2019

Robotic process automation for inventory control and management: a case of Freight Forwarders Solutions

Beryl Okwado Mungla
Faculty of Information Technology (FIT)
Strathmore University

ROBOTIC PROCESS AUTOMATION FOR INVENTORY CONTROL AND MANAGEMENT: A CASE OF FREIGHT FORWARDERS SOLUTIONS

Mungla, Beryl Okwado
060060

A Dissertation Submitted to Strathmore University in Partial Fulfilment of the Requirements of the Degree of Master of Science in Mobile Telecommunications and Innovation (MSc. MTI)

Faculty of Information Technology

Strathmore University

Nairobi, Kenya

June 2019

Declaration

I declare that this work has not been previously submitted and approved for the award of a degree by this or any other University. To the best of my knowledge and belief, the dissertation contains no material previously published or written by another person except where due reference is made in the dissertation itself.

Mungla, Beryl Okwado

………………………….
07th June 2019

Approval

This dissertation of Mungla, Beryl Okwado was reviewed and approved by the following:

Prof. Ismail Lukandu Ateya (D.Sc.)
Senior Lecturer, Faculty of Information Technology
Strathmore University

Dr. Joseph Orero (Ph.D.)
Dean, Faculty of Information Technology
Strathmore University

Prof. Ruth Kiraka
Dean, School of Graduate Studies
Strathmore University

Abstract

Logistics services are a lifeline for most business enterprises. These services cannot be provided efficiently with an ineffective inventory management system in place. Technological advancements enable enterprises acquire information systems to improve operational efficiency. Manual data entry into warehouse management systems has a myriad of setbacks including: High error rates; Slow turnaround time; Investment in additional personnel to countercheck the accuracy of manually entered data; Increased error rates due to unexpected spikes in manual data entry; Deviation of attention from tasks that are cognitive based to those that are rules based resulting in decreased employee productivity.

Robotic process automation, a disruptive, new technology leveraging on artificial intelligence was used in this study to automate the business processes performed in the inventory control and management module of a warehouse management system. Relevant literature was reviewed to better understand how the technology has been implemented in other organisations. The waterfall model was selected for development of the software robots due to its applicability in the selection of business processes best suited for automation as well as throughout the development lifecycle of the robots. Processes that were selected for automation had the following characteristics: mundane, manual, repetitive, rule-based, labour and time intensive.

The developed solution delivered several benefits to the organisation including: Increased accuracy of the information captured in the system; Reduction in error rates during data capture; Significant reduction in time consumed during execution of tasks; Cost savings due to reduction in operational costs; Process improvements due to streamlining; Increased productivity, quality and compliance; and Redeployment of employees to higher value functions. Results from solutions testing showed that majority of the respondents agreed that the software robots had attained the desired results. The aim of this research paper was to explore ways through which technology could be leveraged to transform manual business processes into automated and streamlined processes through robotic process automation technology. The conclusions drawn indicated that process automation increases operational efficiency and employee productivity through redeployment to more cognitive based tasks.

Key Words: Logistics, warehouse, inventory, inventory management

Table of Contents

List of tables

List of figures

Abbreviations and acronyms

AHT	Average Handling Time
AI	Artificial Intelligence
API	Application Programming Interface
BACS	Bank Account Clearing System
ERP	Enterprise Resource Planning
FFS	Freight Forwarders Solutions
FTE	Full-time Employees/Equivalent
HTML	Hyper Text Markup Language
IC	Interactive Client
IoT	Internet of Things
ISG	Information Services Group
IT	Information Technology
ITR	Inventory Turnover Ratio
KPI	Key Performance Indicators
MIT	Massachusetts Institute of Technology
OCR	Optical Character Recognition
PDD	Process Design Document
PHP	Hypertext Processor
RFID	Radio Frequency Identification
ROI	Return on Investment
RPA	Robotic Process Automation
SAP	Systems, Applications, Products
SQL	Structured Query Language
TMS	Transport Management Systems
UAT	User Acceptance Testing
UI	User Interface
UML	Unified Modelling Language
VDI	Virtual Desktop Infrastructure
VM	Virtual Machine
WMS	Warehouse Management System

Acknowledgements

I would like to thank the Almighty God for being a constant source of strength, hope and encouragement during my endeavour to complete this research. None of this would have been possible without His divine grace and guidance.

I would also like to acknowledge my supervisor, Prof. Ismail Ateya, for the professional counselling, support and invaluable guidance provided throughout the preparation and completion of this study. To him I offer my sincerest gratitude.

Finally, I would like to extend my profound gratitude to my family and friends for their unwavering support and continuous encouragement throughout this study. Their words of encouragement greatly motivated me throughout my masters' studies which has culminated in the completion of this research. Your support was greatly appreciated.

Dedication

This dissertation is dedicated to my loving parents, Richard A. Mungla and Grace A. Mungla for their continual prayers, unwavering support, guidance and good will throughout my studies. To my loving siblings, Maureen, Christine, Dr. Prisca and Richard Jnr, I dedicate this to you for your endless support and encouragement which greatly motivated and inspired me to complete this research.

Chapter 1 Introduction

1.1 Background

Logistics, as defined by the Council of Logistics Management involves planning, implementing, and controlling the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption to meet customers' requirements (CSCMP, 2018). The activities involved in logistics management include: warehousing, inventory management, materials handling, supply/demand planning, order fulfilment, fleet management, inbound and outbound transportation management, logistics network design, and management of third party logistics services providers. Logistics, to varied extents also incorporates sourcing and procurement, customer service, packaging and assembly, production planning and scheduling. Strategic, tactical and operational planning are also part of logistics management (Tseng, Yue, & Taylor, 2005).

Inventory management, a fundamental component of supply chain management is the supervision of the flow of merchandise from manufacturers to warehouses then to retail points. A major aspect of inventory management is maintaining detailed records of all products as they enter and leave a warehouse or retail point (Rouse, 2017). Supply chain management is an important aspect to many organisations as it can be used to gain competitive advantage in the market. The supply chain can be defined as the set of activities involved in the transformation of raw materials into final products which are then delivered to customers through retail points. The main activities involved in the supply chain include sourcing of raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer and the information systems required to log and monitor the said activities (Lam & Postle, 2006).

Inventory or stock is the central theme in managing materials. The inventory turnover ratio (ITR) is a barometer of performance of materials management function. In the generally understood term, inventory means a physical stock of goods kept in store to meet the anticipated demand. However, from materials management perspective, an apt definition of inventory is "a usable but idle resource having some economic value." This brings to the fore a paradox in the concept of inventory perceived as a "necessary evil." It is necessary to have physical stock in the system to take care of the anticipated demand because non-availability of materials when needed will lead to delays in production or projects or services delivered. However, keeping inventory is not free because there are opportunity costs of "carrying" or "holding" inventory in the organisation. Thus, the paradox is that we need inventory, but it is not desirable to have inventory. It is this paradoxical situation that makes inventory management a challenging problem area in materials management (Vrat, 2014).

Inventory plays a big part in firms as it accounts for about 56% of the annual turnover. Organisations are faced with a lot of competition in the current markets. This has led to the need for coming up with better methods of controlling inventories and therefore being able to eliminate any wastage in the value chain (Ondiek & Odera, 2012). In this study, the researcher wants to investigate how organisations can benefit from automation of the business processes involved in inventory control and management.

1.2 Problem Statement

At Freight Forwarders Solutions, inventory is controlled and managed using a warehouse management system. However, the activities performed on the system are mostly repetitive, rule-based, mundane, time and labour intensive.

Manual entry of large volumes of data into the system has a variety of challenges, the most notable ones being: High error rates due to human error, inadequate training on proper system usage and illegibility of handwritten forms; Slow turnaround time due to data entry tasks that are text heavy and require an understanding of the text; Investment in additional personnel to review the accuracy of data entered manually into the system; Deviation of attention from the company's core activities to manual data entry and associated tasks that are time and labour intensive; and Finally, high remuneration costs associated with maintaining a fulltime human workforce. These challenges cumulatively could have a detrimental effect on the company's ability to stay focussed on attaining its strategic goals.

1.3 Research Objectives

i. To identify the challenges faced with manual inventory control and management.
ii. To review existing solutions and frameworks for robotic process automation.
iii. To design, develop and test automated inventory control and management software robots.
iv. To validate the automated inventory control and management software robots.

1.4 Research Questions

i. What challenges exist in manual inventory control and management?
ii. What are the existing solutions and frameworks for robotic process automation?
iii. How will the software robots be designed, developed, and tested?

iv. How will the software robots be validated?

1.5 Justification

Several studies have been conducted on inventory control and management in various organisations in Kenya. Kariuki (2013) did an assessment of the factors influencing effectiveness of inventory control in the Ministry of State for Provincial Administration and Internal Security in Nairobi. The study found that long bureaucratic procedures, staff qualification and unavailability of appropriate stock records are the main factors influencing effectiveness of inventory control in the institution. The study did not however address utilisation of efficient inventory control systems to gauge supply chain performance.

Gakinya (2013) did a study to establish the relationship between inventory management techniques and supply chain performance in the Agricultural Sector in Kenya. The study concluded that the sector is embracing implementation of inventory management techniques and that indeed inventory management has a relationship with supply chain performance. Murage (2011) did a study on the effects of inventory levels and stock outs on procurement performance at Kenya Forestry Research Institute. The study concluded that management support is crucial in implementing inventory control techniques. Kamanda and Shale (2018) published a journal on the effects of inventory control systems on supply chain performance in distribution firms at Bollore Africa Limited. The findings concluded that staff competence affects supply chain performance and that management should conduct formal post-employment training to all inventory control staff.

The abovementioned studies revealed the various ways in which inventory control and management affected the organisations under review. However, research into Robotic Process Automation (RPA) and how organisations in the supply chain and logistics industry can leverage on the technology to streamline their business processes and improve overall organisational efficiency has not yet been undertaken. The resultant knowledge gap created the need for this study which sought to explore robotic process automation and its implementation in the supply chain.

1.6 Scope

The aim of this research was to automate the business processes involved in the inventory control and management module of the warehouse management system implemented at Freight Forwarders Solutions. The software robots for the identified business processes were built, tested and validated on the company's test environment before deployment into the production environment.

1.7 Limitations

This research focused on automating the business processes performed in the inventory control and management module of the warehouse management system. Future development will include automating all the viable business processes performed on the warehouse management system in its entirety.

1.8 Summary

This chapter has introduced the research topic and the context under which the study was based. It has also introduced the main objectives that the study sought to answer and ultimately draw conclusions from. The next chapter, literature review focused on what has been studied in this area thus far.

Chapter 2 Literature Review

2.1 Introduction

With the advancements in technology, computers have started listening and speaking, and there are robots that can perform routine tasks that are currently carried out by human beings (Brynjolfsson & McAfee, 2016). Organisations have to find ways of remaining competitive by reducing costs whilst addressing challenges faced by trying to meet consumer needs. Robotic Process Automation (RPA) enables organisations reduce operational costs by automating repetitive and mundane tasks (Forrester Research, 2014). Organisations that have adopted RPA technology have realised various benefits including enormous savings on full-time equivalent (FTE), improved service, quality and speed, lower error rate and staff satisfaction (Willcocks & Lacity, 2016).

There has been successful integration of automated robots into various types of logistics practices. Robotics is being used by e-commerce and third-party logistics companies to gain competitive advantage. The current rate of robotics adoption is thrilling, and the future prospects look promising. Trends in the supply chain industry are highly dynamic with more organisations opting to adopt robotics and automation (Rajana, 2018).

According to a study by Information Services Group (ISG), an international technology research firm, Robotics Process Automation (RPA) enabled a 43% reduction in resources for order-to-cash processes including billing, credit, collections and pricing. The report by ISG forecasts that by 2019, 72% of enterprises will be using RPA to reduce costs, improve productivity, increase compliance and reduce transaction times. RPA offers a fast and efficient way of automating simple, rules-based business processes without having to re-engineer them thus making it ideal for enterprises. Autonomics software is being used by vendors to automate standard operating procedures and correlate data, making the procedures more efficient over time (Green, 2017).

Until recently, the uptake of automation within the supply chain industry has been slow, however, with the development of new capabilities for automation technologies, enterprises globally are increasingly relying on RPA to streamline the flow of goods on the supply-side while attaining a competitive advantage with customers on the demand-side. Initially, RPA software robots were unintelligent and lacked the agility required to process skill-based, non-standardised interactions of complex supply chains that were dependant on human intervention. There is great potential for supply chain management with the continuous advancements in the evolution of automation technology. Software robots are acting more like human employees with the incorporation of more cognitive and knowledge-based capabilities within RPA technology. In order to automate beyond tasks based on well-defined business rules and clear instructions for processing outputs, intelligent automaton is being developed as a conduit between cognitive process automation, intelligent computer vision and intelligent Optical Character Recognition (OCR) (Deckard, 2018).

Due to cognitive augmentation, RPA is increasingly being adopted within the supply chain to mimic the actions of human employees: capturing, replicating, and processing data, communicating with customers, as well as making judgements and learning from past actions (Deckard, 2018).

2.2 Emerging Technology and Inventory Management

2.2.1 Drones in the Warehouse

Robots have made a significant impact in inventory management. They are constantly changing the daily labour required in businesses. Drones are the most recent type of robots. Features that make drones more applicable to workplaces include, improvements in drone technology and battery life. The advanced drone models will enable organisations incorporate robots in roles not previously possible. Companies like DroneScan and Hardis Group use quadcopter technology to improve warehouse inventory management. WalMart is developing their own version of the technology to compete with Amazon. Utilisation of drones in the warehouse goes beyond flying. In 2013, autonomous wheel drones designed by Kiva Systems were adopted by Amazon to organise and prepare merchandise in their warehouses. These drones were designed to work efficiently and never collide with each other. Drones have also been implemented by companies such as Zappos, Staples and Walgreens (Watzinger, Town, & Filman, 2017).

In the warehouse, drone usage varies based on the operation being performed. Some of the typical work performed by the flying co-worker include: Being tasked with counting the inventory amount of Item A, which will be contained in boxes stored on the top shelves of an aisle; The warehouse management system will be fully integrated with the drone’s software thereby allowing the drone to access inventory location data down to the specific aisle, rack or bin level; The drone will map out the optimal travel path to the stock location; The drone will have an optical system that will combine computer vision and deep learning technology – this is a sub-field of machine learning that allows it to recognise images based on a network of learning layers; The drone will arrive at the stock location, which it will know based on X, Y, Z coordinates; The drone will visually inspect the labels, take a photo of the bar-code, or use RFID (radio frequency identification) sensors to relay the inventory count to the central warehouse management system (Watzinger, Town, & Filman, 2017).

The major benefits of incorporating drones in inventory management and supply chains include: Efficient work completion – replacing humans with drones to perform tasks such as barcode scanning can be far more efficient. According to DroneScan, "A drone operator can count as much stock in a warehouse in two days as a team of 80 people with handheld scanners and reach trucks can count in 3 days." This results in overall efficiency with improved rates of inventory management and delivery; Energy saving – replacing workers and machines with drones to scan inventory also has energy benefits in that, organisations are able to save time and energy on the employees' part. A lightweight drone can be used to easily scan inventory instead of having an employee use a lift to access and scan the respective inventory; Safety – implementing drones in inventory stock takes reduces human interaction with machinery and stock. This reduction in risk exposure reduces workplace hazards to human employees (Watzinger, Town, & Filman, 2017).

2.2.2 Using Drones to Relay RFID Signals for Inventory Control

Supply chain management was supposed to be revolutionised by radio frequency identification (RFID) tags. Warehouse managers can log inventory much more efficiently using the battery-free tags which receive power wirelessly from scanners then broadcast identifying numbers as opposed to reading box numbers and recording them manually. However, the scale of modern retail operators renders even RFID scanning inefficient. In 2013, WalMart reported that it lost $3 billion in revenue due to mismatches between its inventory records and its stock. A large retail store can take up to three months to perform a complete inventory review using RFID technology implying that mismatches often go undetected until uncovered by a customer request (Hardesty, 2017).

Researchers from Massachusetts Institute of Technology (MIT) developed a system that enables small, safe, aerial drones to read RFID tags from tens of meters away while identifying the tags' locations with an average error rate of about 19 centimetres. The researchers envision that the system could be implemented in large warehouses for both continuous monitoring, to prevent inventory mismatches, and location of individual items, so that employees can meet customer requests more efficiently and reliably (Hardesty, 2017).

The main challenge during system design was that with autonomous navigation, only small, lightweight drones with plastic rotors were safe enough to fly within close range of humans. These drones were ideal because they would not cause injuries in the event of a collision. However, these drones were too small to carry RFID readers with a range of more than a few centimetres. The researchers countered this challenge by using the drones to relay signals emitted by a standard RFID reader. Not only did this solve the safety problem, but it also meant that drones could be deployed in conjunction with existing RFID inventory systems without requiring new tags, readers, or reader software (Hardesty, 2017).

In summary, with innovation and investments focused on drone technology, new advancements are being brought into the market almost monthly. While drones currently play a major role in inventory counting, they could become the human employee's personal assistant in the future. A generation of drones that can be dispatched to handle e-commerce claims and returns is a possibility. In fact, Amazon is conceptualising a drone-based delivery system called Amazon Prime Air. Drones have proven to be valuable assets in large distribution centres and warehouses. With their RFID scanning abilities and connection to a cloud-based inventory management system, these flying robots can greatly improve inventory practices (Watzinger, Town, & Filman, 2017).

2.3 Robotic Process Automation

Robotic Process Automation (RPA) is a methodology where a computer software is used to complete a specific process that was previously done by a human. Robotic automation software does not replace systems. Instead, it works with the system and performs a particular task in the same way as it has been asked to complete (Sutherland, 2013). RPA interacts with computer systems in a similar way as humans would, except that it is much faster and cheaper. RPA can be used to perform repetitive tasks that involve typing and clicking the same way a salaried employee would (Lu, Li, Chen, Kim, & Serikawa, 2018). RPA does not require changing old systems. RPA can be integrated with any software used by humans and it can be implemented in a short period of time to carry out operational procedures (Asatiani & Penttinen, 2016).

Some processes are better suited for robotic process automation than others. One example of a simple process that is well suited for RPA is a process that includes the tasks of signing in to a computer system, getting data from the system and transforming it to another digital output eventually passing it on to another computer system (Willcocks & Lacity, 2016).

RPA's automation potential increases with the more repetitive and manual processes. Non-repetitive tasks with little recurring patterns are not well suited for automation (Asatiani & Penttinen, 2016). Sutherland (2013) and Wilcocks & Lacity (2016) defined features that a process has to have to increase the opportunity of being suited for RPA. Figure 2.1 shows some of these features.

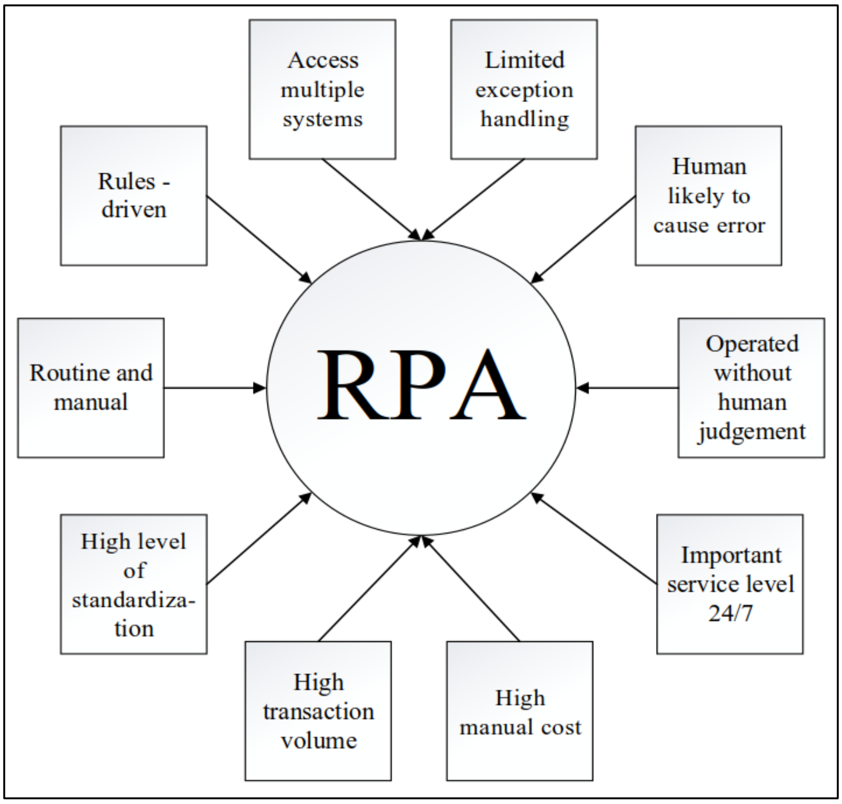

Figure 2.1 Features of Processes Suitable for Robotic Process Automation (Sutherland, 2013), (Willcocks & Lacity, 2016)

RPA robots exist as a software that is installed on a computer. It is called a software robot due to its operation principle. One robot is equal to one software license (Willcocks & Lacity, 2016). The RPA software robot communicates with other information technology (IT) systems on the front-end, while other traditional software is integrated via the back-end. This is one of the reasons why RPA is classified as lightweight IT, but other conventional software is classified as heavyweight IT.

2.3.1 Benefits of RPA adoption for enterprises

Figure 2.2 shows a variety of benefits that are driving enterprises towards RPA. Most significant are the potential cost savings: up to 55% for deterministic, rule-based processes. Speed of execution, accuracy, and compliance are key RPA benefits for organisations, in particular for financial services firms. Retail companies looking for capacity on-demand realise that onboarding human resources for a short period of time requires considerable effort and senior leadership bandwidth; for that reason, they are gravitating towards using RPA instead. Companies can also free-up human resources from non-value-adding work and redirect them to tasks that require judgement to gain more productivity per person and greater employee satisfaction as they undertake higher value work (Genpact, 2017).

Figure 2.2 Benefits of RPA adoption for enterprises (Genpact, 2017)

RPA offers tremendous opportunities, but enterprises need a carefully crafted strategy and execution approach to harness them. A combination of deep process expertise, technology prowess, and domain knowledge is also vital. The six established best practices are: Prioritise best-suited RPA use cases; Determine realistic Return on Investment (ROI) expectations; Establish a well-defined governance structure; Select capable RPA tools and operators; Re-engineer processes to maximise RPA benefits; Enable strong collaboration between the business and IT (Genpact, 2017).

However, for RPA to be successfully implemented, the right human intervention with a profound understanding of the processes to be automated, and with the correct rules and boundaries in place is required at the outset. Therefore, leveraging automation at scale should come with clear governance, an understanding of what it means for the roles of current employees, and the ability to filter out inherent bias which may have been embedded into the technology by its original human creators (Kirkwood, 2018).

2.4 How RPA Impacts the Global Supply Chain

At the core of many organisations, there are often supply chains and their management. Organisations worldwide rely on operations that move products from suppliers to customers, monitor inventory levels, and track shipments to ensure timely delivery of materials. The supply chain is becoming a popular target for automation technologies such as RPA because its processes are highly dependent on the back office (Ostdick, 2016).

In supply chain management, RPA is still a relatively novel concept however it is expected to become much more mainstream in the near future. Companies in industries such as healthcare, commercial food, retail and automotive are starting to adopt RPA technology to overhaul their supply and logistics strategies to foster leaner, cost-effective operations (Ostdick, 2016).

2.4.1 Benefits of RPA in Supply Chain Management

It is important to first consider where RPA can be implemented in the supply chain to better understand the benefits it can provide. A fully automated supply chain in its entirety is not yet a possibility because most front office activities are majorly human dependent. These activities include initiating and maintaining customer relationships, product development, as well as developing strategic plans for the supply network. As a result, human involvement is still a necessity to a certain extent to facilitate successful delivery of goods to customers, however, it should be noted that most of the back-office activities in the supply chain are suitable for automation (Ostdick, 2016).

Automation of Order Processing and Payments

When customers place orders online, they select their desired products, enter their payment information, and receive order and shipping confirmations – all of which happens electronically. Behind the scenes, however, many companies still rely on paper documents and manual labour to execute the transactions that are associated with order processing. These include manually entering customer information into computer systems, processing payments, and sending out email confirmations and order updates. RPA can be implemented to automate such back-office tasks, thereby reducing the need for the associated manual work. This then frees up the human resources, allowing them to focus more on interacting with customers at the front office (Ostdick, 2016).

Automation of Emails

Maintaining regular communication between manufacturers, suppliers, transportation service providers and customers is vital in ensuring that a supply chain runs effectively. According to the Oxford College of Procurement and Supply, "Communication is crucial to supply chain success and yet it is surprisingly one of the biggest areas that require improvement. When it comes to cooperating with staff in other departments, many procurement professionals admit it is very difficult." Effective communication within the supply chain is essential. It is important to ensure open communication between all individuals and companies in situations whereby shipments are delayed, orders cannot be fulfilled as well as when orders have been successfully processed and shipped to build credibility and trust. RPA can be used to automate this communication, automatically triggering an email or text when an order is processed, shipped, or delayed (Ostdick, 2016).

Automation of Procurement and Inventory Management Processes

Inventory control lies at the core of supply chain. Monitoring inventory levels is crucial to manufacturers and suppliers in ensuring they have enough products to meet consumer demands. RPA can be beneficial in this case because the virtual robot workforce can monitor inventory, generate notifications when levels are low and reorder products when levels go below a predefined threshold (Ostdick, 2016).

Additionally, optimal inventory levels can be determined by RPA through real-time reporting based on previous needs. Inventory levels can also be modified based on patterns in demand and reported on. RPA creates convenience and efficiency to providers when accessing inventory levels and assessing current needs (Ostdick, 2016).

As demonstrated, RPA provides automation capable of relieving employees of repetitive, high-volume back office tasks and allowing organisations to execute these tasks faster and effectively. However, RPA may have an even more powerful contribution to supply chains: analytics. By recording and monitoring the actions of software robots in these automation scenarios, RPA can gather information about business patterns and internal workings to reveal potential disruptions and bottlenecks. These insights can be used to target specific areas of the supply chain for improvement and optimisation (Ostdick, 2016).

2.5 Common Challenges in Warehouse Management

Warehouse management is time and energy consuming. Locating thousands of products within the warehouse while also ensuring that hundreds of products are shipped to customers timely is a major challenge. Proper warehouse management can be a daunting task that many companies fail to fully embrace. The key to successful warehouse management is to streamline the warehouse operations and automate processes as much as possible. The most common challenges to warehouse management are discussed herein (Scanco, 2014).

Inventory accuracy. When warehouses are managed manually, inaccuracies in inventory levels arise due to poor visibility of the stock on hand. Inadequate product visibility results in excess or obsolete inventory building up or product shortages caused by high demand. Having excess inventory leads to diminished warehouse space, reduced cash flow, higher inventory costs due to extra stock, and ultimately, poor customer service. Inaccuracies in inventory and product shortages are also major sources of customer dissatisfaction as orders tend to be unfulfilled or delayed. Investment in warehouse management systems and process automation technologies would greatly enhance inventory accuracy and provide businesses with insights on the stock on hand (Scanco, 2014).

Redundant processes. Redundant warehouse processes are detrimental to the success of a warehouse as they are time wasting and reduce employee productivity. Logistics companies that have warehouses need to re-assess their current business processes and streamline workflows to boost employee productivity and optimise efficiency. The companies also need to eliminate redundant or unnecessary processes from the various workstreams and train the warehouse staff on any new and streamlined processes or procedures (Scanco, 2014).

2.6 Key Challenges of Manual Inventory Management

Manual inventory management is faced with a myriad of challenges including errors during data capture, incompleteness of data, and insufficient data for analysis. Furthermore, information regarding stock, products, sales and purchases is not properly organised and managed thus making processing, updating and managing of the information difficult (Opeyemi, Fatoba, & Blessing, 2013).

2.6.1 Lack of Real-Time Data on Inventory Statuses

Lack of knowledge about where a specific product is in a warehouse at any given point in time can be very risky. Lack of real-time data has several implications including: Increased costs as poor inventory tracking causes unnecessary expenditures due to spoilage, rushed shipping costs and overtime charges; Inaccurate inventory balances which often results in shortages or overstocking; Increased lead times and stock outs due to depleted stock means disgruntled customers and reduced customer loyalty; Delayed shipping and delivery implies that customers have to wait longer periods to receive the ordered merchandise; Lack of insights and information makes it difficult to analyse trends across all warehouses and locations, and even harder to make informed operational decisions; Finally, lack of continuous improvement as there is no way of enforcing efficiencies, identifying bottlenecks and streamlining business processes (Maher, 2017).

2.6.2 Relying on Manual Processes

Manual inventory systems are heavily reliant on human actions which amplifies the possibilities of errors occurring. Employees might erroneously record transactions and make mistakes during stock counts. These inaccuracies could result in additional orders being made which would increase the company's inventory carrying costs and use up limited storage space. Inaccurate physical counts could also result in stock outs meaning the business could run out of products at inopportune times (Joseph, 2018).

Traditional techniques for managing inventory such as hand counting, and spreadsheets are time consuming and highly error prone. These methods result in inaccuracies during information analysis leading to rudimentary ways of tracking short and long-term trends, supply chain bottlenecks and inefficiencies. Manual inventory management hinders information sharing and collaboration and subsequently, customer satisfaction and loyalty as well as third party relations may suffer (Maher, 2017).

2.6.3 Unavailability of Inventory Information When Required

Warehouse managers as well as accounting, sales, procurement, logistics, production and customer service personnel all consume different types of inventory information in different quantities. This information needs to be accurate and current however that is rarely the case as the different departments have their own ways of maintaining data. With uncontrolled access, crucial information can be deleted, stolen or otherwise rendered unusable (Maher, 2017).

2.6.4 Non-Scalability of Manual Inventory Control

Tracking inventory on a spreadsheet works well for a few items but will not work as well for large amounts of data. Likewise, processes suitable for a single warehouse, distribution channel or retail location may not be suitable when more are added. Sorting and consolidating all that information is complicated, as is putting it in a format that can be easily used to generate essential analytics (Maher, 2017).

2.7 Robotic Process Automation Frameworks and Architectures

2.7.1 Blue Prism Architecture

Blue Prism comprises of tools, libraries, and runtime environments for RPA. The automation tool's main components are illustrated in figure 2.3. Software robots are made up of one or more business objects that allow the robots to interact with the system user interfaces and processes that contain the logic to be followed by the bot when run. The built-in features that Blue Prism has allows it to connect business objects to various application user interfaces, browser-based HTML interfaces, mainframe applications accessed through terminals, Windows interfaces, and interfaces developed using Java. The business objects implement specific actions on an application's user interface. For example, a business object might log into an application, enter customer details into a specific screen, retrieve a result, then log off (Chappell, 2017).

In Blue Prism, writing code is not required. The Object Studio, a Blue Prism development tool, is used by business analysts and developers to create objects graphically. The Process Studio, also a Blue Prism development tool, is used to graphically define the logic to be followed by the robot when executed. For every step in a Blue Prism process, an action is invoked in the business objects to interact with the application. Processes in Blue Prism mimic human users and how they would interact with applications to execute specific processes. The Blue Prism database runs on Microsoft SQL Servers to store business objects, processes and any other information related to the software robots. The robots can be scheduled to run at specific times, and information about the running robots can be viewed by the human personnel managing them. This process automation tool allows for users to be configured, audit logs viewed, and other management tasks performed as required. Blue Prism's client tools are easily accessible via tabs in a single application called the Interactive Client (IC) which simplifies the tool's usage (Chappell, 2017).

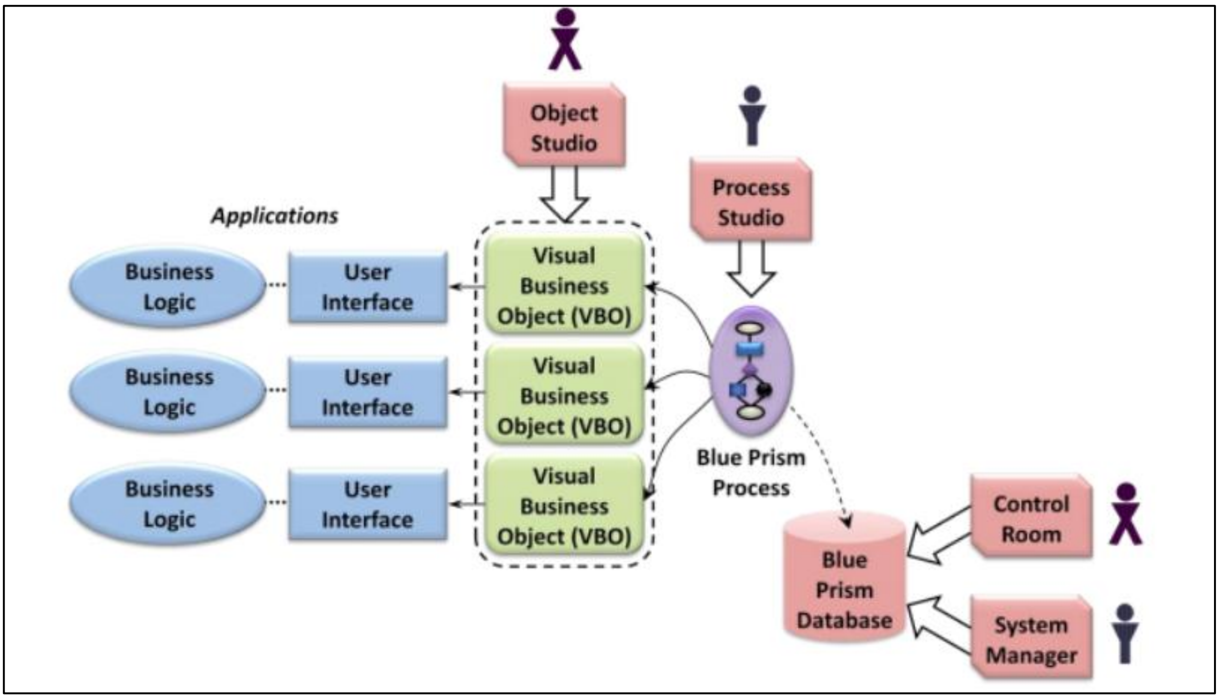

Figure 2.3 Blue Prism Architecture (Srini, 2017)

Information technology and business personnel are both intended to use the Blue Prism process automation tool. IT personnel are required during the initial setup of the robots and to configure the deployments. Proper configuration allows the robots to be reliable, scalable and secure. After configuration, business personnel can create and modify automated processes by themselves. Enterprise RPA, a style of process automation adopted by Blue Prism, allows both IT and business personnel to interact with the software robots thereby ensuring that the robots meet compliance and regulatory requirements; it also ensures that the robots can be developed and modified rapidly due to collaboration between all involved stakeholders (Chappell, 2017).

2.7.2 Automation Anywhere Architecture

Automation Anywhere, a popular robotic process automation tool offers powerful and user-friendly capabilities for automation of complex processes. It is an innovative technology that has altered the way businesses operate by combining conventional RPA with logical elements such as natural language comprehension as well as the ability to read unstructured data. Automation Anywhere is a Web-Based Management System that can be implemented in organisations to automate processes currently performed by human beings. This process automation tool uses a Control Room to execute the automated tasks. This tool can also be used to automate processes end to end thereby minimising the degree of human intervention required when running those processes (Rungta, 2018).

The Automation Anywhere architecture comprises of three major components namely the control room, bot creator and bot runner as illustrated in figure 2.4. The automation tool's major component is the web-based control room, which is the server from where the robots are controlled. User configuration, source code management, license configuration and dashboard management are all performed in the control room. Automation Anywhere can be acquired using a dev license which allows the user to develop, modify and run the bots and a run license which allows the user to only run the bots (Rungta, 2018).

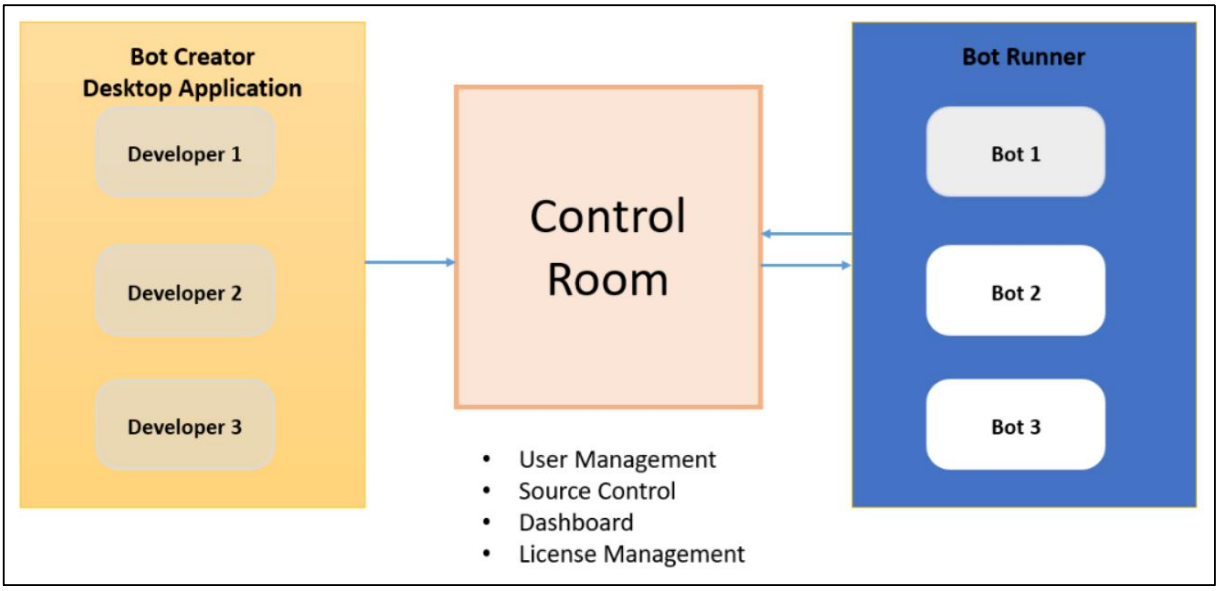

Figure 2.4 Automation Anywhere Architecture (Rungta, 2018)

Bot creators are desktop-based applications used to develop software robots. Dev licenses are required for the bot creators and their configuration is done in the control room. The component where the robots are run is the bot runner. Multiple robots can be run in parallel and the only requirement is to have a run license. The automation tool has the capacity to maintain audit logs and execution logs; these logs allow the users to monitor activity performed while using the tool and to keep track of the status of the robots, that is, whether they ran successfully or failed (Rungta, 2018).

2.7.3 UiPath Architecture

A UiPath server, also referred to as an Orchestrator, is designed to monitor, log and control the execution of robots on client computers. Figure 2.5 illustrates the UiPath Orchestrator architecture which comprises of three layers of logical components. The layers are as follows: Persistence Layer which comprises an SQL Server and ElasticSearch; Web Service

Layer which is used for REST API implementation; and Presentation Layer which is made up of a Web Application, Notification API and OData REST API Endpoints (Bestea, 2017).

The visual component of the UiPath Orchestrator is the Web Application. On the presentation layer, users: interact with the web pages used to control and monitor the robots; create robot groups and assign robots to them; assign processes to groups; analyse logs for each robot or process; and schedule the robots to automatically start and stop at specific times or trigger them manually. The Orchestrator is also made up of a service layer wherein lies a REST API that consists mainly of OData endpoints. Web Applications and Agents both consume the REST API; Agents are supervisors of software robots on the client computers (Bestea, 2017).

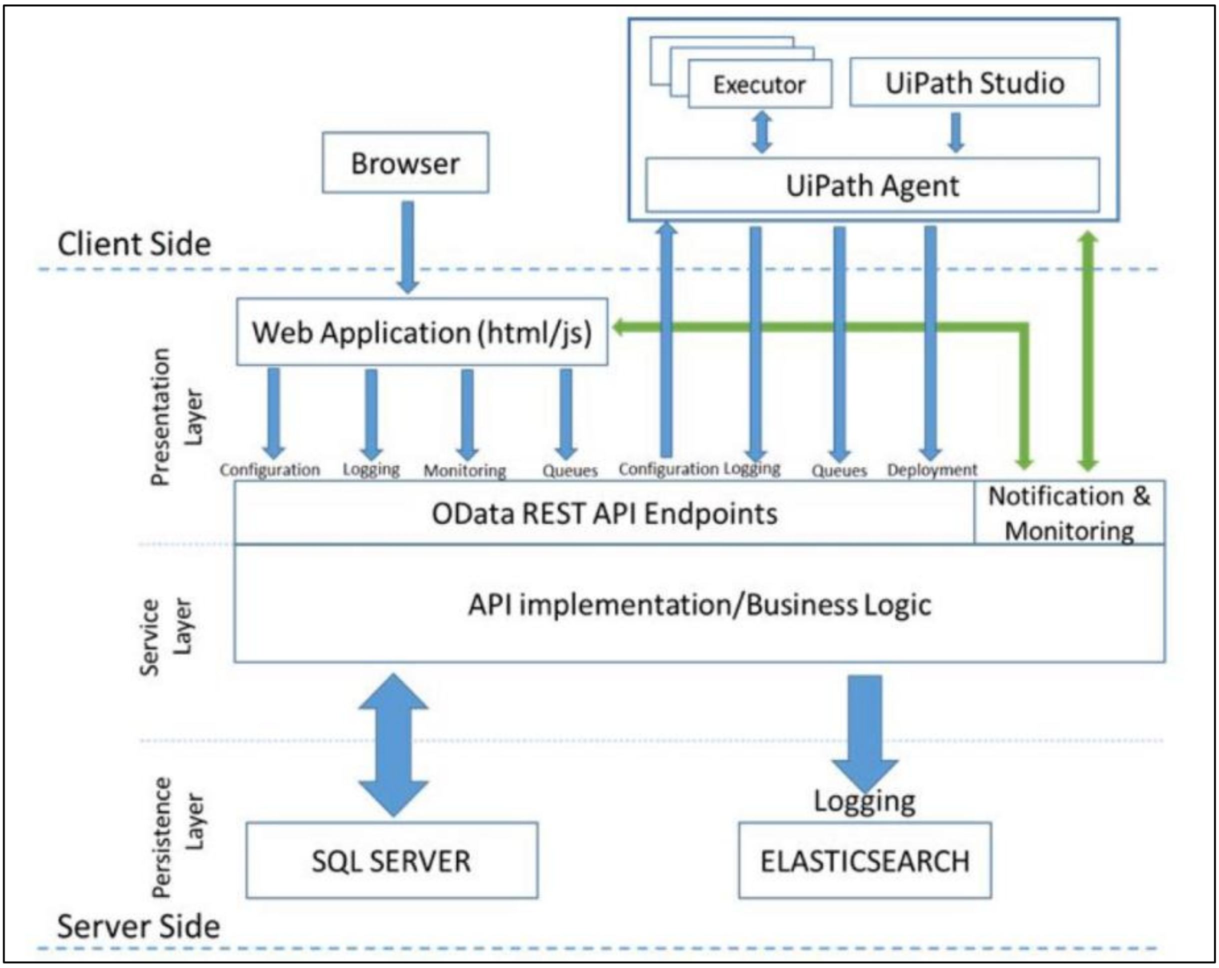

Figure 2.5 UiPath Orchestrator Architecture (Bestea, 2017)

The REST API covers all the Orchestrator functionalities including: Definition and configuration of application users, robots, permissions, environments, assets and releases; Registration of Agents and delivery of configuration settings used for transmission and reception of Server and Agent notifications; Utilisation of WebSocket communication by the

Notification API; Logging of various information such as error messages, explicit messages transmitted by the software robots and other information specific to the environment; Querying package versions that are to be started as a result of the 'Start' command from the Orchestrator; and Queues and queue items management such as addition of items to queues, getting transaction items from queues and setting transaction items' statuses (Bestea, 2017).

The persistence layer comprises of an SQL server which stores robot configurations, robot groups and related processes. The SQL server also performs the following: management of information that flows through the Web Application; queues and queue items management; and storage of messages logged by the software robots (as an alternative to ElasticSearch or in conjunction with ElasticSearch). The other component of the persistence layer is ElasticSearch, also known as an indexer server. ElasticSearch is used to index, and store information logged by the robots, however, its usage can be disabled through configuration. An executor, as illustrated in figure 2.5 represents a running process. UiPath permits concurrent execution of several projects given that each project has it corresponding Executor. UiPath Agent (a Windows service), is the only component through which all Executor messages can be logged to the server (Bestea, 2017).

2.8 Robotic Process Automation Case Studies

2.8.1 RPA at a World Leading Freight and Supply Chain Solutions Company

A market leader in the global supply chain and logistics industry wanted to automate document management which formed part of the back-office activities so as to focus on provision of better customer service and realise a reduction in shipment delays. The aim was to assimilate information in its entirety, for over 22,000 monthly shipments. For accurate information about each shipment to be kept, several documents each requiring unique information had to be maintained. The organisation thus needed a way of automating the collection, consolidation and distribution of shipment details to all relevant stakeholders to enable timely release of shipments and improve overall efficiency. Shipment information also needed to be distributed to all relevant stakeholders and archived to ensure compliance (Automation Anywhere, 2018).

The logistics provider, through RPA technology automated its document management systems and integrated all inbound documents with their Transport Management System (TMS). The organisation also automated the distribution of shipment information to all relevant stakeholders. Process automation allowed the organisation to improve its overall efficiency which resulted in rapid shipment release times as well as improved customer satisfaction (Automation Anywhere, 2018).

RPA aided the logistics provider in automating collection of all electronic documents, thereby allowing data to automatically be collated by shipment and entered into the Transport Management System. The robots were also configured to run checks on shipment documentation regularly to ensure each shipment had updated information (Automation Anywhere, 2018).

Before automation, missing documents were identified manually by the back-office staff then subsequently uploaded to the image archive. All relevant documents were accorded to the respective customer support representatives when merchandise arrived and any conflicts that arose due to missing documents were resolved so that packages were released and delivered timely (Automation Anywhere, 2018).

The logistics provider also integrated Automation Anywhere with its Project Management Software and automated reports retrieval and emailing of documents as PDF attachments. Process automation guaranteed that the right documents were being emailed to the right people based on the business logic used to create the robots. Some of the benefits that the organisation realised as a result of automation included: improved efficiency; faster processing of transactions pertaining to shipment delivery and release; full integration of all information and documentation pertaining to a specific shipment; and ensured that complete documentation was maintained for each shipment (Automation Anywhere, 2018).

2.8.2 Robotic Process Automation at A Global Multinational Corporation

Infosys BPM’s client is an international corporation that provides information technology, business consulting, and outsourcing services to over 1000 clients across 50 countries (Infosys BPM, 2017).

Owing to its large global footprint, the client has employees working in numerous offices across the world. Its human resource office function handles a variety of processes including talent acquisition, talent administration, talent development, employee life cycle, employee experience, compensation and benefits support, and human resource reporting. Each of these processes were composed of several activities that were not only effort-intensive but also crucial for employee satisfaction. Due to the size of the client which had grown rapidly, its human resource function was faced with the challenge of efficiently handling an enormous volume of transactions. It needed to meet the time-critical needs of the business while compromising neither on quality and compliance requirements nor employee satisfaction (Infosys BPM, 2017).

Infosys BPM studied the client's human resource processes and analysed each of their stages in detail to understand the suitability of introducing robotic process automation and reducing the effort involved in dealing with the quantum of data. Following the study, Infosys BPM created use cases for deployment of automation. The ideal process candidates for robotic process automation are deterministic or rule-based in nature. Robotic process automation lends itself particularly well to activities such as: reading/copying/synchronisation of data between web applications, enterprise resource planning (ERP), backend systems; validation/verification of extracted data; reading data/attachments from email; sending emails/mass mailers; scheduling of meetings; data standardisation; and data logging for audit purposes (Infosys BPM, 2017).

The study revealed several such processes that could be successfully automated based on their volumes, average handling time, and risk of error. Infosys BPM categorised the various stages of the processes into four buckets based on the scope for automation: Very High, High, Medium, and Low. The results of the study are presented in figure 2.6 below.

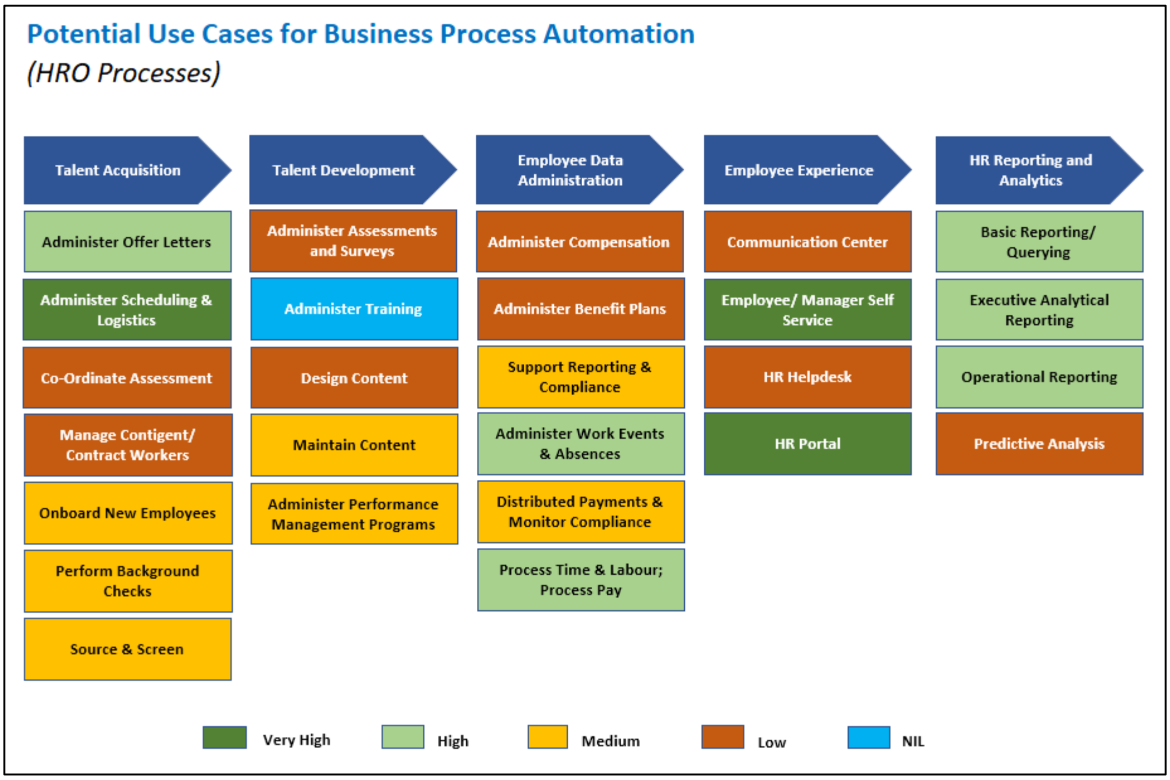

Figure 2.6 Human Resource Office RPA Applicability Use Cases (Infosys BPM, 2017)

Infosys BPM automated several of the processes identified during the scope study. The automation reduced the manual intensive aspects of the work, while speeding up the processes and reducing the possibilities of errors to almost nil. Below are selected examples of processes that benefitted from automation (Infosys BPM, 2017).

Shift allowance calculation: The client gave a shift allowance to its employees working in processes for international clients across different time zones. The allowance was calculated by taking the swipe-in/swipe-out timings from multiple backend systems. This process which was done manually, was time consuming and the scope of error was high owing to the large set of data. Infosys BPM designed the RPA bot to automatically read and validate the data from the multiple backend systems and calculate the allowance. The bot did this periodically leading to on-time clearance of the allowances. The shift allowance automation led to a 65% reduction of manual efforts and 83% reduction in average handling time (AHT) with zero errors (Infosys BPM, 2017).

Background verification for new employees: This process involved cross-verification of details such as name, and date of birth for each interviewed candidate against a set of multiple databases, each holding hundreds of thousands of records. The processing volume and time taken grew exponentially every year owing to the increase in the candidates interviewed and the level of accuracy expected for such a critical process. Infosys BPM designed the RPA bot to receive the required details from the input sources, automatically cross-check the details with the backend databases, and create the process reports at the end of operation without any manual intervention. All the interim reports are reconciled into a final master report which is then automatically uploaded into the backend system in a scheduled manner. The enormous processing load is split across multiple bots to deliver the results in a short timeframe. The background verification automation resulted in 85% reduction in total manual effort involved and 35% reduction in average processing time with zero errors ensuring no compliance faults (Infosys BPM, 2017).

Generation of offer letters for new employees: This process entailed a series of steps which needed to be adhered to perfectly for compliance to regulations without compromising on accuracy. The average handling time (AHT) was approximately 15 minutes per new employee owing to the manual steps involved. Infosys BPM automated the entire process and reduced the processing time by 90% without compromising on the procedural steps and regulations (Infosys BPM, 2017).

Scheduling of client training programs for new employees: Client scheduled training programs need to be blocked in the new employees' calendars along with their respective dates and location details. A huge amount of manual effort was involved, increasing the scope of errors and further compliance issues. Post automation, the process was error free and led to 95% savings on the manual effort (Infosys BPM, 2017).

Training calendar mailers for employees: The human resource team sends out regular emails to the newly on-boarded trainees as well as to existing employees as part of the client's training program. Infosys BPM completely automated this mass mailer system leading to 75% manual effort reduction (Infosys BPM, 2017).

Full and final settlement for retired employees: This payroll process activity required exhaustive and accurate verification of all the pending dues by the employees across the departments of the firm. Mistakes in this process could be detrimental resulting in financial losses and compliance issues. Infosys BPM designed the RPA solution by embedding the business rules in the bot which followed these rules when processing the employee records. The bot increased the processing speed by 95% and ensured all business rules were followed leading to complete compliance (Infosys BPM, 2017).

Infosys BPM's implementation of RPA delivered the following benefits which could not have been achieved through a simple automation program: RPA did not require invasive integration of existing legacy systems as it replicates agent interaction; Human agents no longer needed to perform mundane manual tasks, automation achieved an average manual effort reduction by 70% and a net savings of USD 0.68 Million; The average handling time during processing reduced by 55% resulting in quicker processing and better turn-around time; The zero rate of errors in automated processes improved accuracy of operations; The use of robots ensured ease of scalability for future increase in processing volumes, increase in volumes would simply require deployment of additional software robots; RPA has multiple user roles for increased security; User's activity trails are logged in the form of user logs which can be used for process audits and compliance purposes; Versioning capability is available for bot upgrades. This allows complete user control over any update applied to the bots and enables rollback to an earlier version of a bot, if required. Infosys BPM's expertise in Robotic Process Automation delivered significant gains in productivity and accuracy for the client, and a business case for increased use of automation across the client's business processes (Infosys BPM, 2017).

2.8.3 Robotic Process Automation at The Co-operative Bank

The Co-operative Bank has a procedure known as excess queue which is used daily to accept, reject and return direct debits, cheques and standing orders due to insufficient funds in customer accounts. Daily overnight Bank Account Clearing System (BACS) processing results in queues of customer accounts with pending transactions due to insufficient funds to process these payments. Manual review of approximately 2500 higher risk accounts was performed daily by nine staff at the bank who then decided whether to process or reject payments based on customer account profiles (Blue Prism, 2007).

Process automation using Blue Prism was implemented at the bank which resulted in a virtual taskforce of 20 robots being developed following specific business logic and deployed into the production environment. The robots were integrated with the bank's core banking system and resulted in significant reduction in the time required to complete those tasks – the bots completed the tasks by 11 am compared to the human taskforce that used to complete them at 3pm (Blue Prism, 2007).

Automation of the excess queue procedure resulted in several benefits to the bank including: Automatic customer account management – personnel that were previously involved in manually managing customer accounts were reassigned more cognitive based tasks; Automated outward customer calls resulted in daily call-backs to customers whereas previously these were limited to Saturdays only; Fairness and consistency in customer treatment which is very crucial to the bank; Consistency in following the excess queue procedure ensuring that the bank meets its customary requirements; and improvements in customer service provision which resulted in increased customer retention and satisfaction (Blue Prism, 2007).

2.8.4 Robotic Process Automation at Standard Bank

Standard Bank wanted an efficient way of understanding the profitability of a specified customer, identifying the various personal and business account portfolios for every customer and viewing the total account relationships. However, with planning, time, testing, programming, cost and resources as considerations, Standard Bank wanted a better alternative, other than manually, to associate the accounts with one another and perform the thousands of necessary changes (Foxtrot, 2017).

Not all of Standard Bank's challenges were large in scale. When customers open a new account with a Standard Bank employee, that employee's responsibility code is assigned to the new account. The bank relies on the number to track customer follow-up and numerous other activities. In the event of a job change, each of those accounts would need to be reassigned to a different employee to ensure continuity of service. At up to 5,000 accounts per incident, the manual data maintenance work could take hours (Foxtrot, 2017).

A separate annual dormant debit card purge process required the bank to search manually for cards that had been unused for nine months or more and change their status to "closed". At up to 10,000 cards per year and roughly one minute to perform the process for each card, the project could take over 150 employee-hours to complete (Foxtrot, 2017).

With the goals of improving productivity, efficiency, service, and even profitability, Standard Bank and Trust Company selected Foxtrot software, to help automate these and other processes. Like an "Automated Employee," Foxtrot is an extra pair of hands that accomplishes virtually any manual business and frees traditional employees to serve customers (Foxtrot, 2017).

Foxtrot added flex fields and household numbers common to each account within and between customer portfolios. This figure helps Standard Bank associate the multiple accounts and portfolios that belong to individual customers ("households") and understand their true profitability. In a process considered impossible to complete by hand before Foxtrot, the software performed the requisite 118,000 changes in just a few weeks giving bank employees the freedom to handle their regular duties. Foxtrot still performs monthly maintenance work on new accounts at a rate of about eight records per minute automatically (Foxtrot, 2017).

Foxtrot handles the bank's responsibility code maintenance automatically and with ease. The software now updates the codes at a rate of about 8 per minute, a drastic improvement from the hours of manual effort required before, without error (Foxtrot, 2017).

Standard Bank's annual debit card maintenance reduced from an over 150 hour long manual process to an approximately 5 hour automatic one. Foxtrot could identify a card from among other dormant ones, locate it in Standard Bank's system, and change that card's status to closed in about two seconds without any human intervention. For example, if a customer loses their card and requests a new one, or if they request a PIN mailer, the representative adds a flex field to indicate the request. At the end of the month, a report is run to see the customers that have the flex field. Foxtrot also assesses fees for lost cards or PIN requests (Foxtrot, 2017).

With all the automated processes in place, Standard Bank has more time to serve customers and realise greater efficiency in much of their operations. They have seen a rapid expansion in their use of Foxtrot since it was first acquired in 2002 (Foxtrot, 2017).

2.9 Summary

In this chapter, we have seen how quickly technology is advancing; software robots can now handle mundane, repetitive and time-consuming tasks that are currently performed by humans. To remain competitive, organisations have to respond to the increased challenges of satisfying customers' needs whilst reducing costs of products and/or services offered. Robotic process automation has enabled organisations to automate repetitive and tedious tasks thereby providing a way of reducing operational costs.

From the various case studies that have been reviewed in this chapter, we have observed that organisations that have already deployed robotic process automation technology have not only noticed massive savings on full-time equivalent (FTE), but have also experienced other benefits including improved service, quality and speed, lower error rate and staff satisfaction.

The solution automated the manual business processes undertaken during inventory control and management at Freight Forwarders Solutions that are based on well-defined business rules with clear instructions for processing outputs. This aided the business in achieving efficiency and productivity in operations; minimising inventory costs; maximising sales and profits; integration of the entire business; automation of manual tasks and maintaining customer happiness. The next chapter, explores the methodology that was used throughout the development process of the solution.

Chapter 3 Research Methodology

3.1 Introduction

This chapter covers the methodologies that were used to complete the research objectives that were stated in chapter 1. The first and second research objectives have however, already been answered by the literature review, therefore, in this chapter, the researcher discusses the third and fourth objectives and how they were achieved during the study.

Research methodology is a strategy of enquiry, which moves from the underlying assumptions to research design, and data collection (Myers, 2009). This research employed a mixed research design that combines both the collection and analysis of quantitative and qualitative data. It presents the research design, data collection, and data analysis procedures that were deemed most suitable for addressing the formulated research questions in Chapter 1. The practical procedures are presented, and their theoretical fundamentals discussed.

3.2 Software Development Methodology

The Waterfall method, as illustrated in figure 3.1 was selected for this study. This software development methodology was selected because in RPA, the processes are predetermined and therefore the automation can be divided into well planned phases as shown.

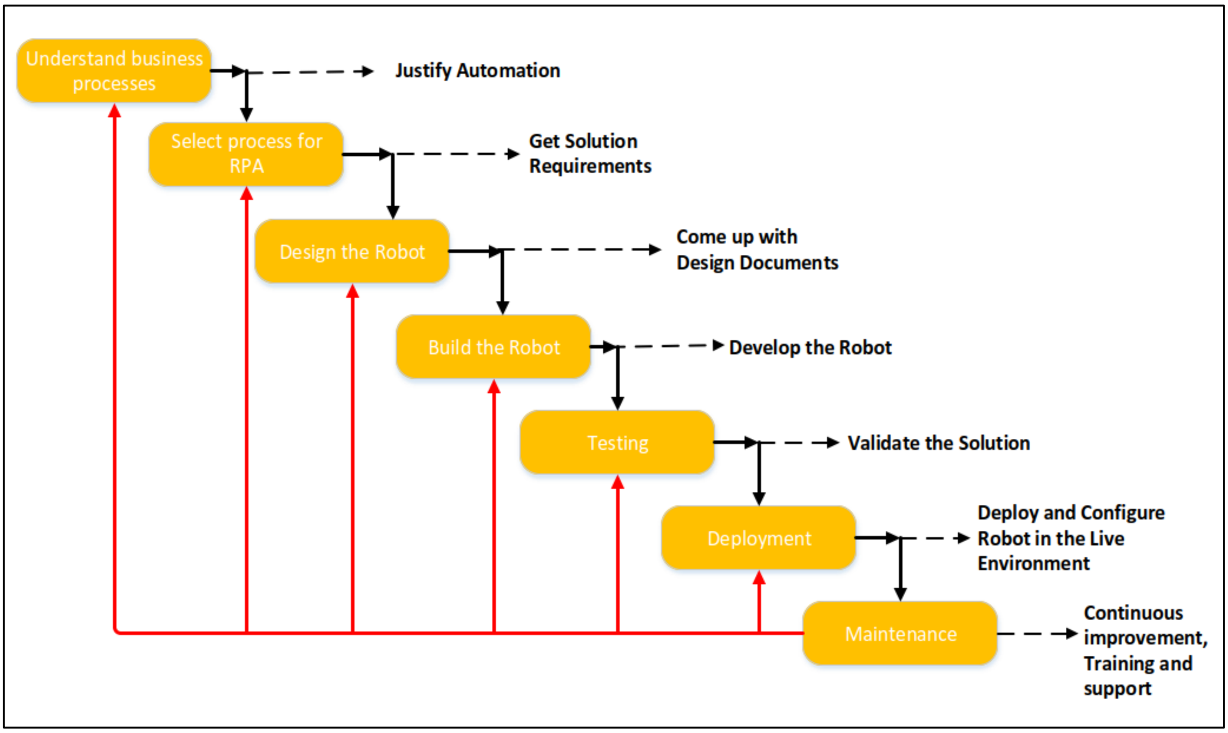

Figure 3.1 RPA Software Development Life Cycle

Each phase ends with deliverable documentation and it allows new players to learn from their more experienced counterparts. It also adds to project and governance security and accountability, which many companies rely on for quality assurance. The delivery of the software robot was broken down into three main phases. The initial phase was the assessment phase, where the business case for the automation was justified. The delivery phase took the automation from design all the way to deployment in the production environment. The last phase was to fully productionise the solution with maintenance and support structures in place.

i. Understand the Business Processes

This phase involved understanding the business processes involved in the inventory control and management module so as to evaluate the organisation's appetite for RPA. Meetings were held with key business stakeholders to gain an in-depth understanding of the business processes and the value addition that automation would bring to the organisation. During the meetings, the researcher documented the process flows in the inventory control and management module of the warehouse management system to gain a clear understanding of how the business users interact with the system. Structured interview questions as illustrated in Appendix A were administered to the business users and the responses collated and analysed using Microsoft Excel. Semi structured interviews were also used because they allowed the researcher to probe the interviewees for additional information thereby offering flexibility.

Business cases justifying the benefits that automation would realise for the organisation were documented for all the processes as part of the feasibility analysis. The Full-Time Equivalent (FTE) and Process Complexity Calculator was used to determine the potential benefits that would be realised as a result of RPA. After the process complexities were calculated, the processes were placed into quadrants that determined which processes were most suitable for automation. The deliverable from this phase was an understanding of the business processes, the systems in place and how the users interact with the systems to accomplish various tasks.

ii. Process Selection for RPA

At this stage, the business processes were prioritised based on their characteristics, that is, whether they are repetitive, rule-based, complex, electronically triggered, number and frequency of exceptions and the possibility of changing them in the near future. The researcher then chose the most repetitive, rule-based, simple (few user interfaces to interact with), electronically triggered processes with standard input formats and minimal or no exceptions and changes and gave them top priority for RPA.

iii. Design, Build and Test

During the design phase, a process design document was created as illustrated in Appendix C and used to design the solution. A detailed process design document was critical to the design of the solution as it described the manual processes to be automated. The researcher used this document to define the 'as-is' (before robotic process automation) and the 'to-be' (after robotic process automation) processes, including their diagrammatic flow charts. The process design document aided the researcher in specifying how the chosen business processes would be automated. It allowed the researcher to specify the scope of the automation, including what would and would not be performed by the robot. Exceptions and how they would be handled by the software robots was also stated in the document.

It was also during this phase that the researcher selected the tool that would be most suitable for building the software robots. The Blue Prism RPA platform was chosen to build the robots during this study because it is user friendly, easy to setup, has high level security features and is very scalable. Blue Prism is also suitable for creating robots that are flexible, adaptable, trainable, dependable and work consistently on their assigned tasks.

During the build and test phase, software robots for the selected business processes were developed in the test environment as per the 'to-be' processes. The robots were tested by the business users to ensure they met the automation requirements. RPA test case templates as illustrated in Appendix D were administered to the business users to guide in testing. A solution design document as illustrated in Appendix F was developed to indicate how the robot would be setup and how it operates. A requirements traceability matrix as illustrated in Appendix E was used throughout the automation process to provide visibility over how automation requirements have been met.

iv. Deployment

During this phase, the software robot was deployed and configured in the live environment. The deliverable was a robot working effectively in the live environment.

v. Maintenance

In this final phase, the robot will be supported for a brief warranty period. Internal support capabilities will be developed through support training to avoid over-reliance on the developer. The deliverable will be a self-sufficient internal support team in the organisation.

3.3 Process Analysis

In the system analysis phase of the research, process assessment was carried out through consultation with the logistics company. Process assessment was carried out to understand the business processes involved in the inventory control and management module and the automation potential that the processes had. The processes were then prioritised based on benefits, cost and complexity.

3.4 Research Design

The function of a research design is to ensure that the evidence obtained enables you to effectively address the research problem logically and as unambiguously as possible (Vaus, 2001). This section includes how data collection was done, the modes of data collection that were used and how the data collected was analysed.

This study employed a mixed research design approach. According to Creswell (2002), a mixed method design is a procedure for collecting, analysing and "mixing" both quantitative and qualitative data at some stage of the research process within a single study, to understand a research problem more completely. This research design approach was chosen by the researcher because when used in combination, quantitative and qualitative methods complement each other and allow for more complete analysis to be carried out.

Semi structured interviews were used during the study to assess the organisation's readiness to adopt RPA and whether the business processes were suitable for automation. The semi structured interviews were used during the feasibility study, requirements analysis, system analysis and design phases of the study. A Full-Time Equivalent (FTE) and Process Complexity Calculator was used in calculating the potential full-time equivalent benefits that would be derived from each process. A Process Design Document (PDD) was used to aid in designing the solution. High-level flowcharts were used during the system design phase of the study to show the major blocks of activity involved in the inventory control and management process and detailed flowcharts were used during system implementation using the Blue Prism RPA software. A solution design template was used to define the "As-Is" processes, the "To-Be" processes and how exceptions will be handled by the software robots. A requirements traceability matrix was used throughout the study to track the delivery of the solution and to ensure that the delivery dates were adhered to. An RPA test case template was used during the testing phase and a post implementation survey during the validation phase. The data collected through the interviews and surveys was collated, analysed and graphically represented using Microsoft Excel.

3.5 Location of Study

The study was carried out in Tatu City, Kiambu County, where the logistics and warehousing company is located. The location was chosen due to the proximity to respondents.

3.6 Target Population

Selection of a study population is important as their characteristics and interests play a role in obtaining accurate results from the study (Kumar, 2011). The target population for the study was Freight Forwarders Solutions' employees based at the Tatu City facility.

3.7 Sampling

Sampling is referred to as the selection of some part of a population based on some predefined rules, in order to obtain information on the total population size (Kothari, 2004). Sampling allows a researcher to draw inferences on a population by examining a fraction of the population. This is done under the assumption that the sample should provide a representation of the entire population under study.

This study has taken the purposive sampling technique. The purposive sampling technique, also known as judgement sampling, is the deliberate choice of a participant due to the qualities the participant possesses (Etikan, Musa, & Alkassim, 2016). This approach was chosen because it involves identifying and selecting individuals that are proficient and well-informed with a phenomenon of interest, in this case, the researcher required participants with adequate knowledge on supply chain, logistics and warehouse management systems. The total population of employees at Freight Forwarders Solutions is 26 and a sample size of 11 was selected as these are the employees who interact with the warehouse management system to perform their daily activities.

3.8 Requirements Gathering

During this phase, the researcher engaged the business users in order to identify the challenges faced with manual data entry into the system as well as their expectations from the business processes to be automated. Different tools have been employed in the requirements gathering process as discussed in the following sub-sections.

3.8.1 Interviews

Structured and semi-structured interviews were used during the collection of primary data. Structured interviews consist of a series of pre-determined questions that all interviewees answer in the same order. In semi-structured interviews, the interviewer prepares a set of identical questions to be answered by all interviewees. At the same time, additional questions might be asked during interviews to clarify and/or further expand certain issues (Dudovskiy, 2011).

Structured and semi-structured interviews were administered to the business users in an effort to increase the understanding of the business as well as the type of business processes performed in the warehouse management system. The characteristics of the business processes performed in the inventory control and management module were assessed based on specific criteria which allowed for the most suitable processes to be selected for automation. The interview questions had predefined responses which allowed for clear and concise feedback to be received, collated and analysed. For this study, the interview questions were printed and handed out to the respondents in person and the feedback received immediately. This increased the timeliness of receipt of the feedback.

3.8.2 Surveys

Surveys are appropriate when a researcher seeks to collect information which can be coded when evaluating a research phenomenon (National Science Foundation, 2002). In this case, surveys were used to gauge the impact derived from the solution to the manual data entry problem. As such, surveys were sent out after the business users had had adequate time to interact with the software robots. The survey was structured as questions with closed ended responses. They were disseminated through Google Forms, and respondents received a link in their email inboxes prompting them to complete the survey.

3.9 System Design

UML is a standard language which is used for object development within the system analysis and design process (Dennis, Wixom, & Roth, 2012). A detailed analysis of the system architecture for the proposed solution was done by making use of UML diagrams. These are discussed in the following subsections.

3.9.1 Flow Chart Diagrams

A Flow Chart, also known as a Process Flow Diagram or Process Map, is a diagram of the steps in a process and their sequence (Walsh-Kelly, 2015). Flow charts were selected for use in this study because they are a good way of communicating the logic of a system to all stakeholders.

Flowcharts are also advantageous in the following ways: They aid in effective analysis of process flows, making it easier to identify and resolve associated problems. This results in significant reductions in the time and costs that would have otherwise been spent in attaining similar results; Program flowcharts serve as good program documentation which increases ease of maintaining the operating programs as the developers know where the issues lie; Flowcharts act as blueprints during systems analysis and program development phases resulting in efficient coding; and Finally, flowcharts increase the efficiency of the debugging process as problem identification is made easier (Walsh-Kelly, 2015).

3.9.2 System Architecture

This is a conceptual model which represents the different components of the system including physical processing components, hardware, software, people and communication among them (Dennis, Wixom, & Roth, 2012). It defined the structure of those components as well as their behaviour and interaction with one another.

3.10 Validation

Validation is the process through which a solution is evaluated to ensure that its features have been built to meet the requirements which were set at the beginning of the implementation (Williams, 2006). Validation of the solution was done using functional testing procedures to ensure that the software robots performed based on the requirements that had been set. These procedures were unit testing to test each individual component, integration testing to test different linked components and system testing to test the overall solution with all interlinked components working together. During the testing phase of the solution, the researcher was keen to obtain feedback on how the automated processes solved the manual data entry problem.

3.11 Summary

In this chapter, the researcher has explained in detail the methods which were applied in the development of the solution right from gathering requirements to testing and validation of the solution.

Chapter 4 System Analysis and Design

4.1 Introduction

This chapter presents the overall design structure of the developed solution. First, analysis was performed on the data collected from the population in relation to the problem this study sought to solve. The product of the analysis was the identification of the business processes that were suitable for robotic process automation. Thereafter, design diagrams are presented to illustrate the interaction relationship between the software robots and the warehouse management system.

4.2 System Analysis

4.2.1 Robotic Process Automation Readiness

Leadership's Understanding of the Strategic Need for Robotic Process Automation

The data collected, as shown in Figure 4.1 revealed that majority of the organisation's leadership wanted to understand more about RPA. This can be attributed to the fact that RPA is an emerging new technology that has been making headlines in the disruptive technology wave space and therefore it follows that the logistics company's leadership would be interested in learning more about it.

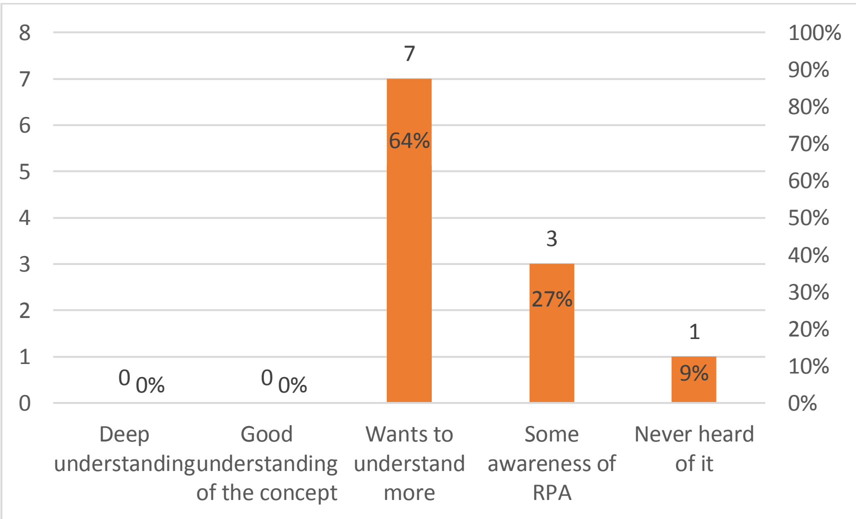

Figure 4.1 How well the organisation's leadership understands the strategic need for RPA

Possibility of Process Improvements Being Made to the Processes Selected for Automation

Most of the processes selected for automation were not likely to change in the next few years as shown in Figure 4.2. The smaller the expected changes, the greater the opportunity to deliver value from RPA, therefore the logistics company is well placed to realise short to long term benefits from process automation.

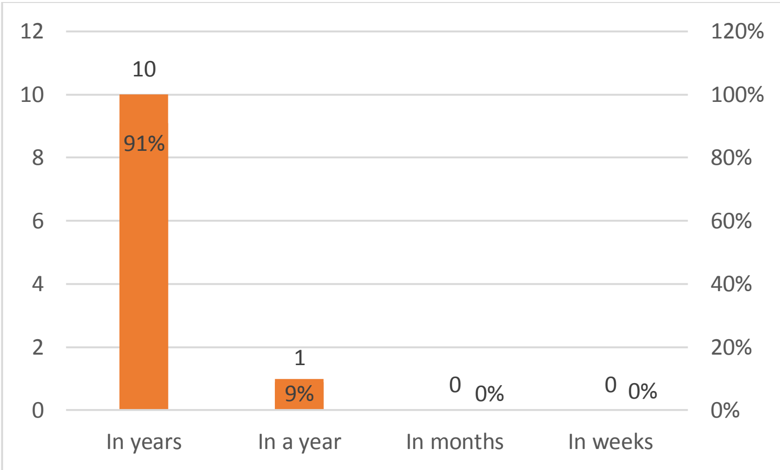

Figure 4.2 Possibility of Process Improvements Being Made to the Processes Selected for Automation

Definition of the Activities within Scope

Majority of the processes in scope had well defined activities which were always followed during process execution as illustrated in Figure 4.3. This implied that those processes were suitable candidates for automation.

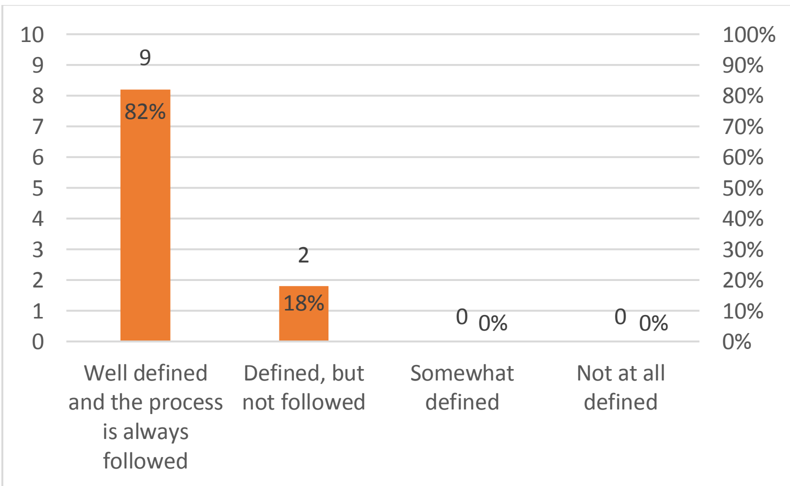

Figure 4.3 Definition of the Activities within Scope

Type of Process Inputs and Outputs (Digital vs. Non-Digital)

From the responses gathered, all the process inputs and outputs are digital as shown in Figure 4.4. The inputs are in the form of standard templates that can be uploaded into the system. The outputs are also digital.

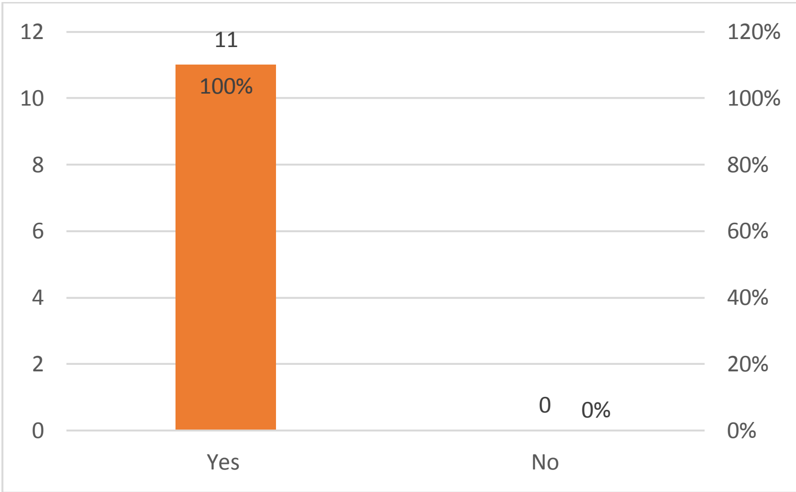

Figure 4.4 Type of Process Inputs and Outputs (Digital vs. Non-Digital)

Frequency with which the Processes are Performed

The question on frequency with which the processes are performed resulted in the responses as illustrated in Figure 4.5. Processes that are performed more frequently are better candidates for automation however even those performed annually can also be automated.

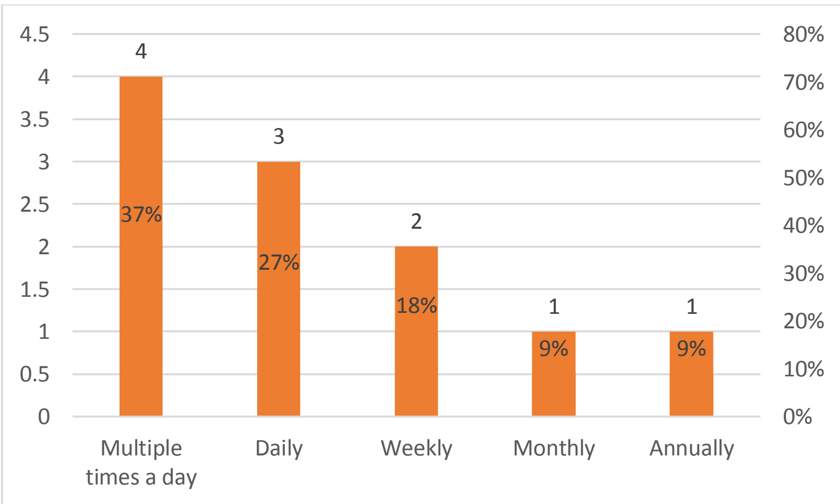

Figure 4.5 Frequency with which Processes are Performed

Types of Process Inputs (Structured vs. Unstructured)

Figure 4.6 shows that majority of the process inputs are well structured and documented with a relatively small percentage being structured but not documented.

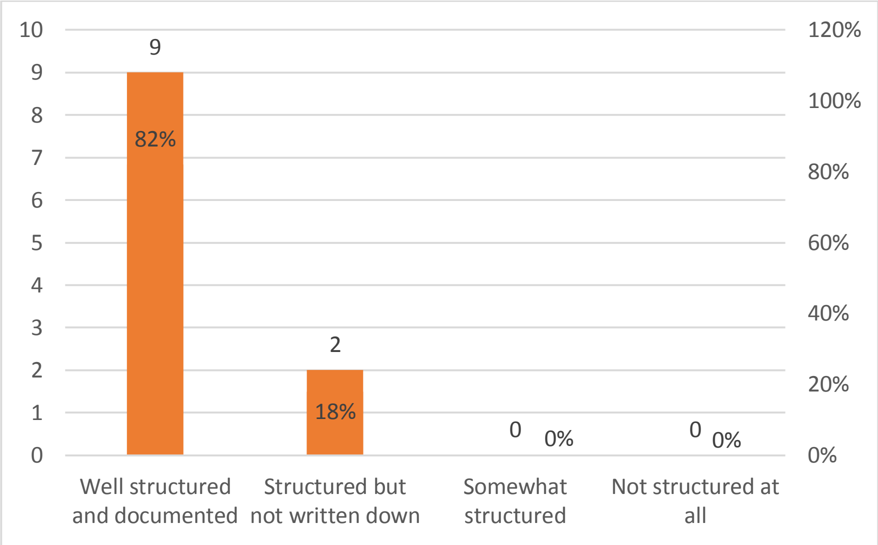

Figure 4.6 Types of Process Inputs (Structured vs. Unstructured)

Human Judgement Required to Execute the Business Processes

Figure 4.7 shows that majority of the business processes do not require human judgment to execute therefore are rule based which makes them prime candidates for automation.

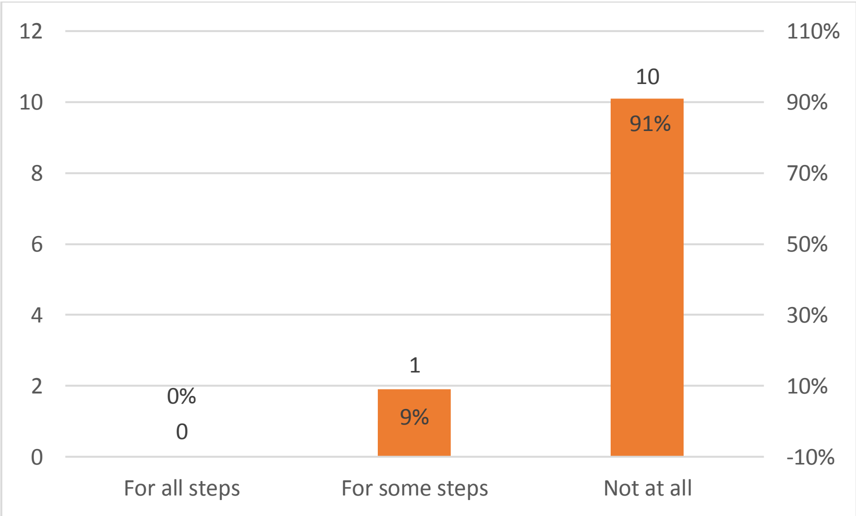

Figure 4.7 Human Judgement Required to Executed the Business Processes

KPIs and Analytical Insights

Figure 4.8 shows that majority of the business processes involve deep analytical insight while the others have some KPIs and insight. These processes are ideal because the KPIs can be measured after automation to gauge whether the software robots significantly surpassed the defined KPIs.

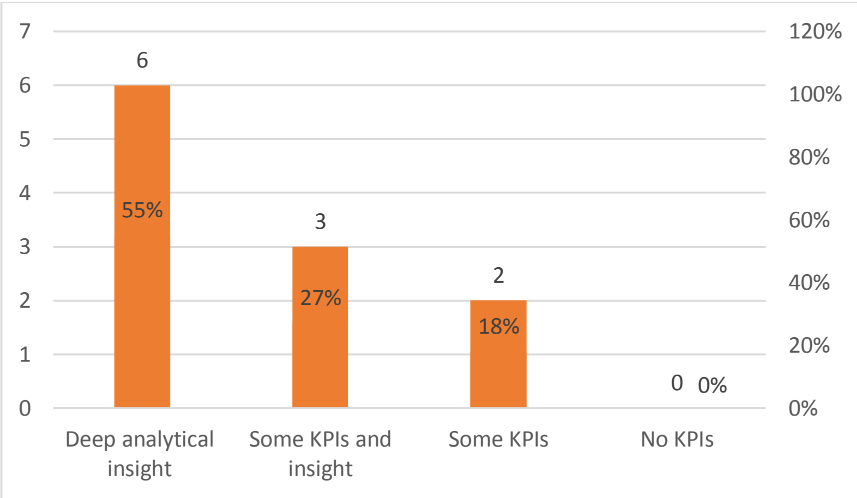

Figure 4.8 KPIs and Analytical Insights

Annual Rate of Turnover of Staff Performing These Processes

Figure 4.9 shows that there is a relatively low annual turnover rate of the staff who perform these processes. This is ideal because these staff can train newer staff on how to execute the software robots after deployment to the live environment and the handover is complete.

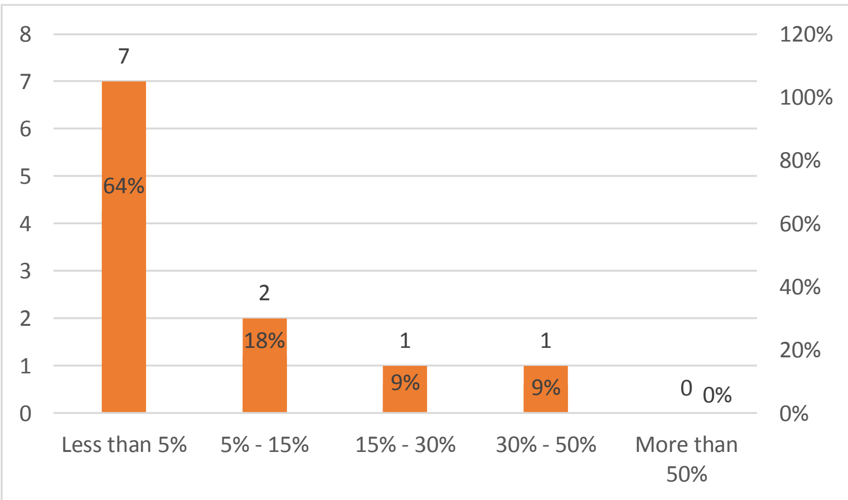

Figure 4.9 Annual Turnover Rate of Staff Performing These Processes

Expenses (per head) of Staff Who Perform These Processes

Figure 4.10 shows the expenses per head of the staff who perform the manual processes at the warehouse. These costs can be reduced once the software robots have been deployed.

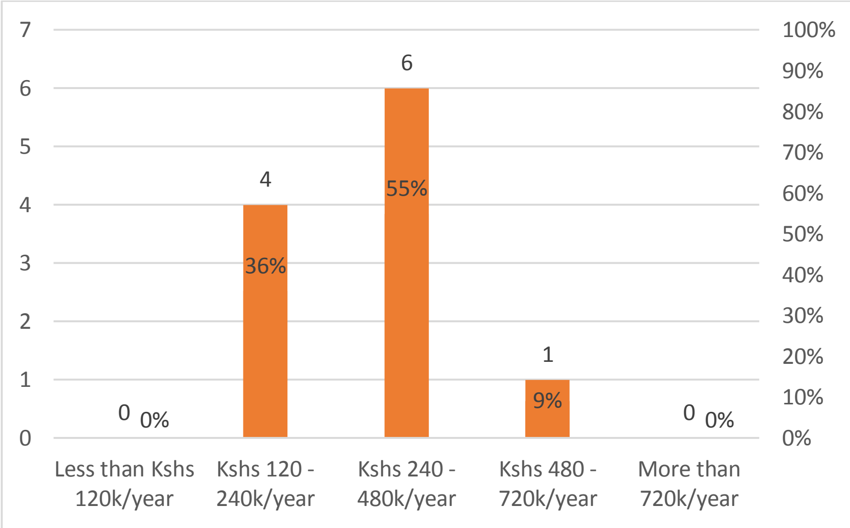

Figure 4.10 Expenses (Per Head) of Staff Who Perform These Processes

Frequency of Screen Estate Changes

Figure 4.11 shows that the system screens for the in-scope processes are likely to change yearly. This is ideal because frequent changes would have increased the rate at which robots must be reconfigured, adding time and cost and thereby reducing potential return on investment.

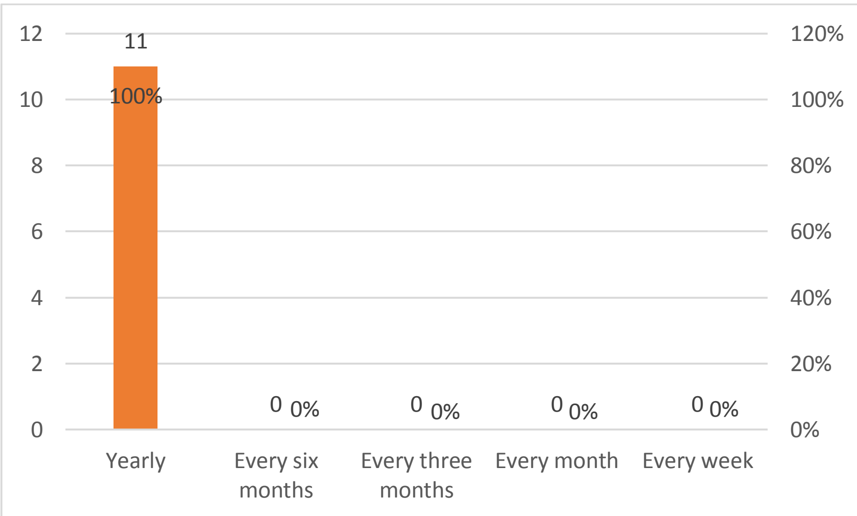

Figure 4.11 Frequency of Screen Estate Changes

4.2.2 RPA Process Selection

Process Uses Standard Data Input

The data used in the execution of the processes in scope requires standard data input as illustrated in figure 4.12. These inputs are in the form of standard templates that are then imported into the system.

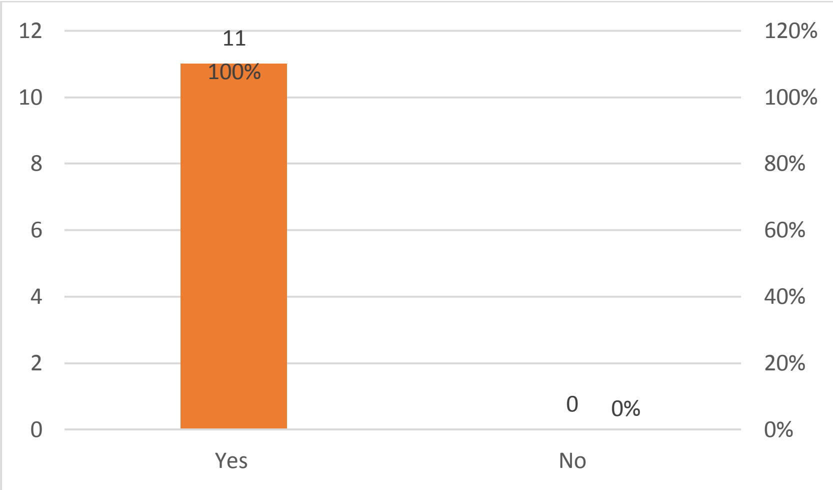

Figure 4.12 Process Uses Standard Data Input

Process Data Origin

Majority of the processes in scope receive data from standard templates and a smaller percentage receives data from emails as illustrated in Figure 4.13. These processes can all be selected for automation.

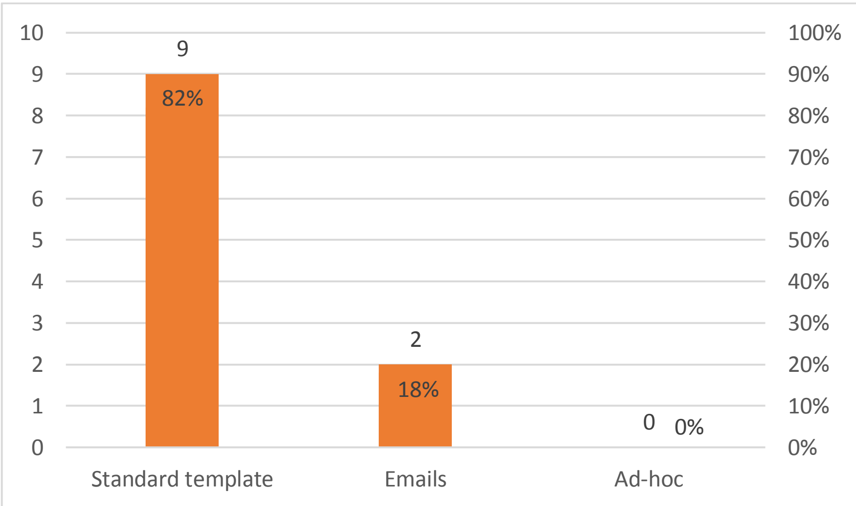

Figure 4.13 Process Data Origin

Type of Processes Involved

All the processes in scope were manual and repetitive as illustrated in Figure 4.14. These types of processes are best suited for process automation.

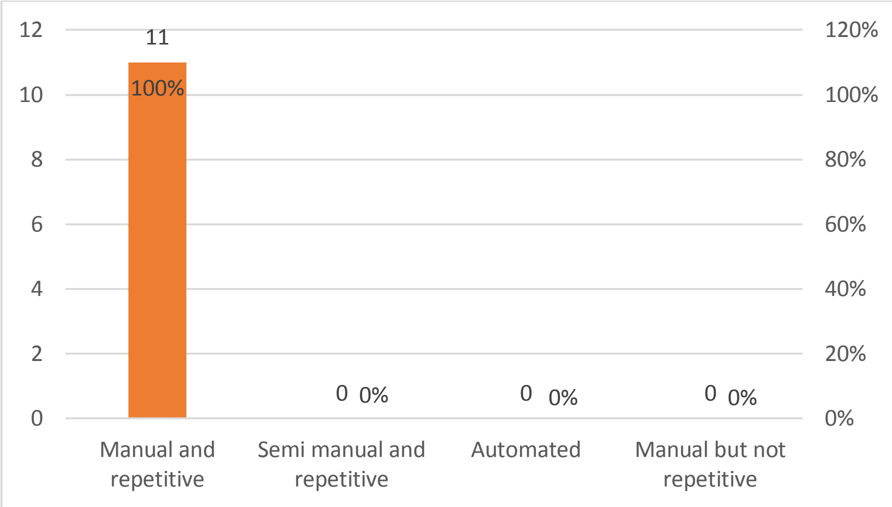

Figure 4.14 Type of Processes Involved

Volume of Processed Data

Figure 4.15 shows that the volume of data processed majorly ranges from medium to high. This can be attributed to different clients having different high seasons and the low volumes of data can be attributed to client low seasons.

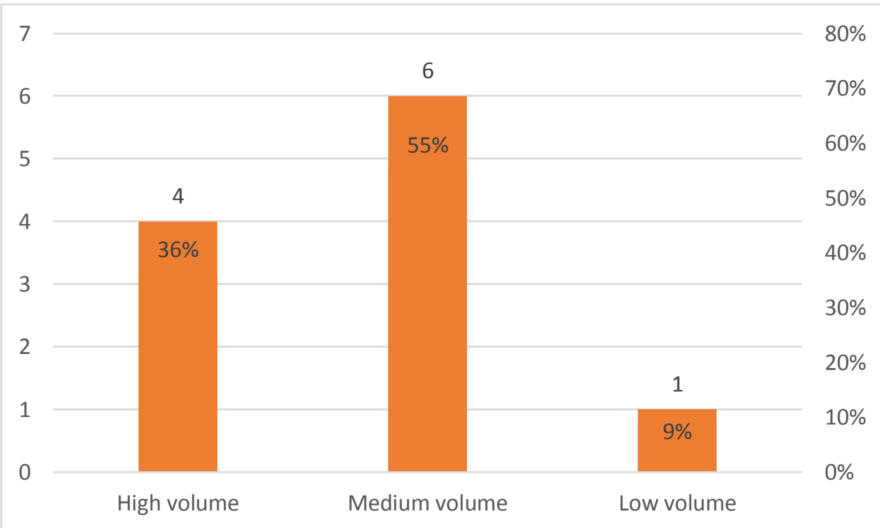

Figure 4.15 Volume of Processed Data

Number of Distinct Screens Involved in Process Execution

Figure 4.16 shows that the number of screens involved in process execution for the processes in scope majorly ranges between 1 to 5 with a few processes ranging between 6 to 10. Fewer number of screens involved reduces the complexity of the software robot.

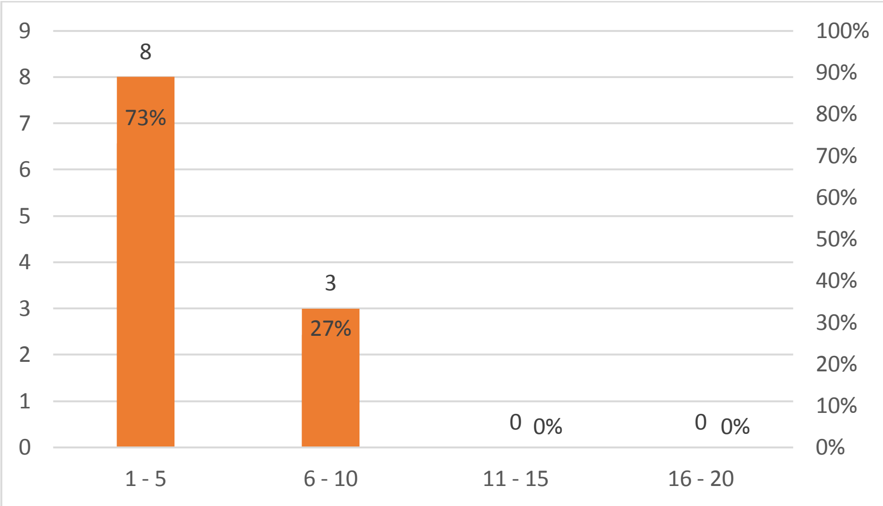

Figure 4.16 Number of Distinct Screens Involved in Process Execution

Error Rate Experienced During Process Execution

Figure 4.17 shows that most of the processes experience an average human error rate during execution with a few processes experiencing low error rates. Error rates can be significantly reduced through process automation thereby reducing the time required for input validation.

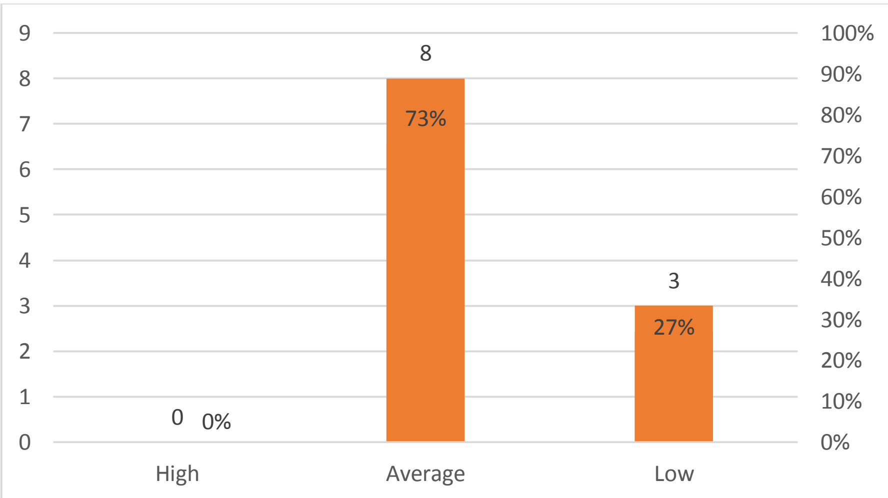

Figure 4.17 Error Rate Experienced during Process Execution

Average Process Handling Time

Figure 4.18 shows that the average process handling time (end-to-end) was approximately 11 to 15 minutes with a few processes taking 16 to 20 and 21 to 25 minutes respectively. These processes' handling times can be significantly reduced through process automation thereby freeing up the employees to perform more judgement-based processes.

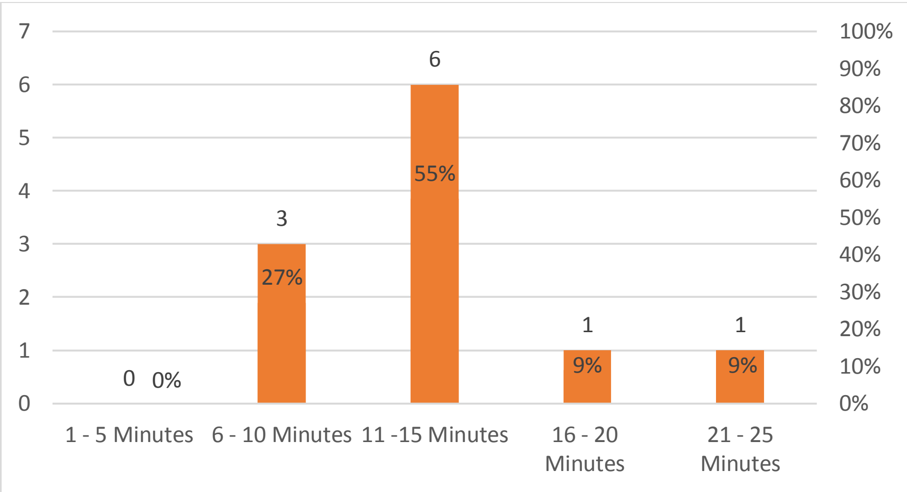

Figure 4.18 Average Process Handling Time

4.2.3 Requirements Determination

i. *Functional Requirements*

A functional requirement is a specification of a function or capability that a system should perform for its users (Dennis, Wixom, & Roth, 2012). The functional requirements which were identified by the respondents of the study indicated the following:

a) The robot should be able to launch the warehouse management system.
b) Login/logout – the robot should be able to access the warehouse management system using the provided login credentials.
c) Warehouse facility selection – the robot should be able to select the correct warehouse facility from a drop-down list.
d) Appointment creation – the robot should be able to create a new shipment appointment.
e) Order creation – the robot should be able to create a new shipment order.
f) Daily inventory reports – the robot should be able to send daily inventory reports to specified email addresses showing client inventory balances.

ii) Non-Functional Requirements

Non-functional requirements are those which relate to the operation and performance of a system (Glinz, 2012). The non-functional requirements identified for this system are:

a) The robots should significantly reduce the average process handling time (end-to-end).
b) The robots should be able to navigate easily through the system.
c) The robots should be able to handle exceptions appropriately.
d) The robots should enable the company realise a reduction in operational costs and increased throughput.
e) The robots should result in significant process improvements by streamlining thereby getting more done in less time.
f) The robots should result in redeployment of employees to higher value functions by taking over the manual and repetitive tasks.
g) The robots should result in increased productivity by minimising manual, error-prone processes and through the ease of expansion of the virtual workforce.
h) The robots should result in improved quality of processes performed by increasing compliance, auditability and consistency with standardised processes.
i) The robots should result in improved customer service due to the elimination of human prone errors.
j) The robots should result in improved compliance since all RPA steps are recorded for historical auditability.

4.2.4 System Implementation

The solution comprised of software robots which automated the selected business processes performed within the inventory control and management module of the warehouse management system. The solution was developed using the Blue Prism RPA platform. For successful implementation, the minimum requirements of the computing device on which the software robots would be developed are as shown in Table 4.1.

Table 4.1 Minimum and Recommended Hardware Requirements

	Minimum	Recommended
CPU	1.4GHz 32-bit (x86)	Dual Core 1.8GHz 64-bit
RAM	4 GB	8GB
Disk Space	200 GB	200 GB

The software tools required for the development, testing and analysis of the solution are as shown in Table 4.2.

Table 4.2 Software Tools Required for the Development of the Solution

Purpose	Software
Designing of UML Diagrams	MS Visio 2007
Designing of System Architecture	MS Visio 2007
Operating System	Windows
RPA Technology Platform	.NET framework 4.7
Application Server	Microsoft SQL Server
Robotic Process Automation	Blue Prism 6.2
Data Analysis	Microsoft Excel
Forecasting	Demand Works

4.3 System Design

4.3.1 Shipment Appointments 'As-Is' Process Flowchart

Figure 4.19 shows the appointments 'as-is' process flow chart, that is, the process flow before robotic process automation.

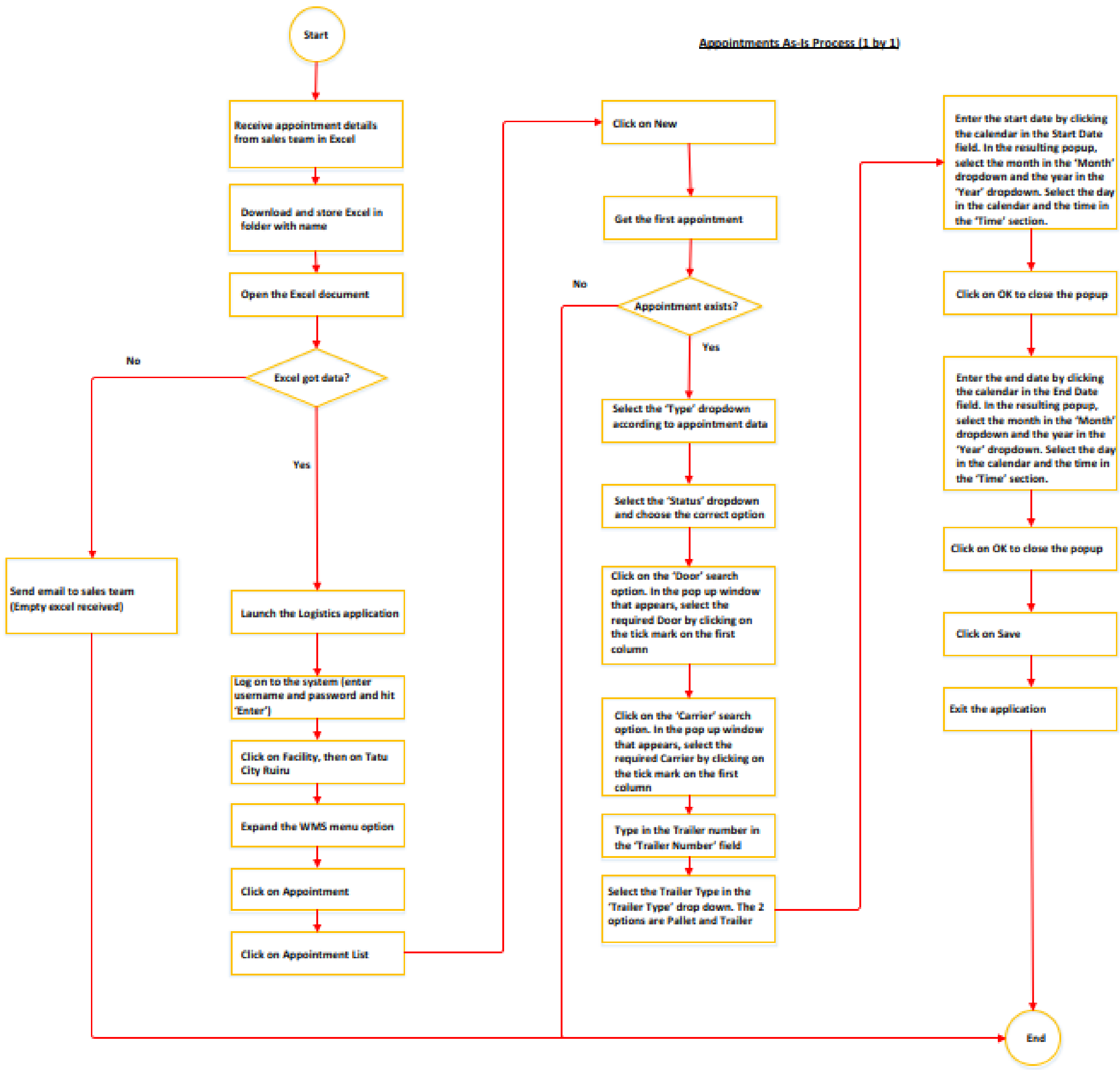

Figure 4.19 Appointments 'As-Is' Process Flowchart

4.3.2 Shipment Appointments 'To-Be' Process Flowchart

Figure 4.20 shows the appointments 'to-be' process flow chart, that is, the process flow after robotic process automation.

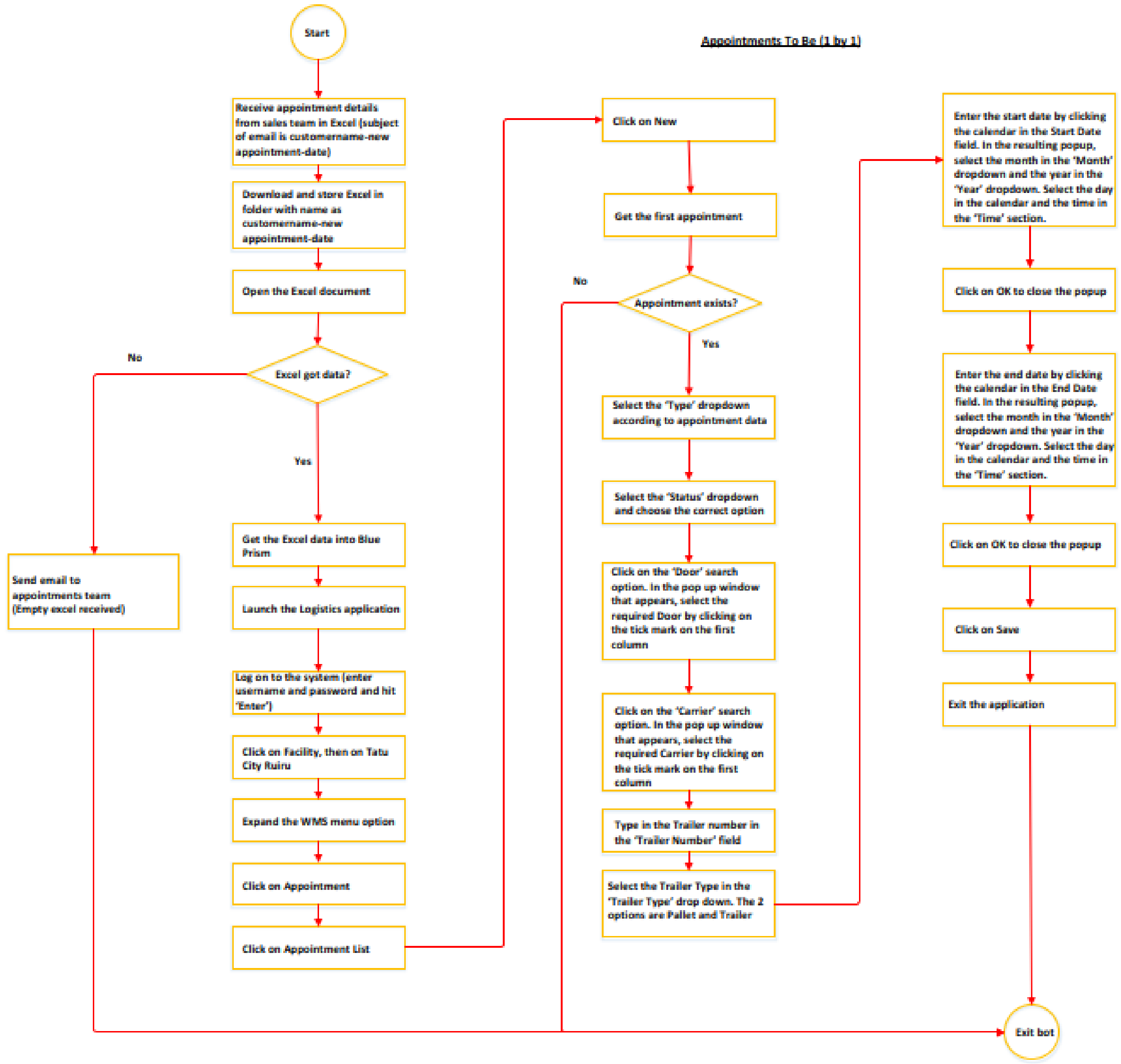

Figure 4.20 Appointments 'To-Be' Process Flowchart

4.3.3 Shipment Orders 'As-Is' Process Flowchart

Figure 4.21 shows the shipment orders 'as-is' process flow chart, that is, the process flow before robotic process automation.

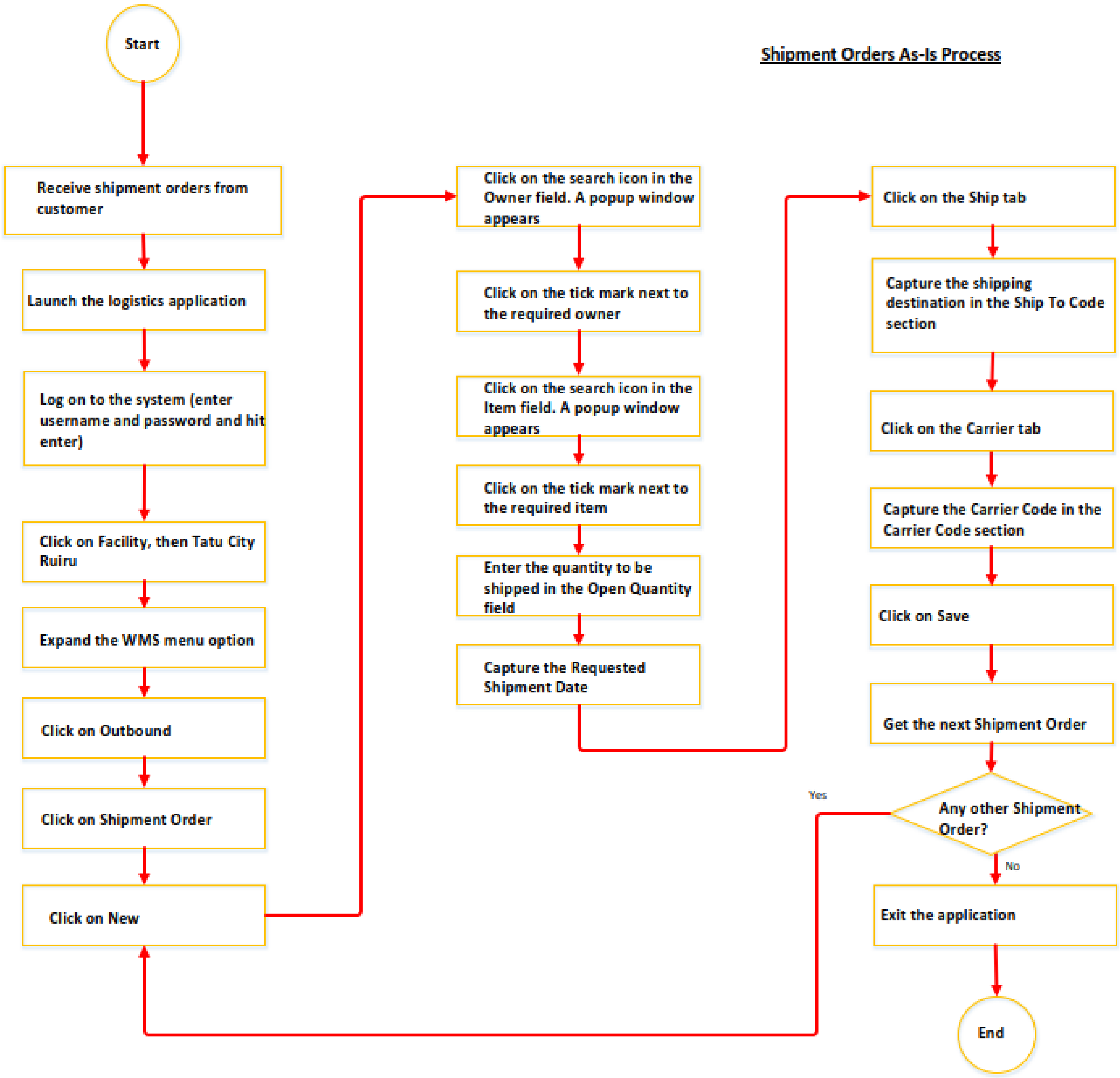

Figure 4.21 Shipment Orders 'As-Is' Process Flowchart

4.3.4 Shipment Orders 'To-Be' Process Flowchart

Figure 4.22 shows the shipment orders 'to-be' process flow chart, that is, the process flow after robotic process automation.

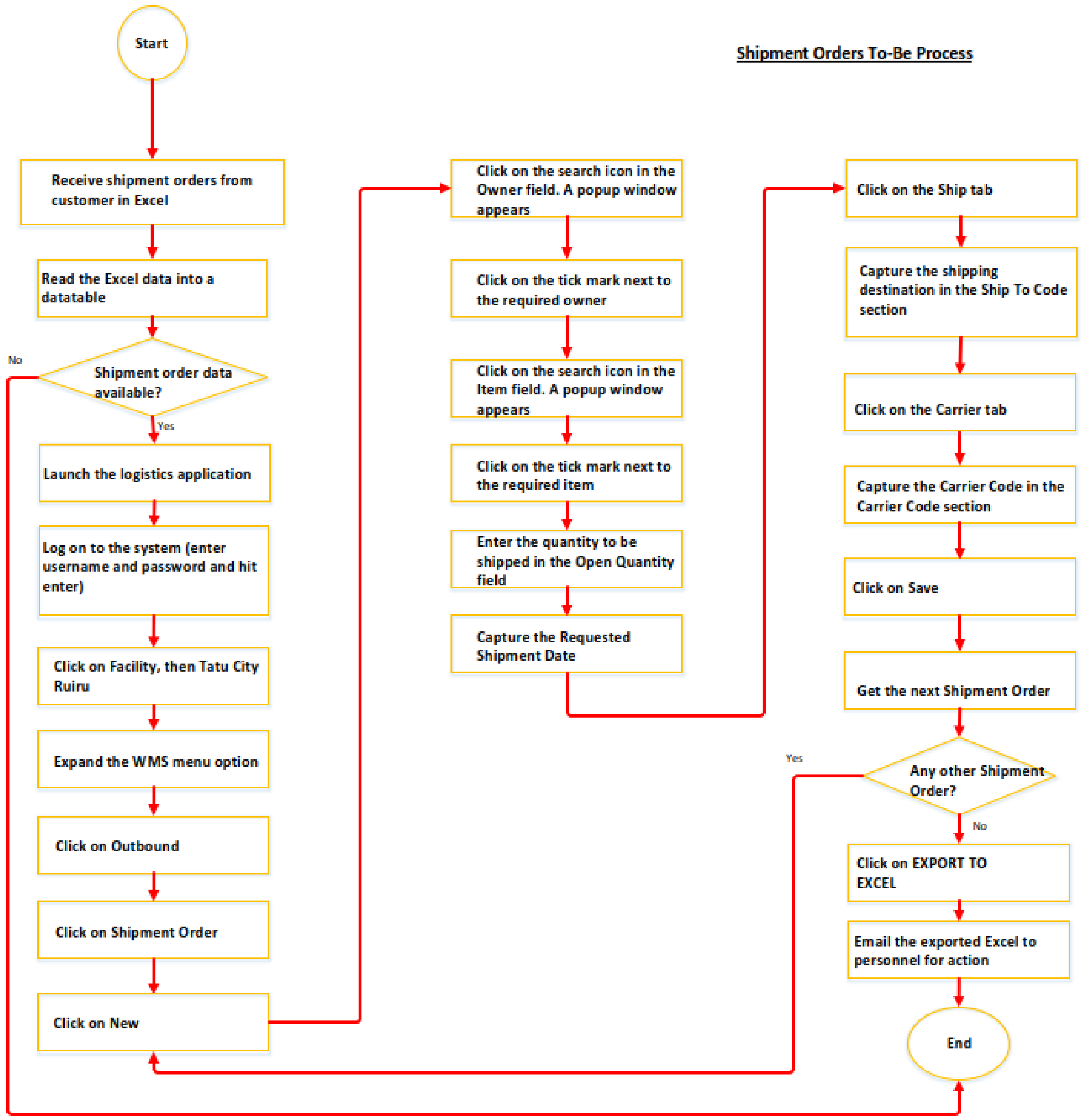

Figure 4.22 Shipment Orders 'To-Be' Process Flowchart

4.3.5 Sending Daily Inventory Reports ‘As-Is’ Process Flowchart

Figure 4.23 shows the sending daily inventory reports ‘as-is’ process flow chart, that is, the process flow before robotic process automation.

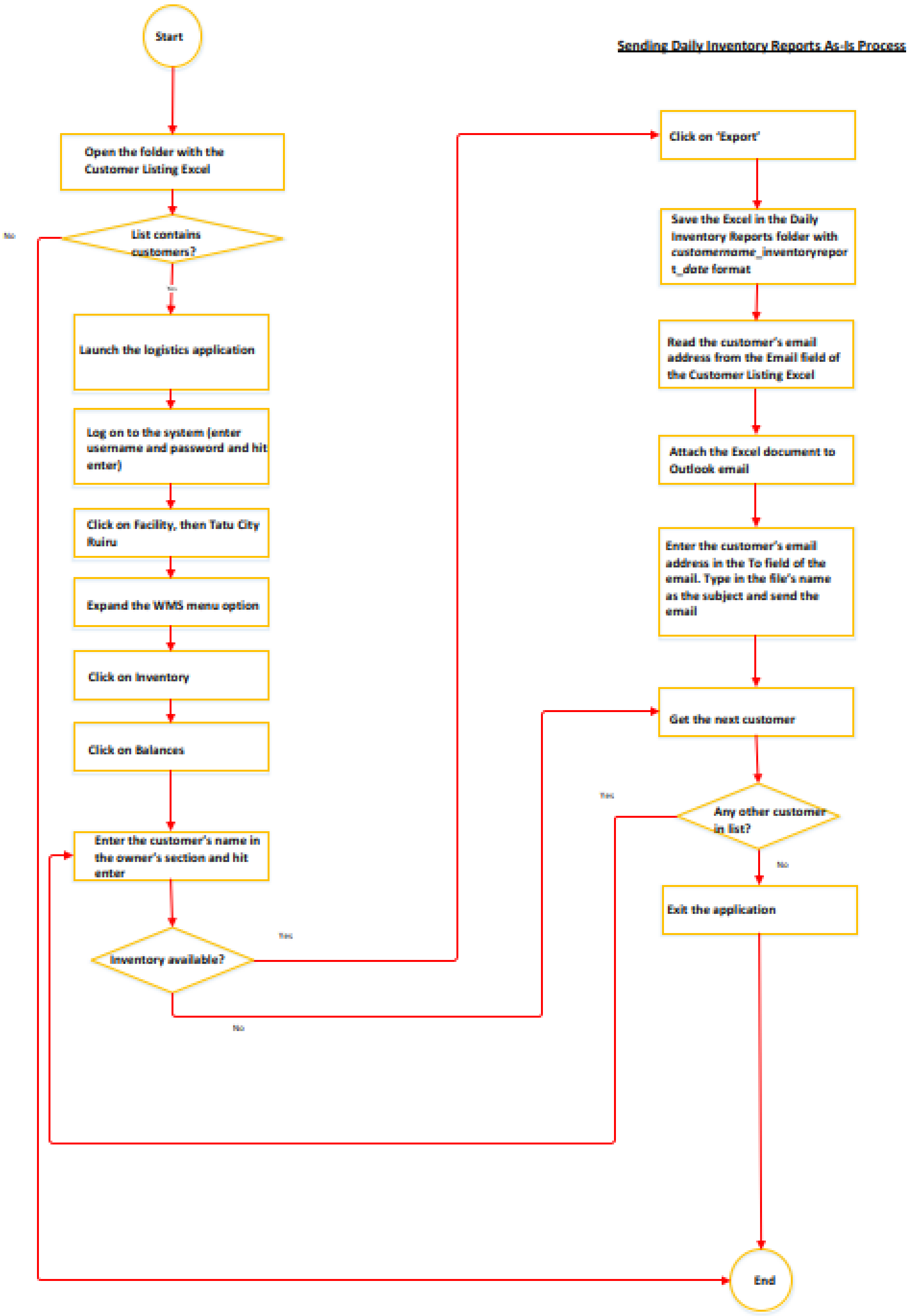

Figure 4.23 Sending Daily Inventory Reports 'As-Is' Process Flowchart

4.3.6 Sending Daily Inventory Reports 'To-Be' Process Flowchart

Figure 4.24 shows the sending daily inventory reports 'to-be' process flow chart, that is, the process flow after robotic process automation.

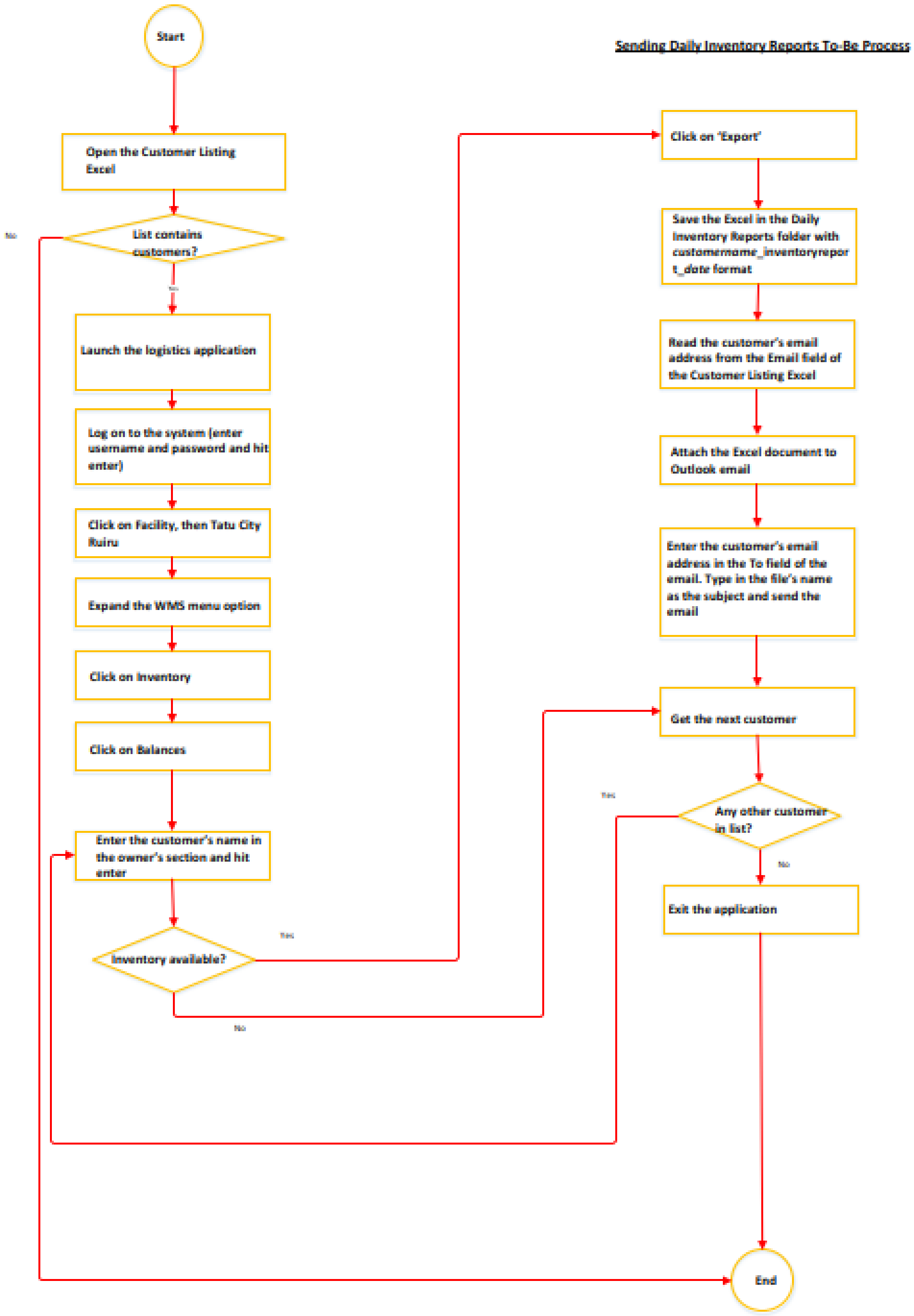

Figure 4.24 Sending Daily Inventory Reports 'To-Be' Process Flowchart

4.3.7 System Architecture

As-Is processes are represented by the existing operations team at Freight Forwarders Solutions. The human workforce uses Microsoft Excel templates to capture process information which they then import into the warehouse management system. To-Be processes are represented by the virtual robot workforce. The software robots also import data into the warehouse management system through Microsoft Excel templates. The RPA database and RPA server are required to configure and run the RPA tool, Blue Prism, used to develop and run the software robots. The core warehouse management applications are all integrated and information passed to and from them to facilitate the daily warehouse management activities performed at the logistics and warehousing company.

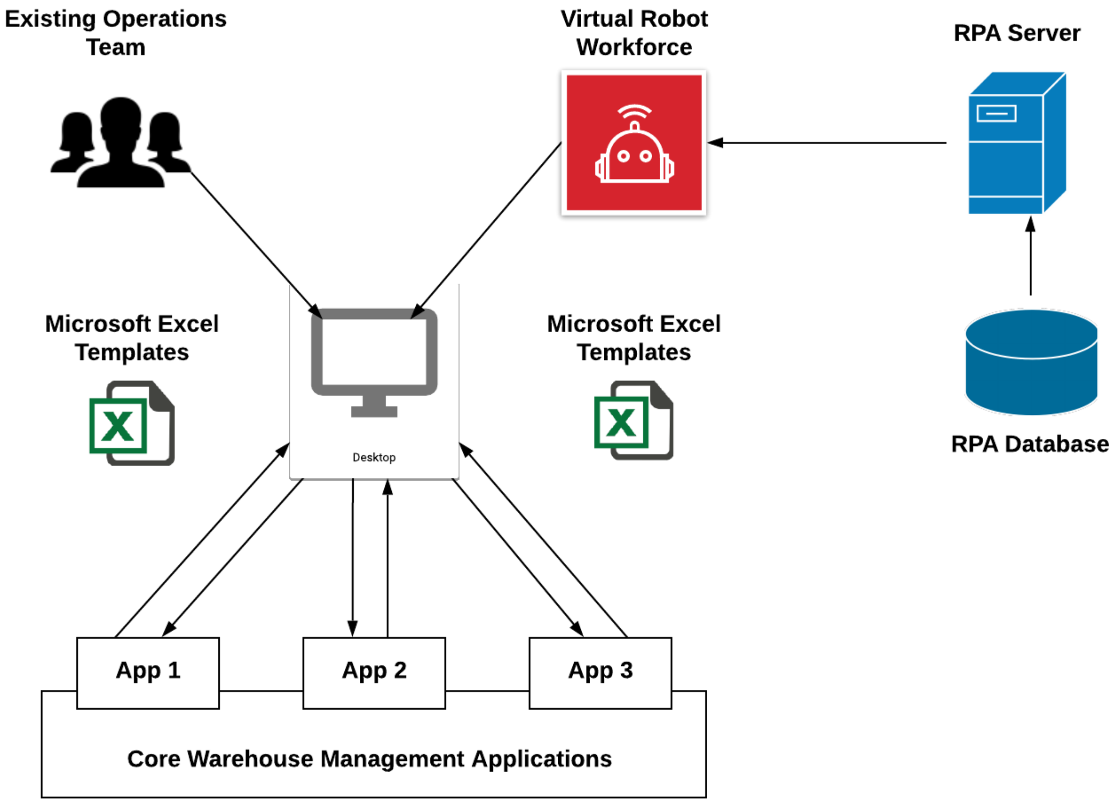

Figure 4.25 Inventory Control and Management Automation Architecture

4.4 Summary

In this chapter, an analysis of the solution was performed by looking at the responses of the subjects of the study on their organisation's readiness for robotic process automation and whether the processes performed on the inventory control and management module of the warehouse management system were suitable for automation. Thereafter the proposed solution was designed using ‘as-is’ and ‘to-be’ process flowcharts to show the processes before and after automation respectively. The system analysis and design phase set the stage for development of the proposed solution which will address the problem identified earlier on in the research.

Chapter 5 System Implementation and Testing

5.1 Introduction

Freight Forwarders Solutions is a logistics and warehousing company located in Nairobi County, Kenya. The company has several manual, repetitive, and rule-based business processes performed daily in the warehouse management system. This research sought to design and develop software robots that would automate the processes performed in the inventory control and management module of the system.

Process automation was done through the Blue Prism RPA platform. In order for the robots to know how the processes were run and executed, they needed to be given the sequence of activities to be performed. This sequence was expressed in flowcharts that the robots used to operate. The flowcharts were created in the RPA software.

5.2 Process Automation

5.2.1 Shipment Appointment Creation

In order to create shipment appointments, the robot first needs to launch the warehouse management system then login using the provided login credentials. The usernames and passwords are stored in data stores. The robot fetches the login credentials from the data store and authenticates into the system. The flowchart illustrating the application launch and subsequent login is as shown in Figure 5.1.

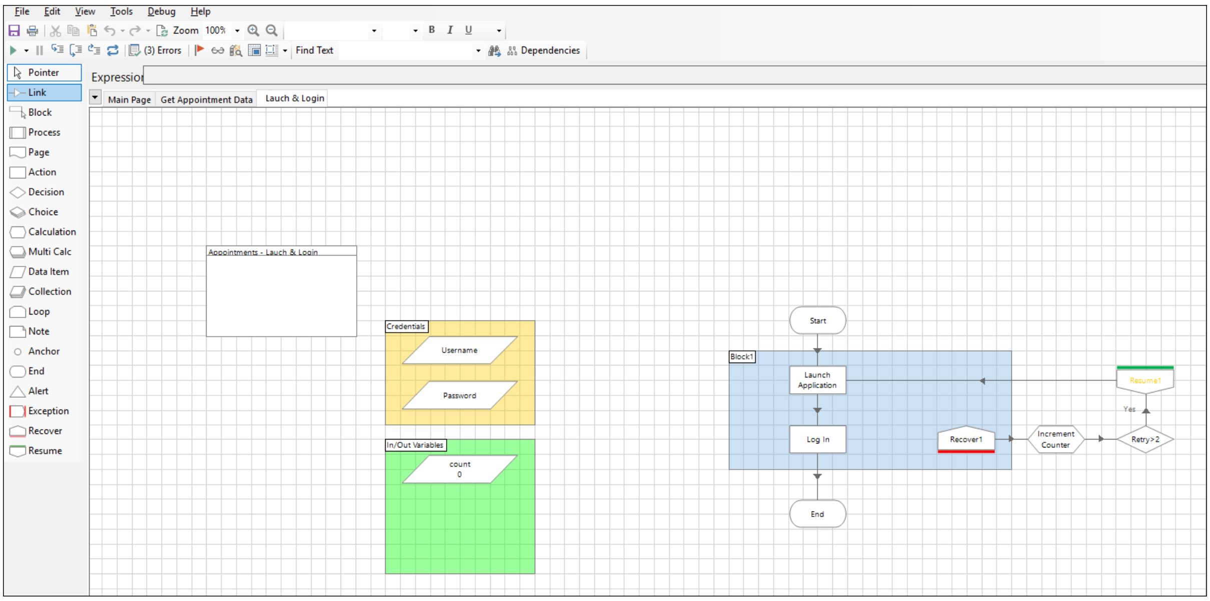

Figure 5.1 Process Launch and Login

Figure 5.2 shows the flowchart that provides the robot with the sequence of activities to be performed during system login. In this case, the user code and password were both pre-set to 005 and stored in the data store. The robot therefore fetches those credentials every time the login process is executed.

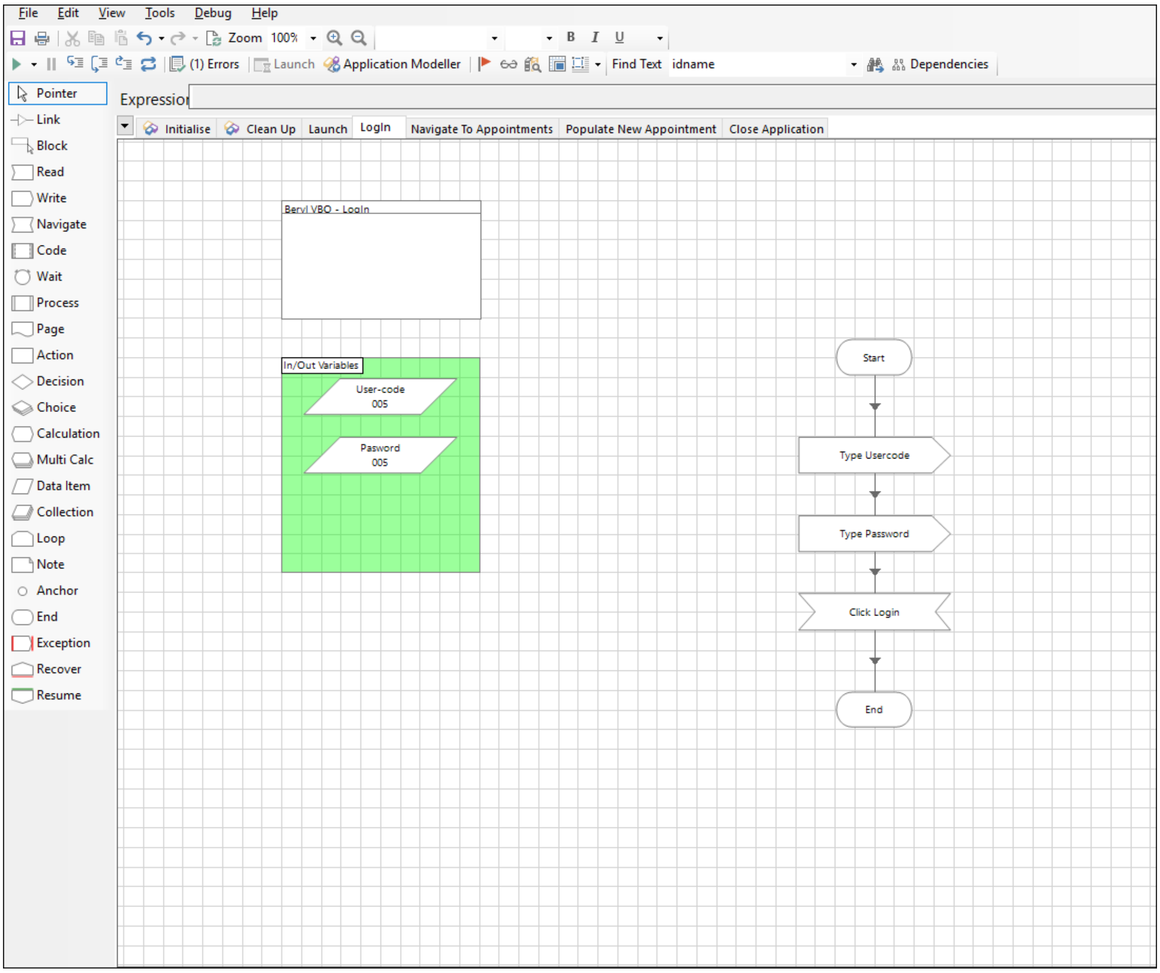

Figure 5.2 Login Process

The sequence of activities required to navigate to the screen where shipment appointments are created is illustrated in Figure 5.3. When the robot is run, it executes the processes sequentially and if any exceptions are thrown, they are handled in a variety of ways as agreed upon with the business users.

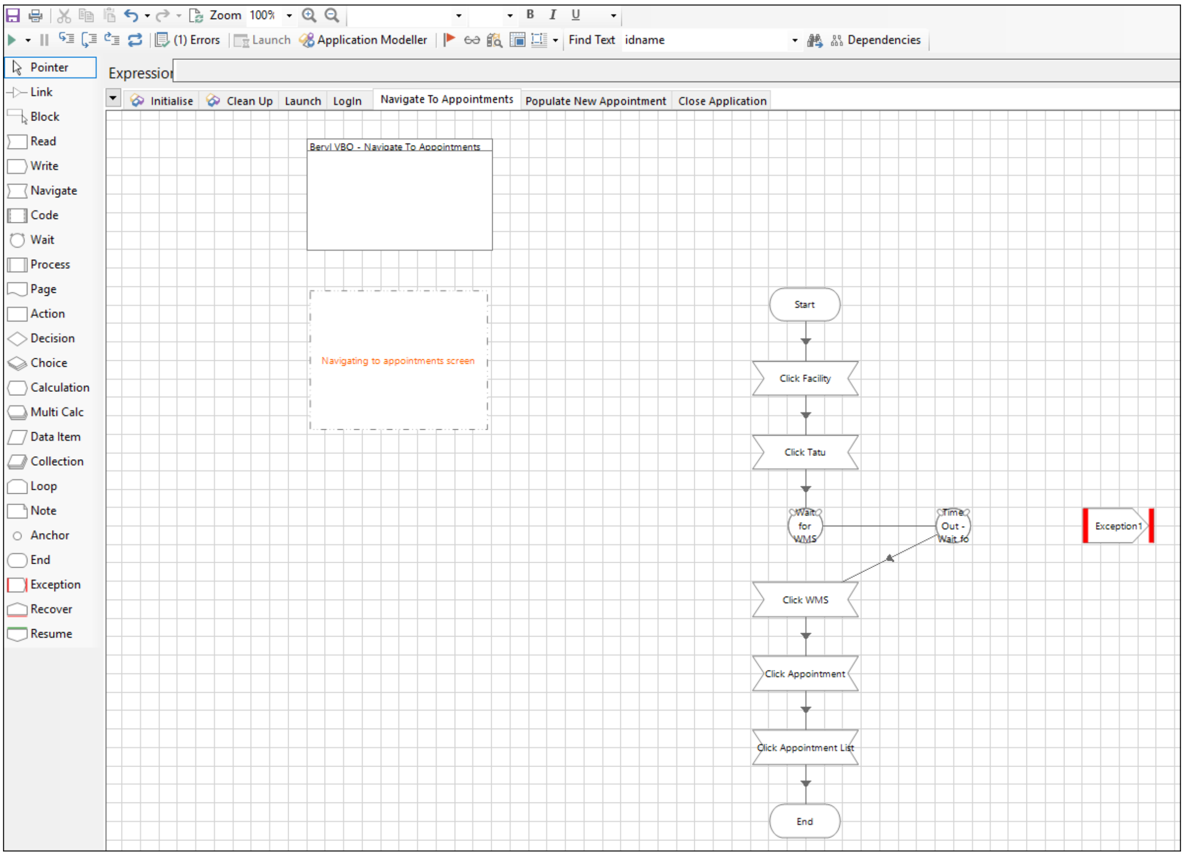

Figure 5.3 Navigating to the Appointment Creation Screen

Figure 5.4 illustrates the sequence of activities to be followed by the robot in order to populate the appointments screen and save the appointment details.

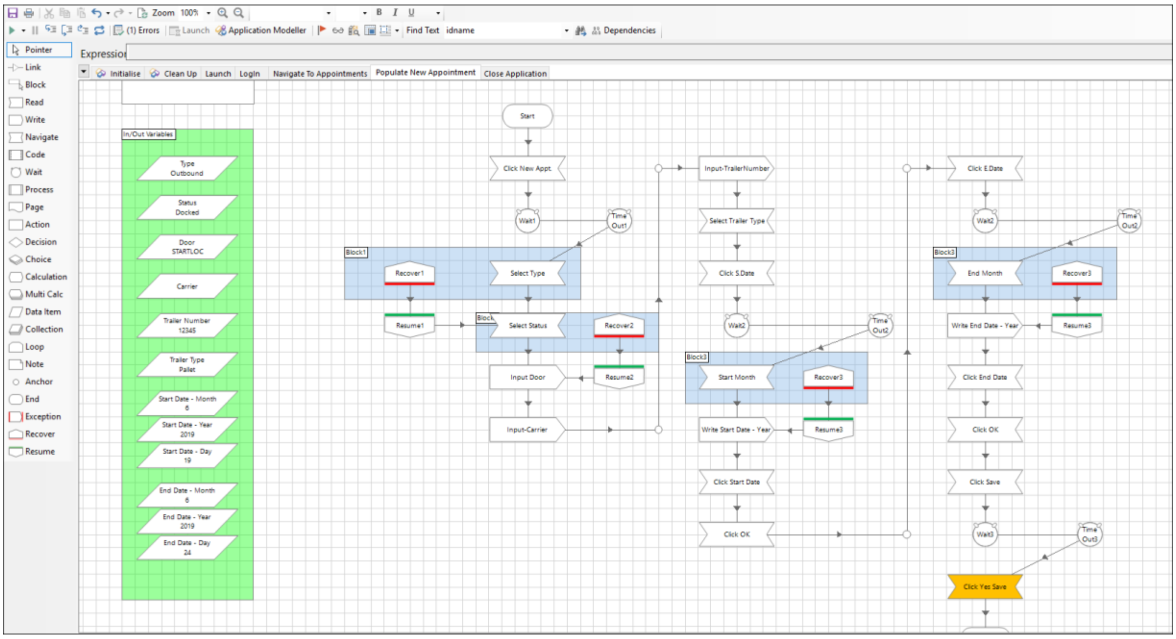

Figure 5.4 Populating and Saving Appointment

Figure 5.5 illustrates the sequence of activities to be followed by the robot in order to fetch appointment data from the Microsoft Excel templates that have been stored in a specific location in the computer.

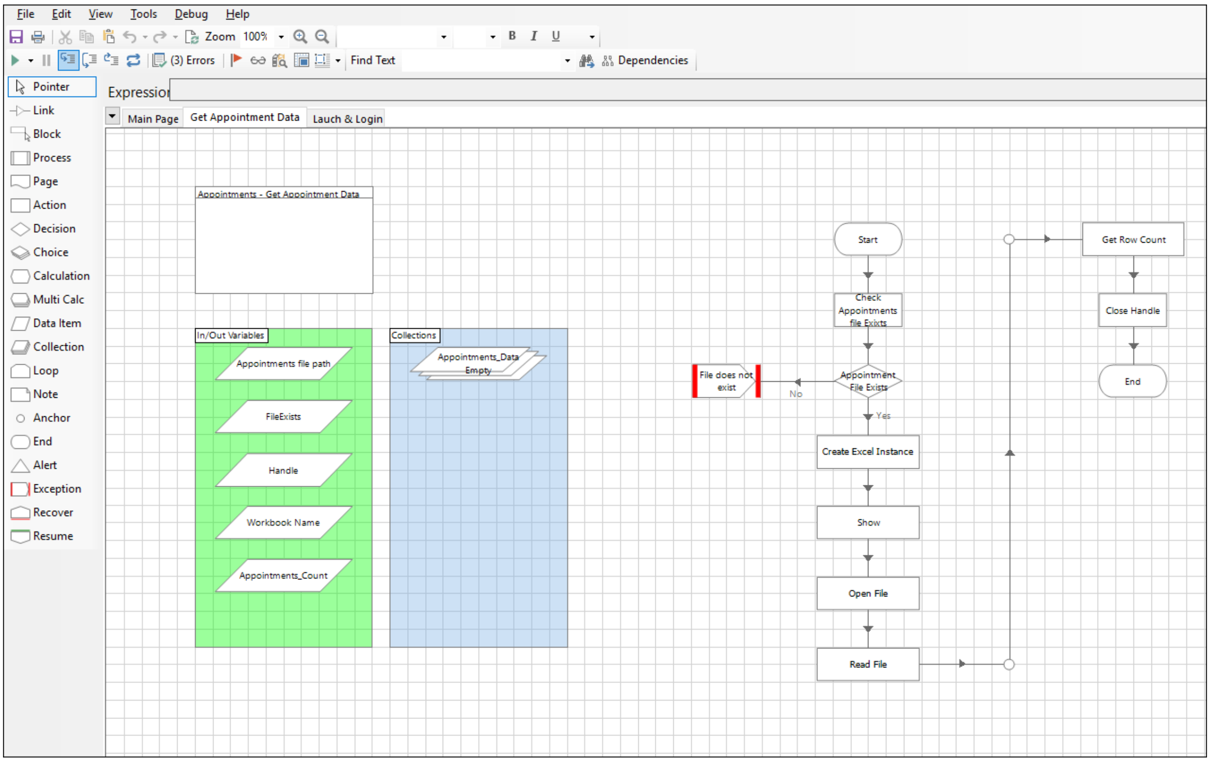

Figure 5.5 Getting Appointment Data from Microsoft Excel

Process flowcharts for the rest of the processes were not included in this dissertation document because they are the equivalent of source code in software development.

5.3 System Testing

This section covers the different testing paradigms that were applied in ensuring the developed solutions perform as expected. This feedback was obtained from both the developer and a group of users who were involved in the testing phase. Different tests were performed as discussed in Chapter 3 and these were functional testing, compatibility testing, usability testing and acceptance testing.

5.3.1 Functional Testing

Functional tests were carried out during the entire software development process. Each software robot was tested individually to ensure that it run correctly. Thereafter the different robots were tested together to ascertain that data was flowing as expected. Lastly the entire solution was built, compiled and all bugs and exceptions resolved. More test results are in Appendix G.

Table 5.1 Shipment Appointment Creation Testing

Test Name	Shipment Appointment Creation		
Test Description	Testing whether the software robot can successfully create an appointment in the warehouse management system		
Utilised Use Case	Existing Customers		
Steps	Robots Actions	System Response	Pass/Fail
1	Robot launches the warehouse management system	The system launches and loads the login page	Pass
2	The robot logs into the system using login credentials	The system validates the login credentials and grants the robot access	Pass
3	The robot navigates to the appointments screen	The system loads the appointments screen	Pass
4	The robot fetches the Microsoft excel template containing appointment information and imports it into the system thereby populating the fields on the appointments screen	The system populates the fields as formatted on the Excel sheet	Pass
Comment	Exceptions were thrown by the robot in cases where mandatory fields were left blank		
Test Pass/Fail	Pass		

5.3.2 Compatibility Testing

Compatibility tests were performed to ascertain that the software robots were compatible with the most common web browsers available.

Table 5.2 Web Browser Testing

Browser	Versions	Compatible (Yes/No)
Microsoft Internet Explorer	4 and above	Yes
Mozilla Firefox	8.0 and above	Yes
Google Chrome	All versions	Yes

5.3.3 Usability Testing

The aim of carrying out usability testing was to gain feedback from the users on various aspects of the developed solution in order to ascertain that its users can see the value in the solution. The aspects tested are the ease of use of the solution and functionality of the solution.

i. Ease of Use

This test was aimed at gauging how well the users were able to learn how to run and execute the software robots. The results are indicated in Figure 5.6 where 78% of the respondents found the robots easy to execute, 18% found it intermediate and 4% found the robots hard to execute. The 4% that found it hard was attributed to the users' limited knowledge in matters technology.

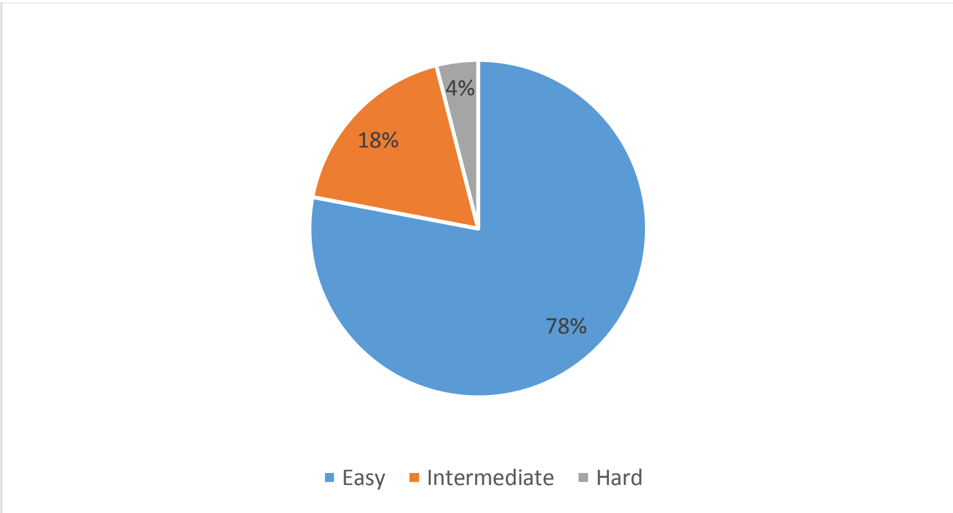

Figure 5.6 Response on Ease of Use of the Software Robots

ii. Functionality

The functionality with which the solution provides is integral to the solution meeting the requirements of the target users. To determine this, the users were asked to indicate their level of satisfaction with the solution. The results are shown in Figure 5.7. All the respondents agreed that the solution had meet the functional requirements as expected.

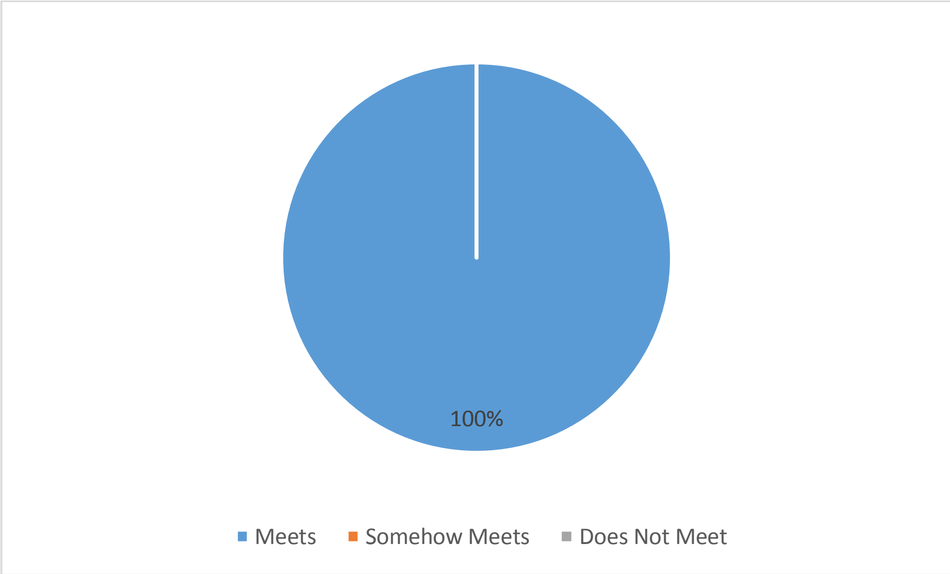

Figure 5.7 Analysis of the Solution against the Functional Requirements

iii. Acceptability

The researcher sought to determine whether the target users would accept the developed solution. As illustrated in Figure 5.8, 95% of the respondents were in agreement that they would accept the solution however 5% were undecided. The undecidedness was attributed to fear of losing one's job to the robots.

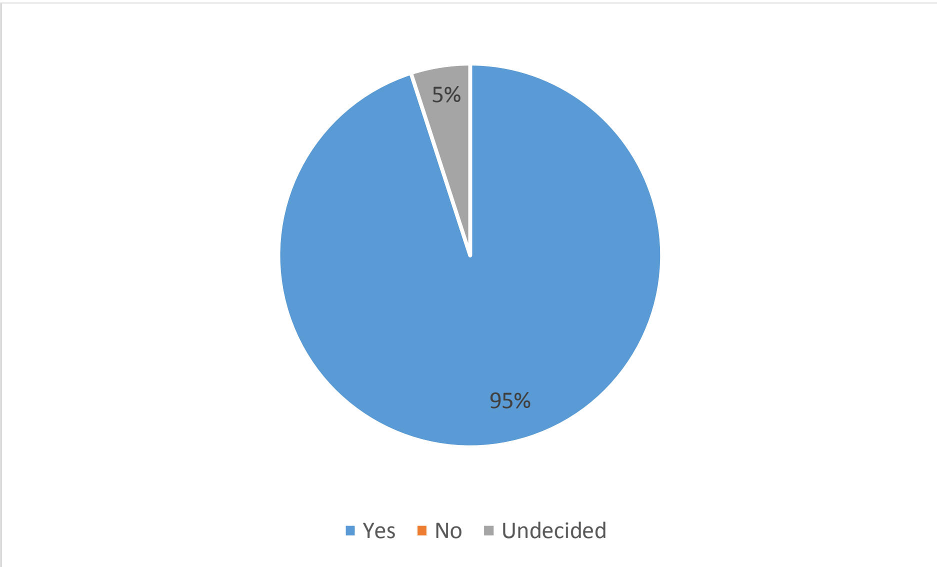

Figure 5.8 Acceptance of the Developed Solution

iv. Training

Finally, the researcher sought to determine whether the training on RPA provided to the target users was useful. All the respondents agreed that the training was very useful as illustrated in Figure 5.9.

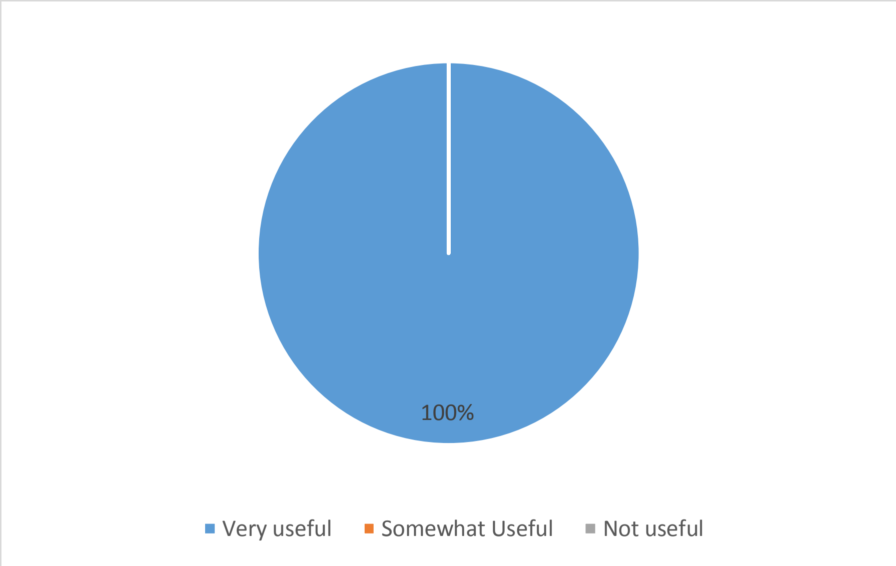

Figure 5.9 Training on RPA

5.4 Summary

This chapter covered the implementation of the automated business processes. The development process was guided by the analysis and design conducted in Chapter 4 as well as the research questions formulated in Chapter 1. The waterfall method was followed in development of the software robots. The aim of automating the business processes was to relieve the human workforce from performing manual, repetitive and rule-based tasks and allow them time and energy to perform the non-repetitive and judgement-based tasks.

Following development of the solution, different types of tests were carried out to assess whether the solution fulfilled the set requirements and whether the functionality provided was satisfactory to the business users. Functional testing was aimed at determining that the requirements had been met. Compatibility testing was carried out to determine the web browsers that the software robots could run on and finally, usability testing was performed to obtain feedback on the ease of use of the solution.

Chapter 6 Discussions

6.1 Review of Research Objectives in Relation to the Developed Solution

The business processes that were automated in the inventory control and management module were developed based on the research objectives which were set in Chapter 1. This section will analyse the objectives against the functionalities of the system.

The first objective was to identify the challenges faced with manual inventory control and management. The aim of this was to gain an understanding of the variety of challenges faced by supply chain and logistics companies in performing activities relating to inventory control and management. This would allow the researcher to identify the best approach to solving the problem based on the challenges that had been identified. This was done through review of different literary works written by other researchers who have studied the automation of business processes in inventory control and management. The major challenges included:

i. High error rates associated with manual data entry.
ii. Slow turnaround time due to data entry tasks that are text heavy and require an understanding of the text.
iii. Investment in additional personnel to vet the accuracy of manual data entry tasks to ensure that the right output is obtained.
iv. Unexpected spikes in manual data entry work puts tremendous pressure on the manual data entry professionals which may cause an increase in error rates.
v. Loss of focus from other core tasks especially since manual data entry is not one of the core tasks of the business. This diverts employees from completing other important activities.
vi. Expenses associated with training the data entry professionals. Providing proper training to the employees' costs organisations a lot of time and money.

The second objective was to review existing solutions and frameworks for robotic process automation. The purpose of this was to identify which of those frameworks would be useful in this study. Literature review helped the researcher achieve this and was performed by analysing reports, journals, and articles that documented implementation of robotic process automation to inventory control and management systems. Subsequently, the researcher identified the best approach to designing the proposed solution by leveraging on those that have been implemented successfully. The architecture consisted of a virtual robot workforce; the virtual robot workforce was linked to an RPA server which is in turn linked to an RPA database;

the core warehouse management applications which interact with the robots through a personal computer; the existing operations team and the Microsoft Excel templates through which information is standardised before being imported into the warehouse management system. This architecture was the blueprint against which the solution was developed.

The third objective was to design, develop and test the automated inventory control and management software robots. This was achieved through identifying requirements with the business users, understanding the process flows of the processes in scope and designing process flowcharts depicting the 'as-is' and 'to-be' process flowcharts. After designing the process flowcharts, the researcher proceeded to the development phase which was achieved through the waterfall software development methodology. Development of the software robots was done using the Blue Prism RPA platform. Finally, the solution was tested after development was completed by a test group that interacted with the robots and provided feedback on their usability, functionality and acceptability. The robots were also tested throughout the development lifecycle by the researcher. The results from the test group showed that RPA can be implemented in other supply chain and logistics companies to automate their processes.

The final objective was to validate the automated inventory control and management software robots. In order to achieve this, the researcher was required to find out if the robots solved the problem of manual data entry into the warehouse management system at Freight Forwarders Solutions. To meet this objective, a survey was sent to the business users who interacted with the robots to inquire from them whether the developed solution addressed and solved the problem. The responses received indicated that the robots indeed met the main objective of automating the inventory control and management processes.

6.2 Advantages of the Developed Solution

The advantages of the automated business processes can be summarised as follows:

i. Automation of shipment appointment creation.
ii. Automation of shipment order processing.
iii. Automation of daily inventory balances report.
iv. Cost savings due to reduced operation costs and increased throughput.
v. Significant process improvements – the software robots get more work done in less time.

vi. Redeployment of resources to higher value functions – the employees offloaded the structured, rule-based, repetitive tasks to the software robots thereby allowing the employees to focus on provision of better customer service and judgement-based tasks.
vii. Improved productivity – the software robots minimised the manual, error-prone processes. The virtual workforce is also easily expandable as the business grows.
viii. Improved quality – the software robots increased compliance and auditability. The robots also increased consistency with the standardised processes.
ix. Improved compliance – all robotic process automation steps are recorded for historical accountability.

6.3 Discussion of the Developed Solution

During the testing phase of the software robots, the respondents were in unison that the developed solution had attained the desired results. They stated that the robots streamlined the manual processes and freed them up for more cognitive tasks. Majority of the respondents agreed that the robots should be deployed into the live environment however a small percentage was indecisive as they felt that the robots threatened their job security. Employee resistance to RPA is a common phenomenon when RPA is initially introduced to organisations, however, once those employees understand that they can be redeployed to perform higher value tasks, they become more accepting of the new technology.

6.4 Summary

This study was conducted with the aim to automate the inventory control and management processes thereby streamlining them. This was motivated by the desire to eliminate the human factor which is present in the current system in place, which as discussed, is highly prone to errors. The product of this research is automated inventory control and management processes.

The results of the tests administered were indicative that the solution passed all the required functionalities. The respondents who participated in this study provided positive feedback and were very keen on adopting the technology and integrating it fully with their warehouse management system.

Chapter 7 Conclusions and Recommendations

7.1 Conclusions

The main purpose of this research was to automate the manual processes performed in the inventory control and management module of the warehouse management system in place at Freight Forwarders Solutions. This was achieved through robotic process automation, a disruptive, new technology that leverages on artificial intelligence. Robotic process automation was used to develop software robots that automated the manual, repetitive, rule-based and time-consuming tasks that are performed by data entry professionals at the logistics company. The developed solution achieved automation and increased the accuracy levels of the information captured in the system as well as the time taken to complete those tasks.

Various literary works written by other researchers in the form of articles, reports, journals and book sections were reviewed in order to gain a deeper understanding of robotic process automation and how it can be leveraged by supply chain and logistics companies to improve efficiency, productivity, quality, compliance and reduction in operational costs among other benefits. A logistics and warehousing company was chosen as a case study for this research. Reviews written by other researchers indicate a direct correlation between robotic process automation and high returns on investment to the organisations that have already implemented the technology. Numerous analyses have also been performed to determine the benefits that RPA can realise to organisations that constitute a wide spectrum of industries.

Information analysed by the researcher included the different ways that other organisations in the supply chain and logistics industry have implemented robotic process automation. Review of the frameworks and architectures used to implement the process automations was performed. The researcher then selected a suitable software development methodology that aided in understanding the company's business processes, selection of the processes most suitable for RPA, designing, building and testing the robot, and finally deploying and maintaining the developed robots. The proposed solution was designed using 'as-is' and 'to-be' process flowcharts. The information gathered during the understand-the-business phase and the process selection for RPA phase of the methodology allowed the researcher to design a solution that would meet the functional requirements of the business users of the warehouse management system. The final product of this study was automation of the processes most suited for RPA within the inventory control and management module of the WMS.

After solution development, testing was performed by a test group who interacted with the software robots in the logistics company's test environment. The results from the respondents involved in the testing indicated that the solution met the study's main objective which was to automate the manual processes involved in inventory control and management. The results of the tests further revealed that the solution was easy to use and met all the functional requirements as stipulated by the business users of the WMS.

7.2 Recommendations

i. Robotic process automation at the logistics company can be extended to include all the modules of the warehouse management system.
ii. Robotic process automation can be incorporated into all the systems involved in warehouse management at the logistics company.
iii. Inventory forecasting following qualitative and quantitative methods can be implemented to predict future trends that can be beneficial to the management of the organisation in terms of short and long term strategic planning.
iv. Finally, robotic process automation can be integrated with the RFID readers used during the receiving process of warehouse management. During the receiving process, stock items are manually received into the WMS by scanning the barcodes using RFID barcode readers. The RFID readers can then be integrated with drones so that scanning of items into the WMS becomes automated resulting in further automation of the warehouse processes.

7.3 Suggestions for Future Work

Researchers can conduct further analyses on the return on investments achieved by the logistics company due to robotic process automation. These studies would be aimed at identifying whether the implementation of RPA would have yielded positive, negative or no impact at all on the performance of the logistics company.

Further research can also be conducted to analyse how drones and hardware robots can be configured with robotic process automation software and implemented in warehouses. These studies would be aimed at exploring the benefits and drawbacks that organisations could realise as a result of having fully automated warehouses.

References

Agus, A., & Noor, Z. M. (2006). *Supply chain management and performance. An Empirical Study*. Kuala Lumpur: A working paper University of Malaysia.

Anagnoste, S. (2017). Robotic Automation Process - The Next Major Revolution in terms of Back Office Operations Improvement. 1-2.

Anton, A. I., Carter, R. A., Earp, J. B., & Williams, L. A. (2001). *EPRAM: Evolutionary Prototyping Risk Analysis & Mitigation.* North Carolina: North Carolina State University.

Asatiani, A., & Penttinen, E. (2016, November 1). *Turning robotic process automation into commercial success – Case OpusCapita.* Retrieved from Sage Journals: https://journals.sagepub.com/doi/10.1057/jittc.2016.5

Automation Anywhere. (2018, July 15). *Customer Case Studies | Automation Anywhere.* Retrieved from Automation Anywhere: https://www.automationanywhere.com/customers/case-studies

Azim, M. (2018, April 10). *A Hybrid Agile Approach to Delivering RPA*. Retrieved from Deloitte: http://blog.deloitte.com.au/hybrid-agile-approach-delivering-rpa/

Bassey, M. (1999). *Case Study Research In Educational Settings.* Buckingham . Philadelphia: Open University Press.

Bergamin, H., Bulanov, N., & Gadhok, T. (2017, March 6). *RPA: Forget everything you've learned about Agile and Waterfall*. Retrieved from LinkedIn: https://www.linkedin.com/pulse/rpa-forget-everything-youve-learned-agile-waterfall-tushar-gadhok/

Bestea, O. (2017, June 25). *Orchestrator Recovery Scenario.* Retrieved from UiPath: https://forum.uipath.com/t/orchestrator-recovery-scenario/3198

Blue Prism. (2007, August 29). *The Co-operative Bank achieves 80% process efficiency improvement with Blue Prism.* Retrieved from BluePrism: https://www.blueprism.com/cstudies/the-co-operative-bank-achieves-80-process-efficiency-improvement-blue-prism

Brynjolfsson, E., & McAfee, A. (2016). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies.* New York, United States : W. W. Norton & Company.

CGF. (2018, February 25). *AI and Robotics Automation in Consumer-Driven Supply Chains.* Retrieved from Consumer Goods Forum:

https://www.theconsumergoodsforum.com/wp-content/uploads/2018/04/201805-CGF-AI-Robotics-Report-with-PA-Consulting.pdf

Chappell, D. (2017, June 30). *Introducing Blue Prism: Robotic Process Automation for the Enterprise.* Retrieved from David Chappell: http://www.davidchappell.com/writing/white_papers/Introducing_Blue_Prism_v2--Chappell.pdf

Chrisos, M. (2018, March 20). *Forecasting Tools and Techniques in Strategic Management*. Retrieved from Tech Funnel: https://www.techfunnel.com/information-technology/forecasting-tools-and-techniques-in-strategic-management/

Creswell, J. W. (2002). *Educational research: Planning, conducting, and evaluating Quantitative and Qualitative research.* Upper Saddle River, NJ: Merrill Prentice Hall.

Creswell, J. W. (2013). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th Edition).* Lincoln: SAGE Publications.

CSCMP. (2018). *CSCMP Supply Chain Management Definitions and Glossary.* Illinois: Council of Supply Chain Management Professionals.

Deckard, M. (2018, March 8). *Benefits and Impact of RPA for Supply Chain Management*. Retrieved from UiPath: https://www.uipath.com/blog/rpa-the-glue-for-supply-chain-management

Denise F. Polit, B. P. (1995). *Nursing Research: Principles and Methods (5th Edition).* Philadelphia: J.B. Lippincott.

Dennis, A., Wixom, B. H., & Roth, R. M. (2012). *System Analysis and Design.* New Jersey: John Wiley & Sons, Inc.

Dudovskiy, J. (2011, June 25). *Interviews - Research Methodology*. Retrieved from Research Methodology: https://research-methodology.net/research-methods/qualitative-research/interviews/

EasyEcom. (2018, February 20). *Inventory Forecasting: Proven Method to Inventory Forecasting and Accurate Budgeting*. Retrieved from Easy Ecom: https://www.easyecom.io/blog/inventory-forecasting/

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics*, 1-4.

Everest Global. (2017). *Robotic Process Automation (RPA): Technology Vendor State of the Market Report.* Dallas, Texas: Everest Global, Inc.

Fersht, P., & Snowdon, J. (2017, June 10). *The Robotic Process Automation market will reach $443 million this year*. Retrieved from Horses for Sources : https://www.horsesforsources.com/RPA-marketsize-HfS_061017

Finances Online. (2018, December 14). *Blue Prism Reviews: Overview, Pricing and Features*. Retrieved from Finances Online: https://reviews.financesonline.com/p/blue-prism/

Forrester Research. (2014, February 13). *Forrester Report - Building a Center of Expertise to Support Robotic Automation - Blue Prism*. Retrieved from Blue Prism: https://www.blueprism.com/wpapers/forrester-report-building-center-expertise-support-robotic-automation

Foxtrot. (2017). *CB&S - Case Study*. Orlando, Florida: EnableSoft, Inc.

Gacek, C., Abd-Allah, A., Clark, B., & Boehm, B. (1995, April 4). *On the Definition of Software System Architecture*. Retrieved from Research Gate: https://www.researchgate.net/publication/2670553_On_the_Definition_of_Software_System_Architecture

Gakinya, A. M. (2013). *Inventory Management and Supply Chain Performance: Non-Governmental Organisations in the Agricultural Sector*. Nairobi: University of Nairobi.

Genpact. (2017, August 24). *The Evolution from Robotic Process Automation to Intelligent Automation*. Retrieved from Research Gate: https://www.researchgate.net/...Robotic_Process_Automation.../the-evolution-from-robotic-process-automation-to-inteligent-automation.pdf

Glinz, M. (2012). On Non-Functional Requirements. *15th IEEE International Requirements Engineering Conference* (pp. 21-26). Zurich, Switzerland: IEEE Computer Society.

Green, W. (2017, May 9). *Robotics 'cutting average costs by 37%'*. Retrieved from Chartered Institute of Procurement & Supply: https://www.cips.org/en/supply-management/news/2017/may/robotics-cutting-average-costs-by-37/

Greene, J., & Caracelli, V. J. (2003). Making paradigmatic series of mixed methods practise. In A. T. Charles Teddlie, *Handbook of mixed methods in social and behavioural research* (pp. 91-110). Thousand Oaks, CA: Sage Publications.

Hardesty, L. (2017). *Drones relay RFID signals for inventory control*. Cambridge, Massachusetts: Massachusetts Institute of Technology.

Hooda, I., & Chhillar, R. S. (2015). Software Test Process, Testing Types and Techniques. *International Journal of Computer Applications* , 10-14.

IBM. (2016, September 8). *Robotic Process Automation. Leading with robotics and automation in a fast-paced, digitally disruptive environment.* Retrieved from IBM Corporation: https://www-935.ibm.com/services/multimedia/dl_17119_rpa_flyer_04.pdf

Infosys BPM. (2017, April 20). *Infosys BPM - Case Studies | Robotic Process Automation*. Retrieved from Infosys BPM: https://www.infosysbpm.com/offerings/functions/robotics-process-automation/case-studies/Pages/rpa-simplifies-hr-processes.aspx

IRPAAI. (2017, November 5). *Definition and Benefits.* Retrieved from Institute for Robotic Process Automation & Artificial Intelligence: https://irpaai.com/definition-and-benefits/

Jane, M. (2017, September 26). *Difficulties in Using a Manual Inventory*. Retrieved from Bizfluent: https://bizfluent.com/info-8007357-difficulties-using-manual-inventory-system.html

Joseph, C. (2018, May 28). *Advantages & Disadvantages to a Manual Inventory Control System*. Retrieved from Chron: https://smallbusiness.chron.com/advantages-disadvantages-manual-inventory-control-system-22693.html

Kamanda, E. N., & Shale, D. N. (2018). Effects of Inventory Control System on Supply Chain Performance in Distribution Firms in Kenya: A Case of Bollore Africa Limited. *International Journal of Management and Commerce Innovations ISSN 2348-7585 Vol. 5, Issue 2*, 265-276.

Kariuki, J. N. (2013). *An Assessment of the Factors Influencing Effectiveness of Inventory Control: Ministry of State for Provincial Administration and Internal Security.* Nairobi.

Kazemi, Y. (2018, November 14). *The New Supply Chain: Four Ways Smart Leaders Can Shake Up Logistics*. Retrieved from Forbes: https://www.forbes.com/sites/yasamankazemi/2018/11/14/the-new-supply-chain-four-ways-smart-leaders-can-shake-up-logistics/#7b501c974d18

Kirkwood, G. (2018, July 11). *Is Robotic Process Automation the Optimal Route to the Supply Chain Dream?* Retrieved from EyeForTransport: https://www.eft.com/technology/robotic-process-automation-optimal-route-supply-chain-dream

Kofax. (2018, October 25). *3 Ways Logistics Providers are Automating Costly Manual Processes.* Retrieved from Kofax: https://www.kofax.com/-/media/Files/E-books/EN/eb_3-ways-logistics-providers-automating-manual-process_en.pdf?crmCampaignID=CMP-08854-W7T3C5

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques.* New Delhi: New Age International Limited.

Kumar, R. (2011). *Research Methodology - A step-by-step guide for beginners.* London: SAGE Publications Ltd.

Lam, J. K., & Postle, R. (2006). International Journal of Clothing Science and Technology, Vol. 18 Issue: 4. *Textile and apparel supply chain management in Hong Kong*, 265-277.

Larman, C. (2004). *Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and Iterative Development (3rd Edition).* Prentice Hall.

Li, X. (2014). Operations Management of Logistics and Supply Chain: Issues and Directions. *Discrete Dynamics in Nature and Society*, 7.

Lu, H., Li, Y., Chen, M., Kim, H., & Serikawa, S. (2018, April 15). *Brain Intelligence: Go beyond Artificial Intelligence.* Retrieved from Springer Link: https://doi.org/10.1007/s11036-017-

Luo, L. (2014). *Software Testing Techniques. Technology Maturation and Research Strategy .* Pittsburg, PA: Carnegie Mellon University.

Maher, S. (2017, August 31). *Overcome the 5 Key Challenges of Inventory Management.* Retrieved from Intuit: http://http-download.intuit.com/http.intuit/CMO/qbes/resources/pdfs/5ChallengesInventoryManagement-QuickBooks.pdf

Middleburg, J.-W. (2017). *Service Automation Framework: For The Design and Delivery Of Automated Services.* Zaltbommel, Netherlands: Van Haren Publishing.

Murage, J. N. (2011). *Commercial Electricity Supply Chain Management Practices in Kenya.* Nairobi: University of Nairobi.

Myers, M. D. (2009). *Qualitative Research in Business & Management.* London: SAGE Publications Limited.

National Science Foundation. (2002). An Overview of Quantitative and Qualitative Data Collection Methods. In *The 2002 User-Friendly Handbook for Project Evaluation* (pp. 43-62).

Nyberg, E. H. (2004). *Prototyping: The Internet Encyclopedia.* Carnegie: Carnegie Mellon University.

Ondiek, G. O., & Odera, O. (2012). Assessment of Materials Management in Kenyan Manufacturing Firms. *Journal of Business Studies Quarterly 2012, Vol. 3, No. 3*, 40-49.

Opeyemi, A., Fatoba, B., & Blessing, A. (2013). Design of a Computerized Inventory Management System for Supermarkets. *International Journal of Science and Research (IJSR), India Online ISSN: 2319-7064*, 340-341.

Ostdick, N. (2016, August 23). *How RPA Impacts the Global Supply Chain*. Retrieved from UiPath: https://www.uipath.com/blog/how-rpa-impacts-the-global-supply-chain

Parahoo, K. (1997). *Nursing Research: Principles, Process and Issues.* London: Macmillan.

Polit, D. F., & Hungler, B. P. (1995). *Nursing Research: Principles and Methods (5th Edition).* Philadelphia: J.B. Lippincott.

Rajana, S. (2018). *Robotics for the Supply Chain.* Melbourne: RMIT University.

Rongala, A. (2015, April 27). *Top 6 Manual Data Entry Challenges Companies Face*. Retrieved from Invensis: https://www.invensis.net/blog/data-processing/top-6-manual-data-entry-challenges-companies-face/

Rouse, M. (2017, October 25). *What is inventory management?* Retrieved from Tech Target: https://searcherp.techtarget.com/definition/inventory-management

Rungta, K. (2018, March 24). *Automation Anywhere Tutorial*. Retrieved from Guru99: https://www.guru99.com/automation-anywhere-tutorial.html

Scanco. (2014, July 14). *Avoid the Most Common Challenges in Warehouse Management*. Retrieved from Scanco: https://www.scanco.com/avoid-the-most-common-challenges-in-warehouse-management/

Srini. (2017, November 11). *Three popular RPA tools functional differences*. Retrieved from Apply Big Analytics: https://www.biganalytics.me/2017/11/popular-rpa-tools-functionality.html

Sutherland, C. (2013). *FRAMING A CONSTITUTION FOR ROBOTISAN.* Bengaluru: HfS Research Ltd.

Sutter, B. (2016, April 12). *How Human Error Effects Manual Inventory Management*. Retrieved from Wasp Barcode: http://www.waspbarcode.com/buzz/human-error-effects-inventory-management/

Tseng, Y.-y., Yue, W. L., & Taylor, M. A. (2005). *The Role of Transportation in Logistics Chain.* Adelaide: Eastern Asia Society for Transportation Studies.

USAID. (2011). *The Logistics Handbook. A Practical Guide for the Supply Chain Management of Health Commodities.* Virginia: USAID | DELIVER PROJECT.

Vaus, D. A. (2001). *What is Research Design?* London: SAGE Publications.

Vrat, P. (2014). Materials Management. An Integrated Systems Approach. In *Basic Concepts in Inventory Management* (pp. 21-22). India: Springer .

Walsh-Kelly, C. M. (2015, August 28). *Flow Chart.* Retrieved from UNC School of Medicine: https://www.med.unc.edu/neurosurgery/files/2018/10/Flow-chart-Process-Flow.pdf

Watzinger, P., Town, K., & Filman, B. (2017, August 15). *The Future of Warehouse Technology: Drones*. Retrieved from Clear Spider: https://www.clearspider.com/blog-warehouse-technology-drones/

Webster, J. (1985). *Introduction to Research in England and Wales.* England: J. Webster.

Willcocks, P. L., & Lacity, P. M. (2016). *Service Automation - Robots and The Future of Work (First Edition).* Ashford, United Kingdom: Steve Brookes Publishing.

Willcocks, P. L., Lacity, P. M., & Craig, A. (2015). The IT Function and Robotic Process Automation. *The Outsourcing Unit Working Research Paper Series, Paper 15/05*.

Williams, L. (2006). Testing Overview and Black-Box Testing Techniques. In *A (Partial) Introduction of Software Engineering Practices and Methods* (pp. 34-59). North Carolina: North Carolina State University.

Appendices

Appendix A: Interview Questions

A.1 Robotic Process Automation Readiness

1. How well does the organisation's leadership understand the strategic need for RPA?
   a) Deep understanding ☐
   b) Good understanding of the concept ☐
   c) Wants to understand more ☐
   d) Some awareness of RPA ☐
   e) Never heard of it ☐

2. How soon will non-RPA process improvements (e.g. Process Re-engineering, API-based automation, or system replacements) be made to the process you want to automate?
   a) In years ☐
   b) In a year ☐
   c) In months ☐
   d) In weeks ☐

3. How well defined are all the activities within scope (including intended responses to rare inputs)?
   a) Well defined and the process is always followed ☐
   b) Defined, but not followed ☐
   c) Somewhat defined ☐
   d) Not at all defined ☐

4. Are the process inputs and outputs all digital?
    a) Yes ☐
    b) No ☐

5. How frequently is the process performed?
    a) Multiple times a day ☐
    b) Daily ☐
    c) Weekly ☐
    d) Monthly ☐
    e) Annually ☐

6. Are the process inputs structured?
    a) Well-structured and documented ☐
    b) Structured but not written down ☐
    c) Somewhat structured ☐
    d) Not structured at all ☐

7. Is human judgement required to perform the process?
    a) For all steps ☐
    b) For some steps ☐
    c) Not at all ☐

8. Do you already have strong KPIs and analytical insight into the performance of the process?
    a) Deep analytical insight ☐
    b) Some KPIs and insight ☐
    c) Some KPIs ☐

d) No KPIs ☐

9. What is the annual rate of turnover of staff performing this process?
    a) Less than 5% ☐
    b) 5% - 15% ☐
    c) 15% - 30% ☐
    d) 30% - 50% ☐
    e) More than 50% ☐

10. How many full-time employees are currently devoted to the activities that will be performed by RPA? (Please provide numeric responses only)

    ____

11. How expensive (per head) are the staff who perform this process?
    a) Less than Kshs 120k/year ☐
    b) Kshs 120 – 240k/year ☐
    c) Kshs 240 – 480k/year ☐
    d) Kshs 480 – 720k/year ☐
    e) More than Kshs 720k/year ☐

12. How frequently does the screen estate change?
    a) Yearly ☐
    b) Every six months ☐
    c) Every three months ☐
    d) Every month ☐
    e) Every week ☐

13. How many disparate systems are involved in the process? (Please provide numeric responses only)

____

14. What is the average handling time for the process (end-to-end)? (Please provide numeric responses only)

____

A.2 RPA Process Selection

Process Name: ____

1. Is there standard data input?
   a) Yes ☐
   b) No ☐

2. Where does the process receive data from?
   a) Standard template ☐
   b) Emails ☐
   c) Ad-hoc ☐

3. What type of processes are involved?
   a) Manual and repetitive ☐
   b) Semi-manual and repetitive ☐
   c) Automated ☐
   d) Manual but not repetitive ☐

4. How much volume of data is processed using these processes?
   a) High volume ☐
   b) Medium volume ☐
   c) Low volume ☐

5. How many distinct screens are involved in the process execution?
   a) 1 – 5 ☐
   b) 6 – 10 ☐
   c) 11 – 15 ☐

d) 16 – 20 ☐

6. What is the error rate experienced during process execution?
    a) High ☐
    b) Average ☐
    c) Low ☐

7. Are the processes expected to change?
    a) Yes ☐
    b) No ☐

8. Any other comments

____

____

____

____

____

Appendix B: Full-Time Equivalent (FTE) and Process Complexity Calculator

1. Potential FTE Benefits and Automation Percentage Calculation

Table B.1 Potential FTE Benefits and Automation Percentage Calculation

Enter Details Here	
Process Name	
Full-Time Equivalent (FTE)	
Rule Based	
Standard Input	
Free Text	
Type	
Process Expected to Change <6 Months	
Exceptions	
Potential FTE Benefits	
Automation %	

*This is only to assess processes at a high level

*Indicative figures are subject to change after deep dive assessment of the processes

2. FTE Weight Calculation

Table B.2 FTE Weight Calculation

Description	Weight
Rule Based process	
Standard Input	
Yes	
No	
Free Text	
Yes	
No	
Type	
Manual and Repetitive	
Semi-Manual and Repetitive	
Automated	
Manual but Not Repetitive	
Process Expected to Change	
Yes	
No	

3. Complexity Calculator

Table B.3 Complexity Calculator

Enter Details Here	
Process Name	
Standard Input	
Free Text	
Application Type	
Number of Screens	
Virtual Desktop Infrastructure (VDI)/Citrix	
Complexity %	
Complexity	

*This is only to assess the processes at a high level.

*Indicative figures are subject to change after deep dive assessment of the processes.

4. Complexity Weight Calculator

Table B.4 Complexity Weight Calculator

Description	Weight
Free Text	
Structured Input	
Yes	
No	
Inputs / Applications	
More Than One Input	

System Applications	
Web Applications	

5. Number of Screens Weight Calculator

Table B.5 Number of Screens Weight Calculator

Number of Screens	Weight
0 – 10	
11 – 20	
20 – 30	
More than 30	

6. Quadrant Determinant

Table B.6 Quadrant Determinant

Complexity	Benefits	Quadrants

*Effort depicted is total effort covering deep dive, development, testing and hypercare.

*Estimated effort per process in each quadrant

Appendix C: Process Design Document

Objective and benefits
A detailed Process Design document is critical to the design of the solution. This document contains detailed information about the process and sub process in a project. The main purpose of a Process Design Document (PDD) is to describe the manual process that is to be automated. A PDD specifies exactly how the process is to be carried out
How to use this tool/enabler
This tool is a document to describe the process that is to be automated, the headings in the document are self-explanatory to understand how the tool is to be used.
When to use this tool/enabler
This tool is used before the start of the development of the process to refer to the AS-IS process.

1. Introduction

The main purpose of a Process Design Document (PDD) is to describe the manual process that is to be automated. A PDD specifies exactly how the process is to be carried out. A diagram and descriptions of every subprocess should be included.

2. Purpose

[Describe the business goal which is fulfilled by the requirements gathered. These objectives should support Overview (section 1). The objectives should be understandable, measurable, and concise. This section serves as the vision statement for the requirements.]

3. Process Walkthrough

[The primary purpose of the process walkthrough is to capture the detailed requirement from the subject matter expert in achieving the set goal. A process walkthrough may contain the flow of events describing the interaction between various applications to complete a process. The walkthrough may also be represented visually in process maps or Flowchart in order to show relationships among subprocesses.]

3.1 Subprocess 1: Creating Appointments on the Warehouse Management System

[Insert text]

3.1.1 Sub Process 1 Flow Diagram AS-IS

[Insert diagram]

3.2 Subprocess 2: Creating Shipment Orders on the Warehouse Management System

[Insert text]

3.2.1 Sub Process 2 Flow Diagram AS-IS

[Insert diagram]

4. Solution Design

4.1 Solution Description

[The primary purpose of the solution description is to give an idea regarding the final automated solution: approach adopted and final outcome]

4.2 Sub Process Flow Diagram TO-BE

[Insert diagram]

5. Process in detail

Detailed Click level model template is used to capture the keystroke level steps for development. This document is made at process level and the information is captured at sub-process level.

Process Exception Handling Model is used to ensure all the scenarios and deviations are captured at the design phase itself. This document is made at process level and the information is captured at sub-process level.

6. System and Access Requirements

The table below illustrates the applications/systems required in order to develop and deploy the automation.

Table C.1 System and Access Requirements

	Application Name	Application Version	Application Type	Access Type (Read/Write)	Links/Shared Path
1					
2					
3					

7. In Scope

This section provides a brief description of the scope of the automation in process.

Table C.2 Scope of Automation Process

	Description
1	
2	
3	
4	

8. Out Scope

This section provides a brief description of what has been deemed out of scope for automation; this can include tool limitation or sub process specific scenarios.

Table C.3 Out of Scope Requirements

	Description
1	
2	
3	
4	

9. Assumptions and Dependencies

At a minimum, as the project begins, assumptions and dependencies must be defined. This includes assumptions made at the beginning of the development effort as well as those made during the development.

- Performance Assumptions

  [To document the performance related assumptions which describes efficiency, effectiveness, quality etc. (if any)]

- ➢ System Assumptions

  [To document the specific system assumptions which may change or upgrade in the near future and may impact the automation functionality.]

- Identified requirements state accurate information about the case discussed with <CLIENT> team during meetings and workshops.
- The PDD is written based on applications as the agents are currently using and the equivalent navigation of that application will be provided by <Project Name> team.
- Factors assumed for the completion of this document that are considered to be true, real, or certain without proof or demonstration are identified in the following table.

Table C.4 Assumptions and Dependencies

	Assumptions and Dependencies
1	
2	
3	
4	

10. Risks and Compliance

Include the risks involved in the process

- To identify who will be responsible for managing the project's risks and issues;
- To specify the project's risk and issue management process;
- To determine any infrastructure changes in the near future;

Appendix D: RPA Test Case Template

Process Name: ____

Automation Date: ____

Table D.1 Test Case Table

Step	Step Action Description	Screenshot	Expected Result	Remarks	UAT Result (Pass or Fail)	Comments
1						
2						
3						
4						

Table D.2 Tester/Reviewer Profile

Tester name and role	
Reviewer name and role	
UAT result (Pass or Fail)	
Observations	
Approved for production date	
Date to be released in production environment (cutover date)	

Appendix E: Requirements Traceability Matrix

Process Name: ____

Document Date: ____

Table E.1 Sub-process Activity

ID	Sub-Process Name (Activity)	ID	WBS Activities	Priority

Table E.2 Solution Design Table

Solution Design								
AS IS Process Maps and Detailing			Video recording			PDD		
Status	Baseline Due Date	Actual Delivery Date	Status	Baseline Due Date	Actual Delivery Date	Status	Baseline Due Date	Actual Delivery Date

Table E.3 Build Table

Build								
Handover to Developer			Test Scenarios			Test Data Definition		
Status	Baseline Due Date	Actual Delivery Date	Status	Baseline Due Date	Actual Delivery Date	Status	Baseline Due Date	Actual Delivery Date

Table E.4 Testing Table

Testing								
UAT Plan			Testing			User Manuals		
Status	Baseline Due Date	Actual Delivery Date	Status	Baseline Due Date	Actual Delivery Date	Status	Baseline Due Date	Actual Delivery Date

Table E.5 Deployment Plan

Training			Lessons Learned			Handover Documentation		
Status	Baseline Due Date	Actual Delivery Date	Status	Baseline Due Date	Actual Delivery Date	Status	Baseline Due Date	Actual Delivery Date

Appendix F: Solution Design Document

1. As-Is Process

[Insert as-is diagram]

2. Solution Requirements

[Insert text]

2.1 Infrastructure Requirements

- Blue Prism to be installed on a development workstation/virtual machine (VM)
- SQL Server
- Access to all systems identified under impacted systems to perform the necessary functions
- Four gigabytes of RAM on the development workstation required for development and testing
- A physical desktop/laptop for development purposes
- Relevant usernames and passwords

2.2 Other Requirements

- Access rights
    - The bot is required to have the required permissions to use Microsoft Excel 2016 as well as Infor Supply Chain Execution's warehouse management system.
- Environment
    - The solution will be deployed and maintained in accordance with warehouse management standards.
- Security
    - All sensitive client information will not be shared on networks outside that of the agreed parties.
- Data requirements
    - Dummy processes and data will be created in order to facilitate development.

3. To-Be Process

[Insert to-be diagram]

4. Exception Handling

Table F.1 Exception Handling Template

Exception	Exception Type (Business, System, User)	Exception Reason	Exception Handling

Appendix G: Functional Testing

i. Shipment Order Creation

Table G.1 Shipment Order Creation Testing

Test Name	Shipment Order Creation		
Test Description	Testing whether the software robot can successfully create a new shipment order		
Steps	Robots Actions	System Response	Pass/Fail
1	Robot launches the warehouse management system	The system launches and loads the login page	Pass
2	The robot logs into the system using login credentials	The system validates the login credentials and grants the robot access	Pass
3	The robot selects the Tatu City warehousing facility	The system loads the Tatu City facility details	Pass
4	The robot expands the WMS menu option	The system expands the WMS menu option	Pass
5	The robot clicks on Outbound	The system loads the Outbound dropdown menu	Pass
6	The robot clicks on Shipment Order	The system loads the Shipment Order dropdown menu	Pass
7	The robot clicks on 'New'	The system loads the New Shipment screen	Pass
8	The robot populates the new shipment order fields	The system gets the shipment order details	Pass
9	The robot exports the shipment order details to excel	The system exports the excel sheet	Pass
10	The robot emails the exported Excel sheet to specific personnel for action	The exported excel sheet is sent as an email attachment to specific personnel for action	Pass
Comment	Exceptions were thrown by the robot in cases where mandatory fields were left blank.		

Test Pass/Fail	Pass

ii. Daily Inventory Reports Generation

Table G.2 Daily Inventory Reports Generation Testing

Test Name	Daily Inventory Reports Generation		
Test Description	Testing whether the software robot can successfully generate the daily inventory reports		
Steps	Robots Actions	System Response	Pass/Fail
1	Robot launches the warehouse management system	The system launches and loads the login page	Pass
2	The robot logs into the system using login credentials	The system validates the login credentials and grants the robot access	Pass
3	The robot selects the Tatu City warehousing facility	The system loads the Tatu City facility details	Pass
4	The robot expands the WMS menu option	The system expands the WMS menu option	Pass
5	The robot clicks on Inventory	The system loads the Inventory dropdown menu	Pass
6	The robot clicks on Balances	The system loads the Inventory Balances screen	Pass
7	The robot enters the customer’s name in the owner’s section and clicks ‘Enter’	The system accepts the robot’s input	Pass
8	If inventory is available, the robot clicks on ‘Export’	The system exports the inventory report	Pass
9	The robot saves the Excel sheet in the Daily Inventory Reports folder	The system saves the Excel sheet in the specified folder	Pass
10	The robot reads the customer’s email address from the email field of the Customer Listing Excel file	The system gets the customer email address	Pass

11	The robot attaches the Excel file to Outlook email	The system attaches the Excel file to Outlook email	Pass
12	The robot enters the customer’s email address in the ‘To’ field of the email, types in the file’s name as the subject and sends the email	The system populates the customer’s email address in the ‘To’ field of the email, populates the subject of the email and sends the email	Pass
13	The robot exits the application if there are no more customers in the Customer List	The system exits	Pass
Comment	Exceptions were thrown by the robot in cases where mandatory fields were left blank.		
Test Pass/Fail	Pass		

Appendix H: Usability Testing

Usability Testing

This form has been designed to obtain feedback on aspects of the developed solution from a business user's perspective. Please select your response from the options provided under each question.

* Required

1. **Email address** *

2. **1. How easy was it to use the software robots?** *
   Mark only one oval.
   - Easy
   - Intermediate
   - Hard

3. **2. Was the training provided on RPA useful?** *
   Mark only one oval.
   - Very useful
   - Somewhat useful
   - Not useful

4. **3. Functionality: Does the solution meet the specified requirements?** *
   Mark only one oval.
   - Yes
   - No

5. **4. Would you like for the developed solution to be implemented by the organisation?** *
   Mark only one oval.
   - Yes
   - No
   - Undecided

☐ Send me a copy of my responses.

Powered by Google Forms