has also mentioned about some talk of a rumour going around that the company is going on a down-sizing exercise and people will be made redundant once the new process and system is operationalised. This revamp thing that we are planning needs to be handled with care. I am hearing of head-hunters enquiring about our top-performing sales people.	Re-definition of user roles and upskilling of users.
Sales	I am not aware about the rumour. But in my informal checks with my team leaders, some are asking why are we doing this? We are in the music books industry, and as you know, this is a rather niche area, with our product being mainly in the classical genre and highly specialized stuff. Why should we be bothered with this online talk? Our customers are likely to be in the adult age-group and would not be keen in online transactions anyway.	Reduce workload on sales department yet improving sales quota.
Packaging and Warehousing	A high proportion of our workers in my department are of the older generations and they are also some of our most loyal and experienced workers. As you know, we do need some classical music background knowledge in our business. The new IT-enable process and business intelligent system may pose a technology challenge to my people. There is worry that the high-tech stuff will actually slow them down.	User Interface has to be simple. User training can be provided to all staff.
IT	We have a lean team in our Information Technology (IT) department and it is a constant struggle to keep up with the demands and expectations of the	

	business units across the various geographically dispersed subsidiaries. Any introduction of new large IT systems will need to be carefully planned as it may cause a degradation of the IT support service. On a more positive note, the IT staff members are actually looking forward to learning and working with new tools and technologies. They are asking how they can find out more on process improvement and redesign concepts and methodologies.	
--	---	--

Systems Design Considerations

Note: Those in grey will be addressed in subsequent phases of the consultancy.

System Design Considerations	Stakeholder	Inferred Solutions
DoReMi have an existing logistics application system but the users are not sure of the details of the process it carries out. This is because the logistics system is a black box since there is no documentation and the original IT/user project managers have left the company.	IT	Provide documentation and user guide for new system.
There are many common tasks across the different departments in DoReMi. For example, there are common tasks to collect customer particulars, to collect their orders, to check their credit worthiness etc. Currently, the different departments in DoReMi do not always carry out these tasks in the same manner. DoReMi management would like to standardise and streamline these tasks so that they are carried out in the most productive way.	All	Standardize and streamline common tasks.
DoReMi have many HR internal forms that need to be automated. Some have simple processes, e.g. fill in by applicant, and review by his supervisor and approval by the supervisor's manager. Others were more complicated, e.g. fill in by applicant, and then route to different approving persons depending on the dollar amount.	HR	HR system supported by approval matrix in financial and HR policies
DoReMi is thinking of implementing a Print-On-Demand business process for the school bulk ordering of music scores (e.g. for music band use). This new business process will not need to	Packaging and Warehousing	Just-In-Time production. Note that production is in-house.

keep an inventory of music scores. Instead, the Print-on-Demand process will perform high-volume in-house printing of the music scores as and when orders come in. This will help reduce warehouse storage space and costs.		
Many of the DoReMi managers gave the requirement that they wanted a tool that could help them with delegation of tasks and tracking of the task status for the various small projects that they need to manage.	All	Tool to delegate tasks and dashboard to monitor task progress for various projects
For music books, DoReMi purchases books from many different publishers. The processing of the publisher's invoices currently takes a lot of manual effort and DoReMi management is hoping to automate this process.	IT	E-invoicing
There are many sales promotions (such as Christmas Sale, New Year Sale etc.) and the price of the books can change often depending on many factors. The IT department currently takes too long to make the changes to the system to cater for the frequent price changes.	Sales & IT	Demand-based pricing or Flash Sale pricing
During peak hours, the cashier is not able to cope with the large number of customers as each payment takes some time (eg: credit card slip printing and signing) and this adds up when there are many customers.	Sales	E-commerce automation will help reduce traffic volume for cashier. More work expected for Packaging and Warehousing team and Shipping team.

Appendix B: Rule Bases

Profitability Rule Base

WHEN	AND	THEN
ROC	NPM	Profitability
Low	Low	Low
Low	Medium	Low
Low	High	Medium
Medium	Low	Low
Medium	Medium	Medium
Medium	High	High
High	Low	Medium
High	Medium	High
High	High	High

Debt Paying Ability Rule Base

WHEN	AND	AND	THEN
CTR	QKR	CHR	DebtPayingAbility
Low	Low	Low	Low
Low	Low	Medium	Low
Low	Low	High	Medium
Low	Medium	Low	Low
Low	Medium	Medium	Medium
Low	Medium	High	Medium
Low	High	Low	Low
Low	High	Medium	Medium
Low	High	High	High
Medium	Low	Low	Low
Medium	Low	Medium	Medium
Medium	Low	High	Medium
Medium	Medium	Low	Low

Medium	Medium	Medium	Medium
Medium	Medium	High	High
Medium	High	Low	Medium
Medium	High	Medium	Medium
Medium	High	High	High
High	Low	Low	Low
High	Low	Medium	Medium
High	Low	High	High
High	Medium	Low	Medium
High	Medium	Medium	Medium
High	Medium	High	High
High	High	Low	Medium
High	High	Medium	High
High	High	High	High

Operation Ability Rule Base

WHEN	THEN
TAT	OperationAbility
Low	Low
Medium	Medium
High	High

Liquidity Rule Base

WHEN	AND	AND	THEN
SAR	DAR	LDR	Liquidity
Low	Low	Low	Low
Low	Low	Medium	Low
Low	Low	High	Low
Low	Medium	Low	Medium
Low	Medium	Medium	Low
Low	Medium	High	Low
Low	High	Low	Medium

Low	High	Medium	Medium
Low	High	High	Medium
Medium	Low	Low	Medium
Medium	Low	Medium	Low
Medium	Low	High	Low
Medium	Medium	Low	Medium
Medium	Medium	Medium	Medium
Medium	Medium	High	Medium
Medium	High	Low	High
Medium	High	Medium	High
Medium	High	High	Medium
High	Low	Low	Medium
High	Low	Medium	Medium
High	Low	High	Medium
High	Medium	Low	High
High	Medium	Medium	High
High	Medium	High	Medium
High	High	Low	High
High	High	Medium	High
High	High	High	High

Credit Risk Rule Base

WHEN	AND	AND	AND	THEN
Profitability	DebtPayingAbility	OperationAbility	Liquidity	CreditRisk
Low	Low	Low	Low	High
Low	Low	Low	Medium	High
Low	Low	Low	High	High
Low	Low	Medium	Low	High
Low	Low	Medium	Medium	High
Low	Low	Medium	High	Medium
Low	Low	High	Low	High
Low	Low	High	Medium	High

Low	Low	High	High	Medium
Low	Medium	Low	Low	High
Low	Medium	Low	Medium	Medium
Low	Medium	Low	High	Medium
Low	Medium	Medium	Low	High
Low	Medium	Medium	Medium	Medium
Low	Medium	Medium	High	Medium
Low	Medium	High	Low	Medium
Low	Medium	High	Medium	Medium
Low	Medium	High	High	Medium
Low	High	Low	Low	Medium
Low	High	Low	Medium	Medium
Low	High	Low	High	Medium
Low	High	Medium	Low	Medium
Low	High	Medium	Medium	Medium
Low	High	Medium	High	Low
Low	High	High	Low	Medium
Low	High	High	Medium	Medium
Low	High	High	High	Low
Medium	Low	Low	Low	High
Medium	Low	Low	Medium	High
Medium	Low	Low	High	Medium
Medium	Low	Medium	Low	High
Medium	Low	Medium	Medium	High
Medium	Low	Medium	High	Medium
Medium	Low	High	Low	High
Medium	Low	High	Medium	Medium
Medium	Low	High	High	Medium
Medium	Medium	Low	Low	High
Medium	Medium	Low	Medium	Medium
Medium	Medium	Low	High	Medium

Medium	Medium	Medium	Low	Medium
Medium	Medium	Medium	Medium	Medium
Medium	Medium	Medium	High	Medium
Medium	Medium	High	Low	Medium
Medium	Medium	High	Medium	Medium
Medium	Medium	High	High	Low
Medium	High	Low	Low	Medium
Medium	High	Low	Medium	Medium
Medium	High	Low	High	Low
Medium	High	Medium	Low	Medium
Medium	High	Medium	Medium	Medium
Medium	High	Medium	High	Low
Medium	High	High	Low	Medium
Medium	High	High	Medium	Low
Medium	High	High	High	Low
High	Low	Low	Low	High
High	Low	Low	Medium	High
High	Low	Low	High	Medium
High	Low	Medium	Low	High
High	Low	Medium	Medium	Medium
High	Low	Medium	High	Medium
High	Low	High	Low	High
High	Low	High	Medium	Medium
High	Low	High	High	Medium
High	Medium	Low	Low	Medium
High	Medium	Low	Medium	Medium
High	Medium	Low	High	Medium
High	Medium	Medium	Low	Medium
High	Medium	Medium	Medium	Medium
High	Medium	Medium	High	Low
High	Medium	High	Low	Medium

High	Medium	High	Medium	Medium
High	Medium	High	High	Low
High	High	Low	Low	Medium
High	High	Low	Medium	Medium
High	High	Low	High	Low
High	High	Medium	Low	Medium
High	High	Medium	Medium	Low
High	High	Medium	High	Low
High	High	High	Low	Medium
High	High	High	Medium	Low
High	High	High	High	Low

Order Approval Rule Base

WHEN	AND	AND	AND	THEN
Defaulter	LatePayment	OrderValue	CreditRisk	Status
Yes				Rejected
No	Yes	>10,000		Rejected
No	No	>10,000	High	Rejected
No	No	>200,000	Medium	Rejected
No	No	>500,000	Low	Rejected

Bulk Purchase Discount Rule Base

WHEN	AND	AND	AND	THEN
NewCustomer	OrderValue	LTV	Frequency of Purchase	Discount
Yes	<=1000	-	-	2%
Yes	<=5000	-	-	3%
Yes	>=10000	-	-	5%
No	<=1000	<=50,000	-	4%
No	<=5000	<=50,000	-	5%
No	>=10000	<=50,000	-	6%
No	<=1000	>=50,000	High	10%

No	<=5000	>=50,000	High	12%
No	>=10000	>=50,000	High	15%
No	<=1000	>=50,000	Medium	8%
No	<=5000	>=50,000	Medium	10%
No	>=10000	>=50,000	Medium	12%
No	<=1000	>=50,000	Low	8%
No	<=5000	>=50,000	Low	9%
No	>=10000	>=50,000	Low	10%

Inventory Decision Rule Base

WHEN	AND	AND	AND	THEN
Stock Level	Product Demand	Supplier Time	Lead Service Level	Increase Stock By
Medium	High	Long	High	40%
Medium	High	Long	Medium	40%
Medium	Low	Long	High	40%
Medium	Low	Long	Medium	40%
Medium	Medium	Long	High	40%
Medium	Medium	Long	Medium	40%
Medium	Medium	Long	Low	40%
Medium	High	Moderate	High	40%
Medium	High	Moderate	Medium	40%
Medium	Low	Moderate	High	40%
Medium	Low	Moderate	Medium	40%
Medium	Medium	Moderate	High	40%
Medium	Medium	Moderate	Medium	40%
Medium	High	Short	High	40%
Medium	High	Short	Medium	40%
Medium	Low	Short	High	40%
Low	Low	Long	High	40%
Low	Low	Long	Medium	40%
Low	Low	Long	Low	40%

Low	High	Moderate	Medium	40%
Low	High	Moderate	Low	40%
Low	Low	Moderate	High	40%
Low	Low	Moderate	Medium	40%
Low	Low	Moderate	Low	40%
Low	Medium	Moderate	High	40%
Low	Medium	Moderate	Medium	40%
Low	High	Short	High	40%
Low	High	Short	Medium	40%
Low	Low	Short	High	40%
Low	Low	Short	Medium	40%
Low	Low	Short	Low	40%
Low	Medium	Short	High	40%
Low	Medium	Short	Medium	40%
Low	High	Long	High	70%
Low	High	Long	Medium	70%
Low	High	Long	Low	70%
Low	Medium	Long	High	70%
Low	Medium	Long	Medium	70%
Low	Medium	Long	Low	70%
Low	High	Moderate	High	70%

Appendix C: Test Cases

Test Case	Description	Expected Outcome															
A1	Customer is a defaulter	Customer order is rejected.															
<div><div>Order List</div><div><div>+ CREATE NEW</div><table><thead><tr><th>Order No.</th><th>Customer</th><th>Order Date</th><th>Status</th><th></th></tr></thead><tbody><tr><td>20</td><td>Jaykay</td><td></td><td>Approved</td><td></td></tr><tr><td>22</td><td>Darryl Leong</td><td>09-03-2019</td><td>Rejected</td><td></td></tr></tbody></table></div></div>			Order No.	Customer	Order Date	Status		20	Jaykay		Approved		22	Darryl Leong	09-03-2019	Rejected	
Order No.	Customer	Order Date	Status														
20	Jaykay		Approved														
22	Darryl Leong	09-03-2019	Rejected														
A2	Customer has low credit risk with no late payment and default payment and has an order with value of \$400,000.	Customer order is pending final approval. (see Order No.18)															
<div><div>Order List</div><div><div>+ CREATE NEW</div><table><thead><tr><th>Order No.</th><th>Customer</th><th>Order Date</th><th>Status</th><th></th></tr></thead><tbody><tr><td>15</td><td>Jaykay</td><td>09-03-2019</td><td>Created</td><td></td></tr><tr><td>18</td><td>Jaykay</td><td>09-03-2019</td><td>Pending Approval</td><td></td></tr></tbody></table></div></div>			Order No.	Customer	Order Date	Status		15	Jaykay	09-03-2019	Created		18	Jaykay	09-03-2019	Pending Approval	
Order No.	Customer	Order Date	Status														
15	Jaykay	09-03-2019	Created														
18	Jaykay	09-03-2019	Pending Approval														
B1	Customer has low profitability, low debt paying ability, medium operation ability and low liquidity.	Customer has a high credit risk. (See Customer:Darryl)															

Customer Evaluation

Customer

Name

Darryl

Credit Risk

Date Registered

Address

Here

Customer Evaluation

is Customer New?

NO

No. of year active

1

Had customer defaulted before?

NO

Did customer had late payment before

NO

Customer Liquidity

Low

Customer Debt Paying Ability

Low

Customer Operation Ability

Medium

Customer Profitability

Low

Customer Purchase Frequency

Medium

Customer LTV

213

SAVE

BACK

Customer List

+ CREATE NEW

Customer No.	Name	Address	Credit Risk
2	Jaykay	Here	Medium
5	Darryl	Here	High

Customer Evaluation

Customer

Name

William

Credit Risk

Date Registered

Address

Here

Customer Evaluation

Is Customer New?

NO

No. of year active

1

Had customer defaulted before?

NO

Did customer had late payment before

NO

Customer Liquidity

High

Customer Debt Paying Ability

Medium

Customer Operation Ability

Medium

Customer Profitability

High

Customer Purchase Frequency

Medium

Customer LTV

11423

SAVE

BACK

Customer List

+ CREATE NEW

Customer No.	Name	Address	Credit Risk	
2	Jaykay	Here	Medium	
5	Darryl	Here	High	
8	William	Here	Low	

<div> <div>Order Detail</div> <div> <div>Order No.</div> <div>20</div> <div>Order Date</div> <div></div> </div> <div> <div>Customer</div> <div>Jaykay</div> <div>Country</div> <div>SG</div> </div> <div> <table> <tr> <th>Product</th> <th>Quantity</th> <th>Value (\$)</th> </tr> <tr> <td>Disneyland</td> <td>20</td> <td>4,000.00</td> </tr> </table> <div> <div>Order Value (\$): 4,000.00</div> <div>Order Discount (%): 3%</div> <div>Discounted Value (\$): 0.00</div> </div> <div> <div>APPROVE</div> <div>REJECT</div> </div> </div> </div>			Product	Quantity	Value (\$)	Disneyland	20	4,000.00
Product	Quantity	Value (\$)						
Disneyland	20	4,000.00						
C2	Customer is not new, Order Value is greater than \$10,000, Customer LTV is greater than \$50,000 and Frequency of Purchase is High	Order Discount is 15%						
<div> <div>Order Detail</div> <div> <div>Order No.</div> <div>18</div> <div>Order Date</div> <div></div> </div> <div> <div>Customer</div> <div>Jaykay</div> <div>Country</div> <div>SG</div> </div> <div> <table> <tr> <th>Product</th> <th>Quantity</th> <th>Value (\$)</th> </tr> <tr> <td>Disneyland</td> <td>2000</td> <td>400,000.00</td> </tr> </table> <div> <div>Order Value (\$): 400,000.00</div> <div>Order Discount (%): 15%</div> <div>Discounted Value (\$): 0.00</div> </div> <div> <div>APPROVE</div> <div>REJECT</div> </div> </div> </div>			Product	Quantity	Value (\$)	Disneyland	2000	400,000.00
Product	Quantity	Value (\$)						
Disneyland	2000	400,000.00						
D1	Inventory Level is High, Demand and Service Level is Low, Supplier Lead Time is Moderate	No prompt generated for Warehouse						

Product Detail

Subtitle here

Product No.

17

Product Title

Disneyland

Product Demand

Low

Service Level

Low

Supplier Lead Time

Moderate

Stock Level

High

SAVE

BACK

Task List

ID

Name

Subject

Status

createdOn

No prompt generated for Warehousing in Task List.

D2	Inventory Level is Low, Demand and Service Level is high, Supplier Lead Time is Moderate	Warehouse is prompted to increase product stock sharply (70% of existing stock quantity)
----	--	--

Supplier Reorder

Product

id

17

productTitle

Disneyland

Original Available Inventory

384

Restock Request

id

28

quantity

268

OK

BACK

Appendix D: Success Measurements for Enhanced Processes

Success Measurement Calculation for Inventory Management Process

Key Improvements:

- 35% improvement in cycle time for a bulk order
- 85% improvement in waiting time in between activities for a bulk order
- 51% improvement in overall time for a bulk order

Process		Bulk Purchase Order Handling Process								
		Check Existing Account	Input Customer Details	Input Order Details	Check Credit Risk	Check Approval	Review Final Approval	Inform Customer	Package Good	Total
As-Is	User	Sales	Sales	Sales	Accounts	Accounts	Accounts	Sales		
	Cycle Time (s)	300	600	600	600	600	300	300	3600	6900
	Waiting Time (mins)	3	5	10	5	5	10	5	10	53
To-Be	User	Automated	Customer	Customer	Automated	Automated	Accounts	Automated		
	Cycle Time (s)	0	300	300	0	0	300	0	3600	4500
	Waiting Time (mins)	0	1	1	0	0	3	0	3	8
Improvement	Cycle Time (s)	300	300	300	600	600	0	300	0	2400
	Cycle Time (%)									35%
	Waiting Time (mins)	3	4	9	5	5	7	5	7	45
	Waiting Time (%)									85%
	Overall Time (%)									51%

Success Measurement Calculation for Inventory Management Process

Key Improvements:

- 23% improvement in cycle time for a bulk order
- 80% improvement in waiting time in between activities for a bulk order
- 35% improvement in overall time for a bulk order

Process		Inventory Management Process							
		Check Inventory Level	Check Supply Order	Make Supply Order	Check Approval	Review Final Approval	Receive and Store Supply Order	Update Inventory	Total
As-Is	User	Warehousing / Packaging	Warehousing / Packaging	Warehousing / Packaging	Accounts	Accounts	Warehousing / Packaging		
	Cycle Time (s)	600	600	600	600	300	7200	600	10500
	Waiting Time (mins)	5	5	5	5	10	10	5	45
To-Be	User	Automated	Automated	Warehousing / Packaging	Automated	Accounts	Warehousing / Packaging	Automated	
	Cycle Time (s)	0	0	600	0	300	7200	0	8100

	Waiting Time (mins)	0	0	3	0	3	3	0	9
Improvement	Cycle Time (s)	600	600	0	600	0	0	600	2400
	Cycle Time (%)								23%
	Waiting Time (mins)	5	5	2	5	7	7	5	36
	Waiting Time (%)								80%
	Overall Time (%)								35%