DEVELOP THE WAREHOUSE MANAGEMENT SYSTEM: A CASE STUDY OF PAPER MANUFACTURER

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ABSTRACT

This research involves the study and development of a warehouse management system (WMS) in the paper industry; more specifically, it is a case study of Thai Paper Company Limited. The purpose of the WMS was to store the finished products efficiently in a limited area. In the former system, the inventory application did not indicate the products' position nor did it indicate the space where products were stored. This caused errors in searching for products. In addition duplicate and conflicting data sometimes occurred also, the inventory application could not be related to the main system, SAP and the other systems.

This research aimed to solve the problems mentioned above by developing a WMS to replace the former system. This new system aimed to increase the efficiency in decisions making regarding products' position, to reduce the errors in searching for products, as well as reduce the warehouse checking time and warehouse overflow and installation cost.

The results revealed that the new WMS enabled users to make a better decision in terms of the allocation of space in the warehouse. According to the satisfaction evaluation, 20.34% of the users were very satisfied with the system; 68% were satisfied; and 11.67% were neither satisfied nor dissatisfied.

KEY WORDS: WAREHOUSE MANAGEMENT SYSTEM/ WMS/ PAPER MANUFACTURER

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บทคัดย่อ

งานวิจัยนี้ เป็นการศึกษาและพัฒนาระบบการจัดการคลังสินค้า ในธุรกิจอุตสาหกรรมกระดาษ กรณีศึกษา บริษัท ผลิตภัณฑ์กระดาษไทย จำกัด ในการจัดเก็บสินค้าสำเร็จรูปให้ได้อย่างมีประสิทธิภาพในพื้นที่จำกัด ซึ่งระบบเดิมในการจัดเก็บสินค้าไม่สามารถระบุตำแหน่งที่ตั้งของสินค้าและพื้นที่ว่างที่จะนำสินค้าเข้าไปจัดเก็บได้ จึงเกิดความผิดพลาดในการค้นหาสินค้า ระบุตำแหน่งของสินค้า การหยิบสินค้าผิดพลาดบ่อยครั้ง รวมทั้งโปรแกรมการจัดเก็บสินค้าไม่สามารถเชื่อมโยงข้อมูลกับระบบ SAP ซึ่งเป็นระบบหลัก และระบบอื่นๆที่ใช้อยู่ในปัจจุบัน จึงทำให้เกิดความซ้ำซ้อนและความผิดพลาดของข้อมูล

งานวิจัยนี้จึงมุ่งเน้นในการแก้ปัญหาดังกล่าวโดยการพัฒนาระบบการจัดการสินค้า แทนโปรแกรมการจัดเก็บสินค้าเดิม ซึ่งจะเพิ่มประสิทธิภาพในการตัดสินใจเลือกตำแหน่งในการจัดคลังสินค้า, ลดความผิดพลาดในการค้นหาสินค้า, ลดเวลาในการตรวจสอบคลังสินค้า, ลดปัญหาสินค้าล้นคลัง และลดค่าใช้จ่ายในการติดตั้งและใช้งาน

ผลการใช้ระบบการจัดการคลังสินค้า พบว่าสามารถเข้าไปช่วยในการตัดสินใจจัดการพื้นที่ในคลังสินค้าเป็นอย่างมาก จากการประเมินความพึงพอใจของผู้ใช้ระบบร้อยละ 20.34 พึงพอใจอย่างยิ่งร้อยละ 68.00 พึงพอใจ และร้อยละ 11.67 รู้สึกเฉยๆ

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114 หน้า

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CHAPTER I
INTRODUCTION

1.1. Background and Problems statement

In the world of business, warehousing has the important role in supply chain and more effects both success and failure in business. The professionals of logistics have been improving existing warehouse operations, the productivity, quality, and cycle time. To support customer demand the important factor is just in time while technology is the part of warehouse management improvement.[4]

The warehouse management systems (WMS) is used to control the movement and storage of materials within an operation and process of the associated transactions. Directed picking, directed replenishment, and directed put away are the key to WMS. The detailed setup and processing within a WMS can vary significantly from one software vendor to another, however the basic logic is a combination of item, location, quantity, unit of measure, and order information to determine where to stock, where to pick, and in what sequence to perform these operations.

The case of Thai Paper Co., Ltd producing the goods both by orders and standard sizes has customers both domestic, Bangkok and circumference, and export. The products of Thai Paper Co., Ltd have many SKUs and need a lot of storage area where is free from damp and any damages. From these conditions cause the shortage storage area and sometimes making the products adulteration due to the area optimization. There are also the mistakes in the put-away and picking, the average picking mistakes are 3-4 times a day, which are waste of time and may cause the dragging in the delivery. For the inventory management system, the company cannot develop the system to connect to main system (SAP system) using the existing information.

Theses are the reasons to study the inventory management system to solve the location problem which emphasizing on location decision as the best

location suggestion, finding the free space, finding the goods for delivery and supporting the warehouse operations including the reports. The researcher also expects that WMS would have the effectiveness in location management and can improve the performance of warehousing.

As the above reasons, the researcher is interested in the warehouse management system (WMS) to solve the location problem and to make a convenient decision for the best storage location. The researcher also expects that WMS would have the effectiveness in location management and can improve the performance of warehousing.

1.2. Objectives

The main object of study is to design and develop a prototype for Warehouse Management System in this case study.

1.3. Scope of work

A case study of paper manufacturer on the warehouse management system application has the following scopes of work:

1. The warehouse management system including the goods receiving, put-away, goods picking, goods returning and warehouse checking on the concepts of First in First out (FIFO).

2. The location management mentioned in this study refers to only the Domestic and Export Zone.

3. The goods management mentioned in this study refers to the goods status; normal, broken, hold.

4. The goods transactions including category, searching and location suggestion.

1.4. Expected results

The expected result is the warehouse management system that would be improved in the location decision.

CHAPTER II
LITERATURE REVIEW

2.1 Business Review

2.1.1 Warehousing [2][31]

A warehouse is a commercial building for storage goods. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs, etc. Some warehouses are completely automated, with no workers working inside. The pallets and products are moved with a system of automated conveyors and automated storage and retrieval machines coordinated by programmable logic controllers and computers running logistics automation software.

The direction and tracking of materials in the warehouse is coordinated by the WMS, Warehouse Management System, which is a database driven computer program. The WMS is used by logistics personnel to improve the efficiency of the warehouse by directing putaways and to maintain the accurate inventory by recording warehouse transactions. Traditional warehousing has been declining since the last decades of the 20th century with the gradual introduction of Just In Time (JIT) techniques designed to improve the return on investment of a business by reducing in-process inventory.

The warehousing is more important, it warehousing increases the utility of goods by broadening time availability to prospective customers. In other words, by using warehouses, companies can make goods available *when* and *where* customers demand. This warehousing function continues to be increasingly important as companies and industries use customer services as a dynamic, value-adding competitive tool.

2.1.1.1 Warehouse Operations

To understand the warehouse operations, the movement and the storage processes are shown in Figure 2.1

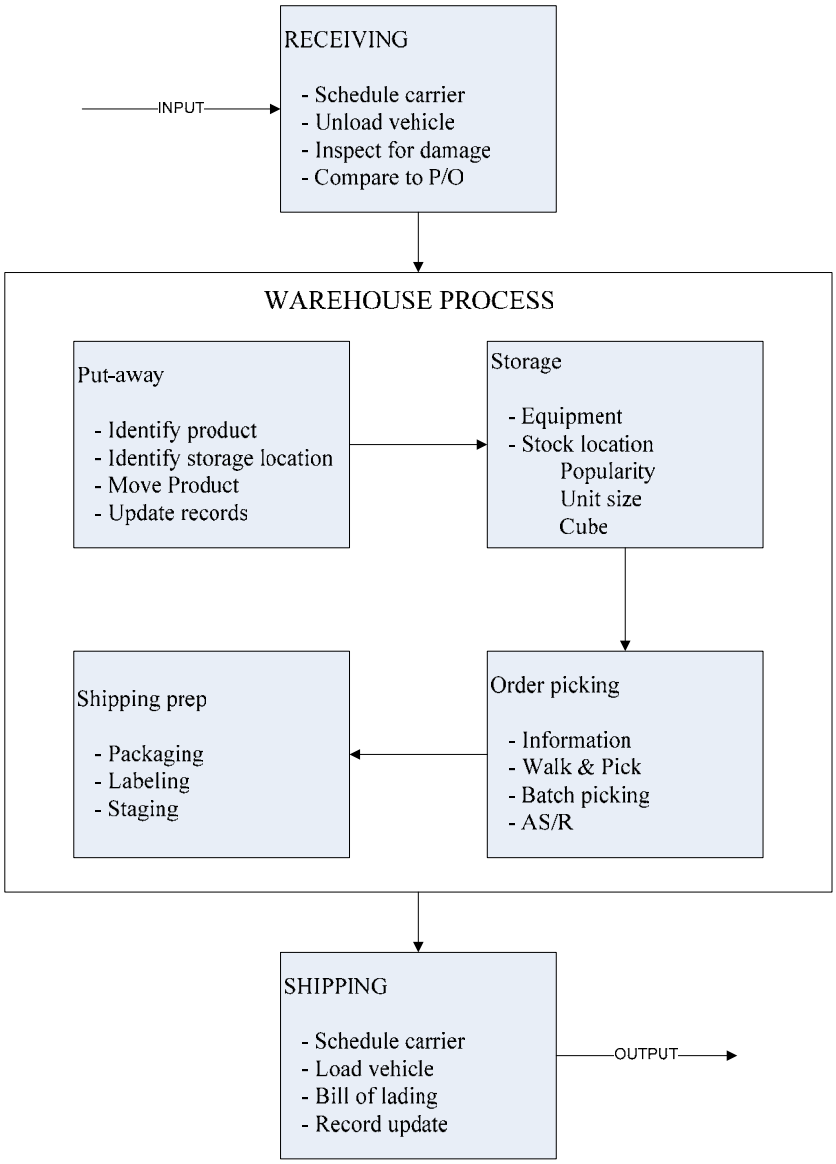


Figure 2.1 warehouse operations: the movement and storage processes [2]

Receiving: At the receiving operation, it allows the warehouse to schedule receipt and unloading within the warehouse. Product will be inspected and any noted exceptions, such as damage, incorrect counts, wrong descriptions, and so on.

Put-away: The put-away operation physically moves the items from receiving location to the storage area of the warehouse. When product is put-away, the storage location should also be scanned to record where the product has been placed. This information will subsequently be used to construct efficient pick-lists to guide the order-pickers in retrieving the product for customers.

Order-picking: This process requires warehouse personnel to select the items ordered by the customer or manufacturing operation in the storage area. The order information is given to the warehouse personnel on a pick slip. The AS/R process is an automated storage while retrieval materials-handling system would run the picking process, when the order arrives at the shipping preparation area, the items would be placed in an exterior (shipping) package or on a pallet. Then, a shipping label indicating the ship-to person/firm and address is attached to the package. Finally, the complete customer order is staged for loading into the transport vehicle.

Shipping: The final movement process occurs at the shipping operation. Product is likely to be staged if it must be loaded in reverse order of delivery or if shipping long distances. When one must work due to the staged freight, it must be double handled. The trailer is likely to be scanned here to register its departure from the warehouse.

2.1.1.2 Equipment

Forklifts [29]

Forklift is a powered industrial truck used to lift and transport materials, normally by means of steel forks inserted under the load. Forklifts are most commonly used to move loads stored on pallets. The load capacity is 3,000 – 5,000 kilogram and it uses power diesel, electric and LPG.

Figure 2.2 Specifications of Paper Handling Forklifts

2.1.1.3 Storage Platform

Pallets

A pallet is a flat transport structure designed to support a variety of goods in a stable fashion while being lifted by any mobile forklift or other jacking devices. The goods are placed on top of the pallet, and can be secured by straps or stretch-wrapped plastic film. While most of pallets are made of wood, pallets manufactured from plastic, metal, paper can also be found.

Figure 2.3 Disposable pallet and 2-way entry pallet

2.1.1.4 Conventional storage system

Block Stacking

Bulk storage using block stacking can result in the minimum cost of storage since cube utilization is high and no storage medium is required, but material accessibility is low since only the top of the front stack is accessible and loads at bottom of a stack must not require support.

2.1.1.5 Design of fast picking area [2]

The fast-pick or forward-pick area is one that is convenient to pick. Many of the most popular stock keeping units are stored in relatively small amounts, so that most picking can be accomplished within a relatively small area. The fast-pick area may require replenishment from bulk storage, or reserve. The fast picking zone is essential in achieving high productivity in zone picking and most effective in large operations with high total number of SKUs, high total numbers of orders.

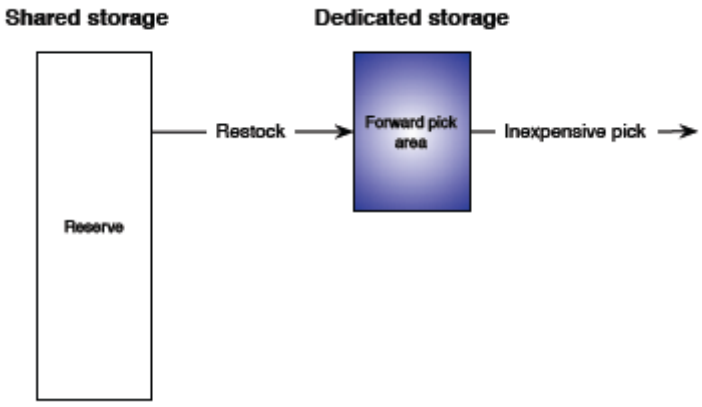


Figure 2.4 In the simplest case, all the SKUs in the fast-pick area have been already chosen.

Benefit of fast pick area is a concentrating activity in a small footprint to reduce picking costs increasing the responsiveness and free up space to deal with growth, seasons, and other fluctuations. The configuration of a warehouse can be optimized based on physical size of the SKUs and a history of customer orders. To do this, the researcher must know the physical dimensions of the storage units and the number of selling units per storage unit.

2.1.2 Warehouse management system (WMS)

A warehouse management system (WMS) is basically just the software to track and manage warehouse activities. It is a database of SKUs and a stock locater system so the firm can manage the inventory of SKUs and inventory of storage locations. WMS is generally built around an industrial strength relational database product such as Oracle, Informix, Sybase, DB2, or other. At a minimum, the database tracks all product arriving and all product shipped out.

WMS should track the inventory of storage locations in the warehouse. The good WMS would track every place where product can be which including the forks of individual forklift trucks and manage the inventory of storage locations. The WMS should enable warehouse operators to optimize pick, put-away, and

replenishment functions by employing powerful system logic to select the best locations and sequences. [4]

A Basic feature of WMS including tools to support

- Appointment scheduling
- Receiving
- Quality assurance
- Put-away
- Location tracking
- Work-order management
- Picking
- Packing and consolidation
- Shipping

High-end features including support for

- RF-directed operation
- Cycle counting
- Carton manifesting
- Replenishment
- Value-added services
- Vendor/carrier compliance
- Trailer manifesting
- Configurability
- Returns
- Pick/put to light
- Yard management
- Wave management
- Labor management
- Task interleaving
- Flow-through processing

Advanced features including support for

- Multi-DC view
- SKUs slotting
- Broken-case flow

- EDI capability
- Parcel shipping
- Impact analysis
- Traffic management
- Import/export management
- ASP capability

The warehouse advantage features with radio frequency (RF) devices, bar-code tags. Warehouse management systems (WMS) are used to manage the movement and storage of materials in a warehouse. There are three types of products: Tier 3, Tier 2, and Tier 1. Tier 3 WMS are the least expensive type. They allow warehouse personnel to manage the flow of materials on conveyors and can be integrated into picking systems. Tier 2 WMS applications are more robust than Tier 1 systems, but do not contain all of the features of a Tier 3 WMS. Typically, WMS are used in large-scale or high-volume warehousing environments. Storage location management, automatic order selection, inventory control & replenishment, and shipping & receiving are common features.

Advantages of Warehouse Management System (WMS)

1. Reducing Errors in receiving, stocking, picking, and shipping operations.

2. Improving Inventory Accuracy through barcode products and bin locations.

3. Increasing Productivity by having operators spend more time on receiving goods and filling orders.

4. Reducing Paper Work by rendering daily activities forms obsolete.

5. Improving Space Utilization by logical stocking of different-sized products.

6. Eliminating the Physical Inventory through inherent accuracy and cycle counting features of WMS.

7. Controlling with the better Workload Control from the view of completed and upcoming activities.

8. Improving Labor Management and Reporting due to WMS vast reporting capabilities.

9. Supporting EDI Requirements through the detailed shipping information automatically generated by WMS.

2.1.2.1 Commercial WMS software

MySAP [28]

mySAP Supply Chain Management (mySAP SCM) is an integrated supply chain management solution for planning, execution, coordination, and collaboration of all supply chain activities. It can define and manage all types of storage areas, such as rack storage, bulk storage, picking area with fixed storage bins for each material, and ground-level shelving. The warehouse management capability of mySAP supports the rational packing process, goods issue to shipping, goods receipt of raw materials and trading goods, goods receipt and put-away, replenishment in the picking area, production supply and Support RF (Radio Frequency)

This software achieves complete stock transparency and always knows what is in the warehouse. It can show the history of the warehouse processes in detail. The warehouse processes reduce significantly the error rate, cost per transaction and cost of paper. For this reason, the business can increase customer satisfaction.

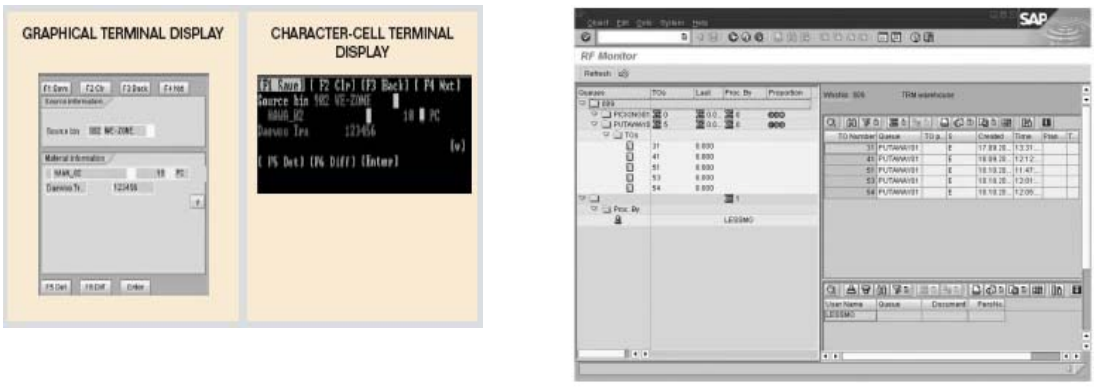


Figure 2.5 WMS with MySAP Screen

Oracle Warehouse Management [27]

Oracle WMS offers order, cluster, zone, bulk, label based or user configurable pick methodologies. Oracle WMS automated task prioritization as well as task dispatching based on user and equipment skill sets. Oracle WMS can optimize warehouse storage space based on directed put-away and dynamic slotting. Optimal storage locations are configurable parameters like velocity, size (volume) and material classifications rules. This software makes flexibility with the support of lot and sub-lot control, dual unit of measure, grade, potency and any number of flexibly defined other attributes of products.

Oracle WMS supports the reverse logistic operations and product received on returning document guiding the subsequent inspection and rework processing. The Oracle WMS can improve operational productivity and reduce cost through process automation, storage optimization, automated task, dispatching and cross docking. Oracle WMS increases accuracy, data and shipment via bar code scanning and tracking

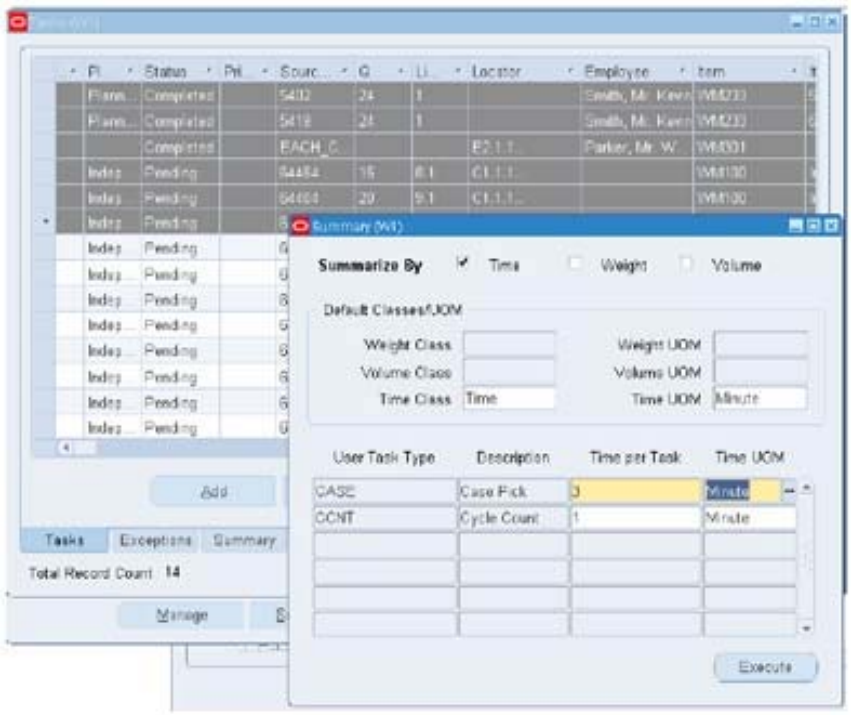


Figure 2.6 Oracle WMS Screen

Microsoft Dynamics AX for industrial distributors [26]

Microsoft Dynamics AX for industrial distributors is a Microsoft product which supports the financial systems with sales, warehouse operations, suppliers, and customers. Dynamics AX integrating automatic data collection functionality with enterprise resource planning (ERP) and support Standards-based radio frequency identification (RFID) infrastructure platform. Dynamics AX integrated with Microsoft products; Microsoft SQL Server 2000, Microsoft Internet Information Services 6.0, the Microsoft Office system, and the Microsoft Office Outlook 2003 messaging client. Dynamics AX was designed with one database, one toolbox, one business logic, and one source code. Dynamics AX easy implemented web based systems for customer communications and accurate demand-forecasting models.

Adonix X3 [19]

Adonix Geode GX is a versatile Warehouse Management System (WMS) designed for mid-sized manufacturers and distributors that can run either stand-alone or as an integrated component of Adonix X3. Adonix supports RF devices, barcode scanner, barcode wands, keyboard wedges, hand-held scanner and clocking stations. Overall System, Adonix X3 supports ASN/expected receipt, Stock reservation management, Batch/lot control, Serial number control, Transfers and external warehouse management, Date management: Expiration, Use By, Sell By, FIFO, LIFO, other ,EAN-13 code management ,GALIA, INOVERT, EDIFACT and EANCOM EDI standards supported (using 3rd Party translation tools). It supports for industry-standard Windows and Unix operating systems as well as Microsoft SQL Server and Oracle databases.

CatalystCommand Warehouse Management [22]

CatalystCommand Warehouse Management manages all aspects of distribution center warehouse operations including receiving and put-away to order selection, picking, loading and shipping. The system interfaces are easier installation and tighter integration between systems, applications and equipment. Benefits include the inventory reduction, cost savings, higher throughput and

customer satisfaction improvement. The system support RFID technology. Being a web-based application, it is scalable and resides on a thin server or a series of servers.

SAP System [28]

SAP (Systems, Applications and Products in Data Processing) stands for Systems, Applications and Products in Data Processing. It is the name of the company and also the name of the software. It is one of the ERP (Enterprise Resource Planning) systems. Similar products are Oracle and Peoplesoft. ERP is used by companies to plan, organize, integrate and manage their various operations like accounting, financing, manufacturing and human resources. The main target is to improve the efficiency and accuracy.

ABAP (Advanced Business Application Programming)

ABAP is the programming language used by SAP developers to build transactions that make up the R/3 application. It is also used by companies to customize the R/3 application; providing additional business functionality.

Accellos WMS

Accellos WMS is a WMS module of the SAP system. Accellos WMS supports warehouse operation; Picking, Receiving, Counting, Locating, Adjustments, Lots/Serial Tracking, Order Allocation, Wave Planning, Management Reporting, Single carrier Shipping and Expiry Management. This system supports RF (Radio frequency) and wireless devices.

Accellos WMS provides functional enhancements to SAP Business One include:

- Multi-bin inventory allows the warehouse to optimize stock movement
- Real-time inventory position lets the enterprise making the better decisions
- Batch and serial traceability let companies granularly manage their inventory
- Bar code enabling processes enforce accuracy, resulting in increasing customer satisfaction and reducing error handling costs.

- Hard allocation reserves product from specific bin locations, ensuring that the right product goes to the right customer.
- Flexible allocation lets the warehouse reserving stock by FIFO, LIFO or expiry date
- Advanced pick and pack screen allow more flexible pick document release, resulting in the optimized workload batches.
- Flexible zone configurations allow the warehouse to efficiently distribute workload between employees and set up quarantine areas.
- Pack size handling lets the warehouse meeting customer specific pack size ordering requirements, optimizing materials handling equipment usage and reducing bin replenishment.
- Labor statistics reporting allows the warehouse to manage employees efficiently and forecast labor requirements.

Commercial WMS software has a full feature to support warehouse operation for receiving, put-away to order selection, loading and shipping transaction. Some software has a location decision support but it cannot integrate with SAP system and expensive cost. This case study has a specific style to set up location and is flexible to allocate the location. These are the results of design and WMS software development for the case study.

2.2 Technical Review

2.2.1. Borland Delphi 2006 [1][23]

Borland Delphi is a visual programming tool that a powerful OOP language used primarily to build the client/server application for Microsoft Windows or Linux, with an emphasis on databases. Based on Object Pascal, it was designed to give developers the ability to build applications easily. You can write Win32 applications and recompile to code based on this class library, the VCL and .NET. You can move code from the VCL to CLX and have RAD program running natively on Linux.

Delphi is distributed in various versions with different features: Personal, Professional, Enterprise and Architect. Delphi for the linux platform is Borland Kylix. Delphi and Kylix complie source code into native x86 code or managed .NET code. They include the VCL/CLX (Visual Component Library), supporting the COM independent interfaces with reference counted class implementations, and supporting a large number of third party components. A strong emphasis is placed on database connectivity.

Database connectivity is InterBase, dBase, Paradox, ADO, MySQL, Microsoft SQL Server and more.

Delphi Advantages

- Suitable for Rapid Application Development (RAD)
- Based on a well-designed language, high-level and strongly typed, but being able to use low-level code for hardware access and performance(McConnell 1993:49)
- A large community on Usenet and the web
- Can compile to a single executable, simplify distribution and eliminate DLL version issues
- Many VCL (Visual Component Library) and third-party components (usually available with full source code) and tools (documentation, debug tools, etc.)
- Quick optimizing compiler is able to use assembler code
- Multiple platform native code from the same source code
- High level of source compatibility between versions
- Class helpers to bridge functionality available natively in the Delphi RTL
- The language's object orientation features only class- and interface-based polymorphism
- Delphi 2005, Delphi 2006 and Delphi 2007 all of which support advanced refactoring features such as Method Extraction, etc.

- Metaclasses are first class objects
- There are dedicated string types (as well as null-terminated strings). Strings can be added by using the '+' sign, rather than using functions.
- Objects are actually references to the objects (like in Java), which Delphi implicitly dereferences
- Delphi is strongly type-based.
- Delphi's compiler is extremely efficient and fast.
- Early adopter of "Dependency Injection" or "Inversion of Control". The VCL is a sophisticated "re-usable" component model, extensible by the developer.

Delphi 2006 Professional

Delphi Studio 2006 with the complete RAD can support for C and C# in addition to Delphi Win32 and Delphi for .NET programming languages. It is designed for individual developers, ISVs, and smaller organizations building desktop and Web applications with local database connectivity. Delphi 2006 is a complete environment for the visual design, compilation, and debugging for Windows applications. Program can be targeted for Win32 and Microsoft .NET applications using a common source code base.

- RAD with supporting the Delphi, C++ and C# programming language
- Visual WYSIWYG client and Web application development
- Local database connectivity for Borland InterBase®, dBase®, Paradox®, ADO, MySQL®, MSDE®, and Access
- Basic object-relational mapping and transparent local xml object persistence features
- Win32, Microsoft .NET, and ASP.NET support

2.2.2 PHP (Hypertext Preprocessor) [5]

PHP is a server-side scripting language for creating dynamic web pages as well as with ASP or ColdFusion. It can be embedded into HTML. The PHP code is enclosed in special <??> that allows you jumping into and out of "PHP mode". PHP or something like client-side JavaScript is the code executed on the server, generating HTML which is sent to the client. PHP files would be ended in .php. Server is the default extension for PHP files. PHP runs on many operation system; Windows NT, Windows Server, Unix, Linux and other.

PHP supports many databases such as Microsoft SQL Server, MySQL, PostgreSQL. PHP can support talking to other services using protocols such as LDAP, IMAP, SNMP, NNTP, POP3, HTTP, COM. PHP also supports Java objects and using them transparently as PHP objects. It can use CORBA extension to access the remote objects.

Adabas D	InterBase	PostgreSQL
dBase	FrontBase	SQLite
Empress	mSQL	Solid
FilePro (read-only)	Direct MS-SQL	Sybase
Hyperwave	MySQL	Velocis
IBM DB2	ODBC	Unix dbm
Informix	Oracle (OCI7 and OCI8)	
Ingres	Ovrimos	

Table 2.1 Database Support PHP

PHP Advantages

1. PHP can run on many Operation systems such as Windows NT, Unix, Linux and other.
2. PHP can build an Apache module, IIS, CGI.
3. PHP is an Open Source which is free download at http://www.php.net/
4. PHP can use with XML.
5. PHP can use with file systems.

The official PHP web site

- http://www.php.net
- http://www.zend.com
- http://www.phpbuilder.com
- http://www.phpwizard.net
- http://phpclasses.upperdesign.com
- http://weberdev.com

2.2.3 Database

RDBMS [6][24]

RDBMS is a Relational Data Base Management System Relational DBMS. A database management system is a complicated program used to create, process, and administer the databases. The condition that the system supports a tabular structure for the data, with enforced relationships between the tables. This excludes the databases that do not support a tabular structure or do not enforce relationships between tables.

RDBMS must support: A data definition language (DDL), A data manipulation language (DML), A data integrity language and A data control language (DCL). The E-R Model explicitly defines relationships. A relation has one primary key which must be a unique key and additional unique key called candidate keys. A foreign key is an attribute placed in a relation to represent a relationship.

Overview SQL [6][30]

SQL (pronounced "see-quell") stands for Structured Query Language. SQL is used to communicate with a database. Today, SQL is an international standard language for relational database management systems. Using SQL, the statement can be the new tables, join tables together, inserted, updated and deleted. It can be queried in many ways. Some common relational database management systems using SQL are: Oracle, Sybase, Microsoft SQL Server, Access, Ingres, etc.

SQL Data Manipulation Language (DML)

SQL (Structured Query Language) is syntax for executing queries. But the SQL language also includes syntax to update, insert, and delete records. These query and update commands together form the Data Manipulation Language (DML) part of SQL:

- **SELECT** - extracts data from a database table
- **UPDATE** - updates data in a database table
- **DELETE** - deletes data from a database table
- **INSERT INTO** - inserts new data into a database table

SQL Data Definition Language (DDL)

The Data Definition Language (DDL) part of SQL permits database tables to be created or deleted. We can also define indexes (keys), specify links between tables, and impose constraints between database tables. The most important DDL statements in SQL are:

- **CREATE TABLE** - creates a new database table
- **ALTER TABLE** - alters (changes) a database table
- **DROP TABLE** - deletes a database table
- **CREATE INDEX** - creates an index (search key)
- **DROP INDEX** - deletes an index

2.3 Measurement of Attitudes

Likert scale [25]

A Likert scale is an attitude measurement used in research. It is a type of response scale often used in questionnaires. The scale is named after Rensis Likert, who published a report describing its use. A Likert scale item is a statement. The respondent is asked to indicate his or her degree of agreement with the statement or any kind of subjective or objective evaluation of the statement. The levels of scale are three, five, seven and nine. Often five ordered response levels are used. It showed in term of mean, variance, skew ness and kurtosis after a simple transformation was applied.

The format of a typical five-level Likert item is:

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

The first step is to define what you are trying to measure. Next you have to create the set of potential scale items and should be rate on 1 to 5 response scale. You can create the items by yourself based on your intimate understanding of the subject matter. The next step is to have a group of judge rates the items and reverse in term of mean, variance or more.

2.4 Related Research

Sumrit Phokhew [13] designed and developed a Material Management & Control System (MMCS) using client/server technology and a relational database for the Major Hollywood Entertainment. The MMC system was developed by Borland Delphi 7.0, operated under Microsoft Window XP. The MMCS consists of 9 functions, i.e. Purchasing, Receiving, Returning to Suppliers, Import Sales History from POS System, Issuing, Returning to Warehouse, Forecasting, Inventory Checking, and Inventory Adjustment.

The result of MMCS application can provide the better operation and management for a retail business. It was flexible and satisfied to retail business activities. MMCS decreased large amount of incorrect data in the current manual system and increased the efficiency of retail business performance.

Nattapol Kithararak [10] developed the prototype warehouse sale order and inventory system via Pocket PC phone using GPRS communication. The tire factory was the case study that supported sales departments with the effective and efficient sales orders. This prototype will work as the order-center for administrators, sale persons and customers. This warehouse sales order system has been created using PHP and MySQL. The application has five sections: A product-data management system and sale order data management through website. A sale person-order, a customer-order, Sale person-order, a summary report system builds via computer PC and a pocket PC phone for the manufacturing department and director. The system would require an internet network for a computer PC or laptop, and the GPRS communication network for a pocket PC phone.

The result of system was very satisfied and decreased the order process. It reduced the processing time by 77.98% and increased the satisfaction of all users.

Yaovares Phainpaniporn [11] developed a prototype at a tracking system in shipment status for improving the efficiency of the working process for both sales and shipping agents. This system was developed by using PHP, MySql and Javascript.

The result of this research was a prototype of a shipment status tracking system which supported working flow. This prototype would connect to a database

for tracking information about the status of each shipment. More than that, it would support users by checking request documents. It would notice if there was any missing document.

Panida Rakmanee [14] studied the feasibility of investment in web-based technology for order tracking system in the fabric textile industry. The author studied the feasibility in technical, operational and financial terms. This study also analyzed and evaluated different components for preparing the web-base, formulated an implementation plan, and calculated the cost of investment for a period of 4 years. The order tracking system in this research consisted of 11 sub-systems, namely: the Information Searching system, the Administration system, the Sales and Credit Evaluation system, the Color Order system, the Order Purchasing system, the Weaving Plan system, the Dyeing Plan system, the Weaving Production system, the Dyeing Production system, the Delivery system, the Invoice system, and the Administrator system.

Peter Ibach and team [12] developed an asset tracking which offered high potential to improve the efficiency of warehouse management. This project was present system MagicMap, that was developed for real-time positioning based on WLAN signal strength measurements, and described how it seamlessly integrated into a warehouse management scenario. This system measured the positioning accuracy and real-time capabilities of MagicMap in comparison with two similar systems (Ekahau and MobileLocator Light) in a typical warehouse setup. Result showed the applicability of all three WLAN-based systems at an average positioning deviation of 3-5 meters and a tracking delay below 150 seconds providing some physical constrains were considered.

Ekachai Sastravaha [16] developed the prototype of Dynamic Programming Model for Optimal Storage proposing the basic in solving the optimal storage problem by means of the dynamic programming theory and control, an automatic machine by microcomputer, microcontroller or microprocessor. So this method may be use in its application to industrial work.

Tanavut Songvanich [17] developed a wireless warehouse application which divided into 2 parts: application for computer and application for handheld device that interchanged information via web service. The first part of application was for computer to demonstrate the information of warehouse areas, fulfill purchasing order and pick up items from sale order which operating on windows Pocket PC and data management with Microsoft SQL Server for Windows CE. Both of applications were developed by Microsoft visual studio .NET and C# language.

Kwanta Rimsuwan [15] designed and developed the application for warehouse management system for Meiko Trans (Thailand) Co., Ltd. The application was developed by Visual Basic under Windows 2000. This system was the inventory stock collecting, inventory management and ordering for customer lists, by using barcode system for data entry. The system was friendly-user and satisfied, reduced procedure and increased potential. This research was useful and could develop the industrial inventory management system.

CHAPTER III
METHODOLOGY

3.1 Step of Research Methodology

The steps of research methodology are base on Software Development Life Cycle (SDLC) which are divided into 6 phases as shown in Figure 3.1

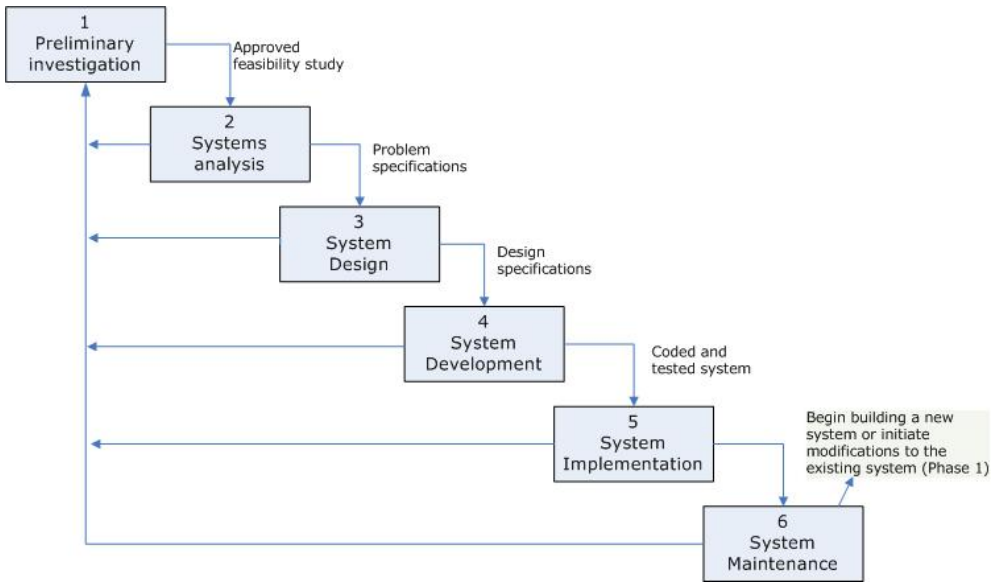


Figure 3.1 Software Development Life Cycle Diagram (SDLC)

3.1.1 Preliminary Investigation

The preliminary investigation is a feasibility study or a system survey to verify a problem or existing deticiency. This research will be studyied the existing information system to find the problem feasibility and objectives. Gathering information of existing system consists of three steps, i.e. user interviews, archival data sources and observing operations

The first step of gathering is to interview the manager and officers of warehouse department about the information background, steps of work, business rule, transaction and existing system including the problems and requirements.

A clearly understanding environment of company. Archival data is gathered from source document, reports, files, system processing and communication channels to keep the investigation well grounded in the ways data and operations are related.

After that it is observing operation to watching the work flow through the office. It may often be useful for the analysis to do the actual work and processing of documents.

3.1.2 System Analysis

After gathering the data completely, the analysis is the next step for identifying the system. Investigating and defying the requirements of Business Activity Model, Data Flow Diagram (DFD) for specifications of system, new system requirements and hardware & software specifications. It will be designed by using a Top-Down method and Microsoft Visio 2003 as a tool. Table 3.1 provides definitions for the symbols used in a DFD.

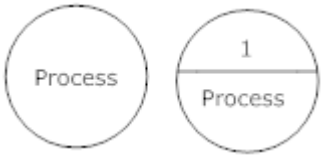
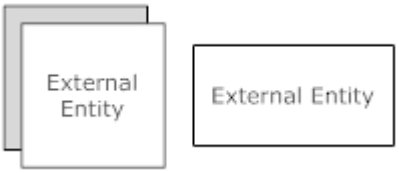
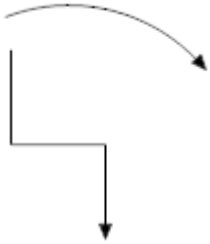
Name	Notation	Description
Process		A process transforms incoming data flow into outgoing data flow.
External Entity		External entities are objects outside the system, with which the system communicates. External entities are sources and destinations of the system's inputs and outputs.
Dataflow		Dataflows are pipelines through which packets of information flow. Label the arrows with the name of the data that moves through it.
Datastore		Datastores are repositories of data in the system. They are sometimes also referred to as files.

Table 3.1 Description of data flow diagram symbols

3.1.3 System Design

Database design

The specifications and requirement of new system consisted of the database management and the warehouse management system application design (Figure 3.3). The database design is base on the relational database management (RDBMS). An Entity Relationship (E-R diagram) and Normalization are the structural represents of the database and transformed into relational tables.

A stored procedure is a name group of SQL statement that have been previously created and stored in the server database. It can reduce the network traffic and latency, boosting application performance. Due to warehouse management

system applications using N-Tier Application model, the researcher needs to write the store procedures. (Figure 3.4)

User Interface Design

User interface designs are graphical. The graphic user interface (GUI) is provided in the internet browser, 2D graphic mode and barcode methods in the computer operating system.

Architecture Design

The architecture designs are included techniques for distributing data, processes, and interfaces to network locations in a distributed computing environment. Physical data-flow diagrams are used to model an information system's architecture, client-server (Lan-based include cable and wireless connections) as shown in Figure 3.5.

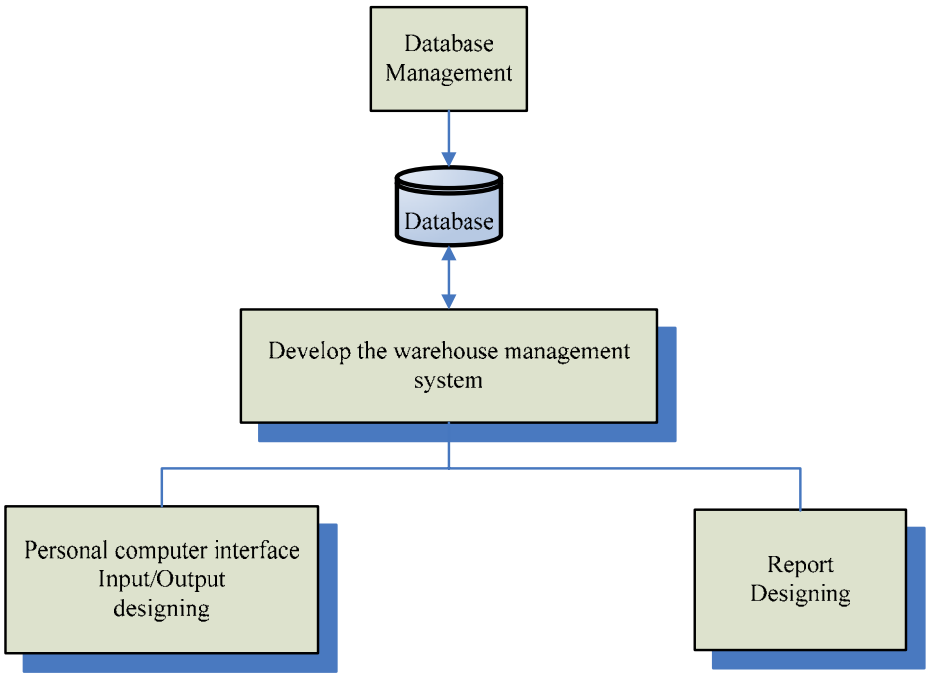


Figure 3.2 Design and development the system

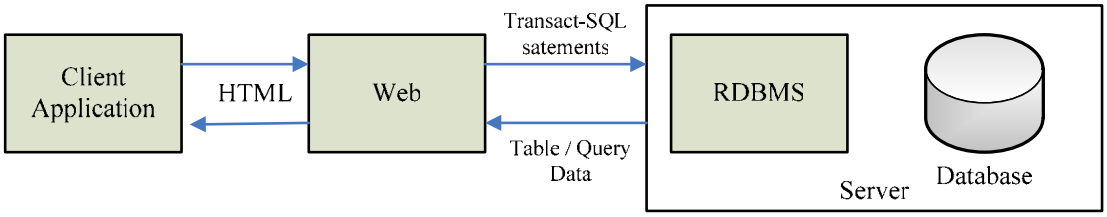


Figure 3.3 Database Connection

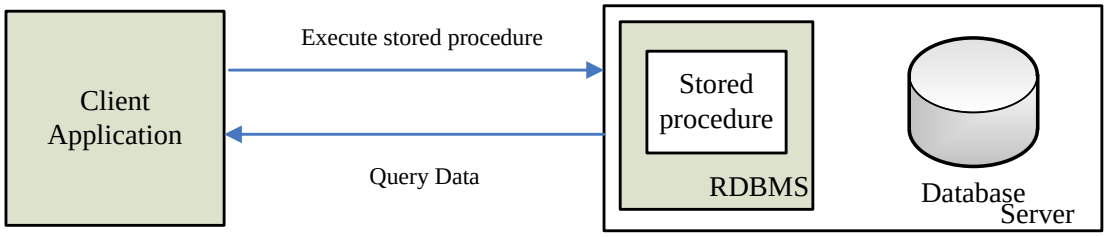


Figure 3.4 Stored procedure database connections

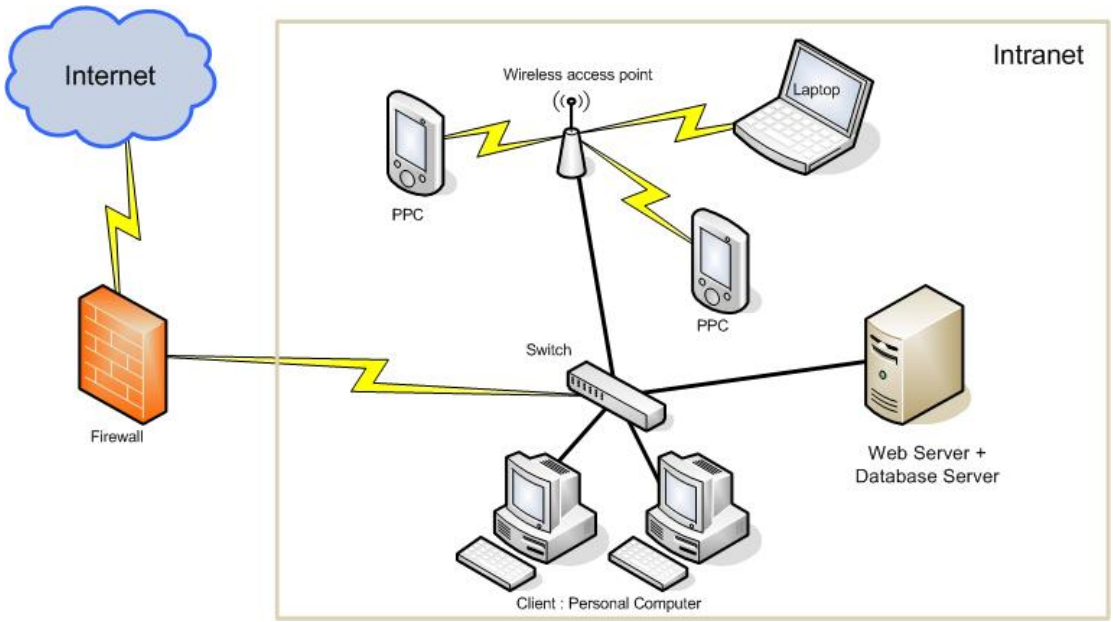


Figure 3.5 Network Architecture Design

3.1.4 System development

The development of system will create system design information in the previous phase. The development of system has three parts. The first is location management application for creating location and setting line. After that the developing warehouse management system application and another is web reporting via intranet network.

The testing system is the final phase in the development of system process so this system will be tested the functional system.

3.1.5 Implementation

The step of implementing the warehouse management system is the hardware and software setting for server such as conflict Database Server, IIS Web Server, installation web application and testing the network system. The researcher will train staff to use the application.

3.1.6 Maintenance

After implementing the system errors and bugs which may be found. The developer must improve the system and consult the system.

3.2 Research Tools

3.2.1 Hardware used for application development

- **Web and Database Server**

  CPU : Intel 2x Xeon CPU 3GHz or greater
  Main Memory : 1 GB or greater
  Hard Disk : 40 GB RAID 5
  Monitor : SVGA
  Network Adaptor : 1 GB Transfer

- **Coding and Client Testing**

  CPU : Pentium IV 3.0 GHz
  Main Memory : 512 MB

Hard Disk : 40 GB
Monitor : SVGA
Network Adaptor : 1 GB Transfer

3.2.2 Software used for application development

- **Server**

  Operating System : Microsoft Windows 2000 Server
  DBMS : MS-SQL 2000
  Web Server : IIS 5
  Server Side Scripting : PHP 4.4.4

- **Development**

  Operating System : Microsoft Windows XP
  Programming Language : Delphi 2006 Developer
  Editor : Crimson Editor 3.51
  Web Browser : Microsoft Internet Explorer 6
  Database Client tools : Enterprise Manager, Query Analyzer

- **Client**

  Operating System : Microsoft Windows XP
  Web Browser : Microsoft Internet Explorer 6

3.3 The Research Evaluation

The research evaluations are divided into categories: effective time of activities and the system performance. The questionnaire is used to collect the opinions and satisfaction toward this system from users.

3.4 Research Time

Activities	Month							
	1st	2nd	3rd	4th	5th	6th	7th	8th
1. Preliminary Investigation	→							
2. System analysis		→						
3. System Design			→					
4. System Development				→	→	→		
5. System testing					→	→		
6. Implementation						→	→	
7. Evaluation and Maintenance								→
8. Conclusion								→

3.5 The process of WMS development

The researcher has come to study the work process including the problems within the warehouse by interviewing and field study. The researcher observed the warehouse operation; receiving, put-away, checking and relocation, order picking, returning to warehouse, returning to production process and studied the conditions including the main database.

After the system analysis and DFD development with the condition Material No & Lot & Machine No as the main condition for choosing the place, receiving, picking and finding the free space, the researcher designs the database using RDBMS concept for User Interface design as a warehouse area showing and the input-output information at the Architecture design base on client-server using date from PLS and WHH database.

As for the system development, we would classify into 2 parts. The first part is the system operation which based on Delphi as the developing tool. The second part is the display both graphic and report using base on web application by PHP. After contacting staff who control the database which the researcher wants to connect for the permission, the researcher sets up the database server (MSSQL 2000), IIS web server and install PHP file then install the WMS and test the application by staff. After that, the researcher trains staff to use the new application, implements the bugs & error and follow up the application usage.

CHAPTER IV
A CASE STUDY ON INFORMATION GATHERING

4.1 Overview Organization of Business

Thai Paper Company Limited (TPC) is a company under main parent company, Siam Cement Public Company Limited (SCG) (Figure 4.1). TPC is the part of total value chain in paper and packaging business in SCG that transforms very basic natural raw material into the most widely used media and paper, to carry information and knowledge to the people of the same and different generations. The value chain starts from plantation of trees which will be harvested and fed to pulp mills. The pulp is then used as a main raw material for TPC for making paper. TPC is not only emphasizing on the commitment with the customers but also the quality of the products, which make TPC being a real leader paper company in Thailand.

Thus TPC has to be intent in warehouse operation to support customer and the quality of the products. The warehouse department has developed quality controls especially the best storage locations that are very convenient indeed to shipping.

Therefore, on researching the system of warehouse management system is selected to study how to solve the location problems.

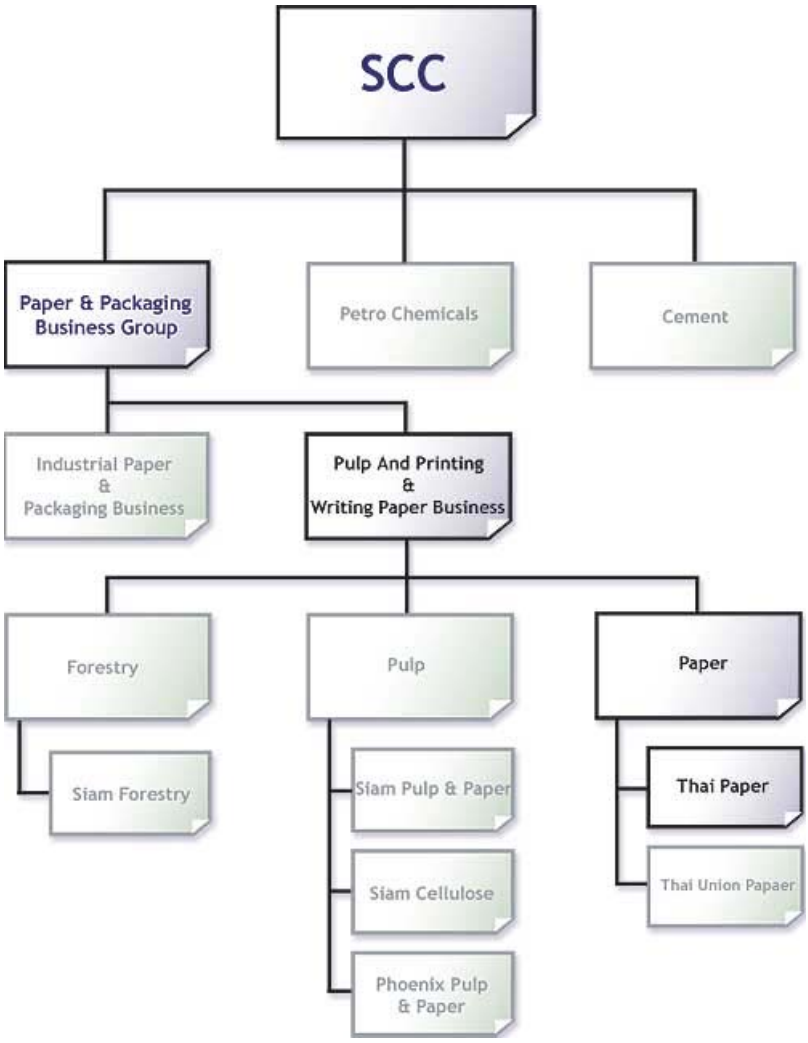


Figure 4.1 Organization Chart of Thai Paper Co.,Ltd.

4.2 Organization of Banpong warehouse

The organization chart displays the marketing department of Thai Paper Co., Ltd. The marketing department has 7 sections and 18 subdivisions as shown in Figure 4.2.

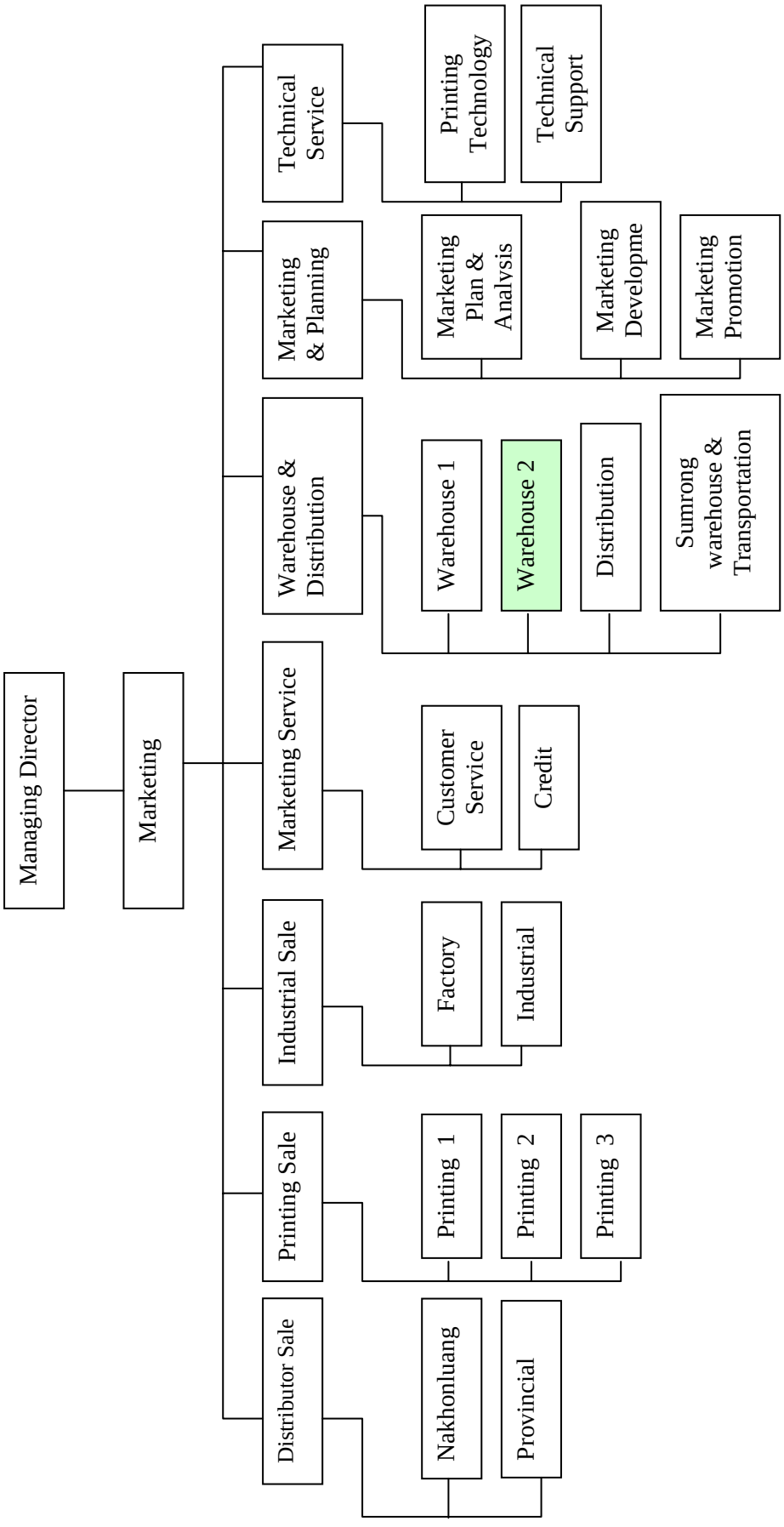


Figure 4.2 Organization Chart of Marketing

4.3 Current Business Process

4.3.1 Products

The company produces 3 kinds of paper which are Coated Paper, Uncoated Paper and Specialty Paper: Coated Paper & Uncoated Paper. This 3 products are also categorized into rolls and reams. The warehouse has 494 SKUs in domestic zone and 219 SKUs in export zone as total 688 SKUs. The Table 4.1 shows types and descriptions of papers.

Paper Type	Description
Coated Paper	▪ Both-Sides Coated Paper - Gross Premium ▪ Artcard Paper - Premium ▪ Both-Sides Coated Paper - Matt Premium ▪ One-Side Coated Paper ▪ Carbonless Paper CB/CFB/CF
Uncoated Paper	▪ Offset Premium White Paper ▪ Plain Paper For Copier ▪ Computer Print Out Paper ▪ White Card Paper - Premium White / Color Card Paper ▪ Manifold Paper - White, Blue, Green, Yellow, Pink ▪ Green Read Paper ▪ Colored Woodfree Paper
Specialty Paper	1. Coated Paper ▪ Textured Paper ▪ One - Side Art Card Paper ▪ Silk Coated Paper - Premium 2. Uncoated Paper ▪ White Card Paper / Antifungi ▪ White Kraft Paper ▪ Colored Kraft Paper - Light Yellow ▪ Colored Kraft Paper – Gold ▪ Colored Kraft Paper - Cream ▪ Colored Kraft Paper – Green ▪ Interleaving Paper - Glass ▪ Interleaving Paper - Stainless Steel ▪ Machine Finished Paper ▪ Machine Glaze Paper ▪ Transfer Base Paper ▪ White Card Paper / Postcard ▪ White Kraft Paper - Linen ▪ Masking Paper

Table 4.1 Table of Paper Type and Description

4.3.2 Storage system

The production in warehouse is consisted of rolls and reams types. They are allocated by block stacking storage system. Rolls are overlaid 6-8 rolls per column while reams are packed in the pallet and overlaid 3-4 pallets per column.

4.3.3 Warehouse Layout Map

The warehouse has the storage space about 3,896 squares metric within about 2,356 squares metric in the domestic zone and about 1,540 squares metric in the export zone. The domestic zone has the storage space in 8 blocks and 2 tents including block number F1 – F7 and tent no.2-3, G. In the gab of driving lane keeps space on 1.5 metric. The export zone has the storage space in 4 blocks and 2 tents including block number M1-M4 and Tent no.1, 4. This zone has pre-stage space for goods preparing and loading to the containers. If the storage space of block is full, staff will store goods on the driving lane and block edge. The stored type offers a wide range of block stacking, the lane had been designed in 45 degree and 90 degree to make it compatible for picking. As shown in figure 4.3-4.5.

Figure 4.3 Block Stacking in warehouse

Figure 4.4 Warehouse Map

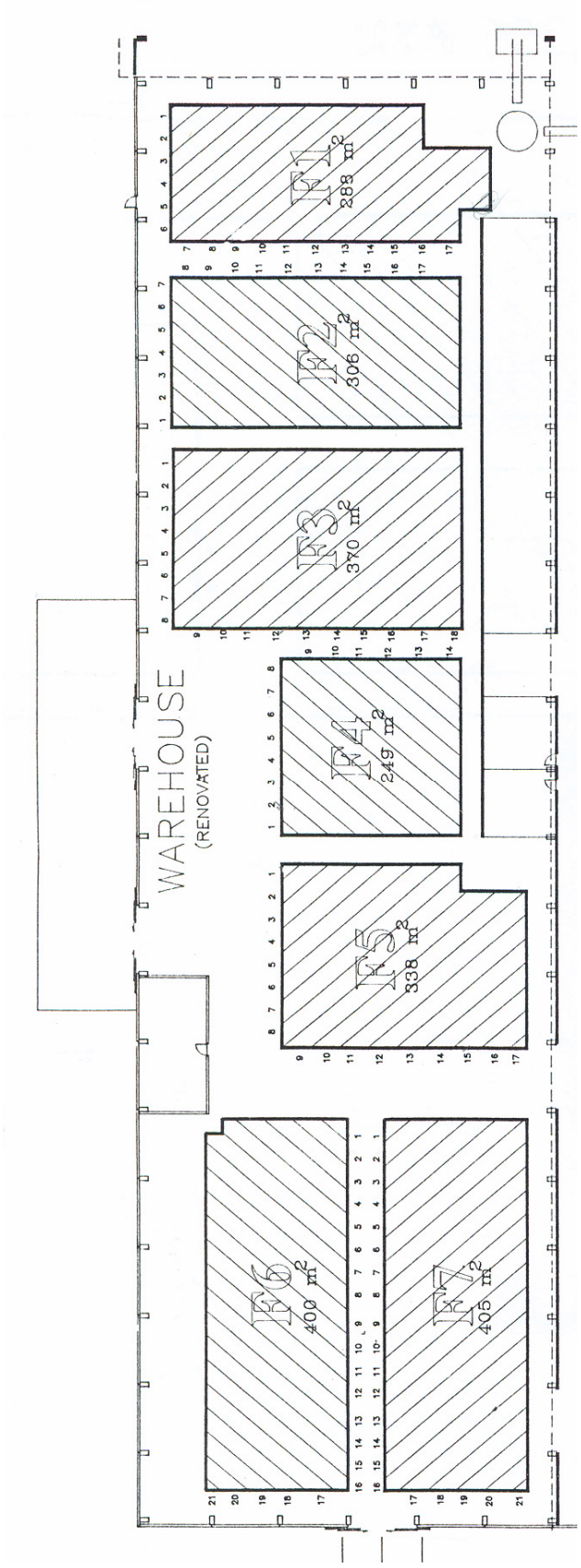


Figure 4.5 Domestic Zone Map

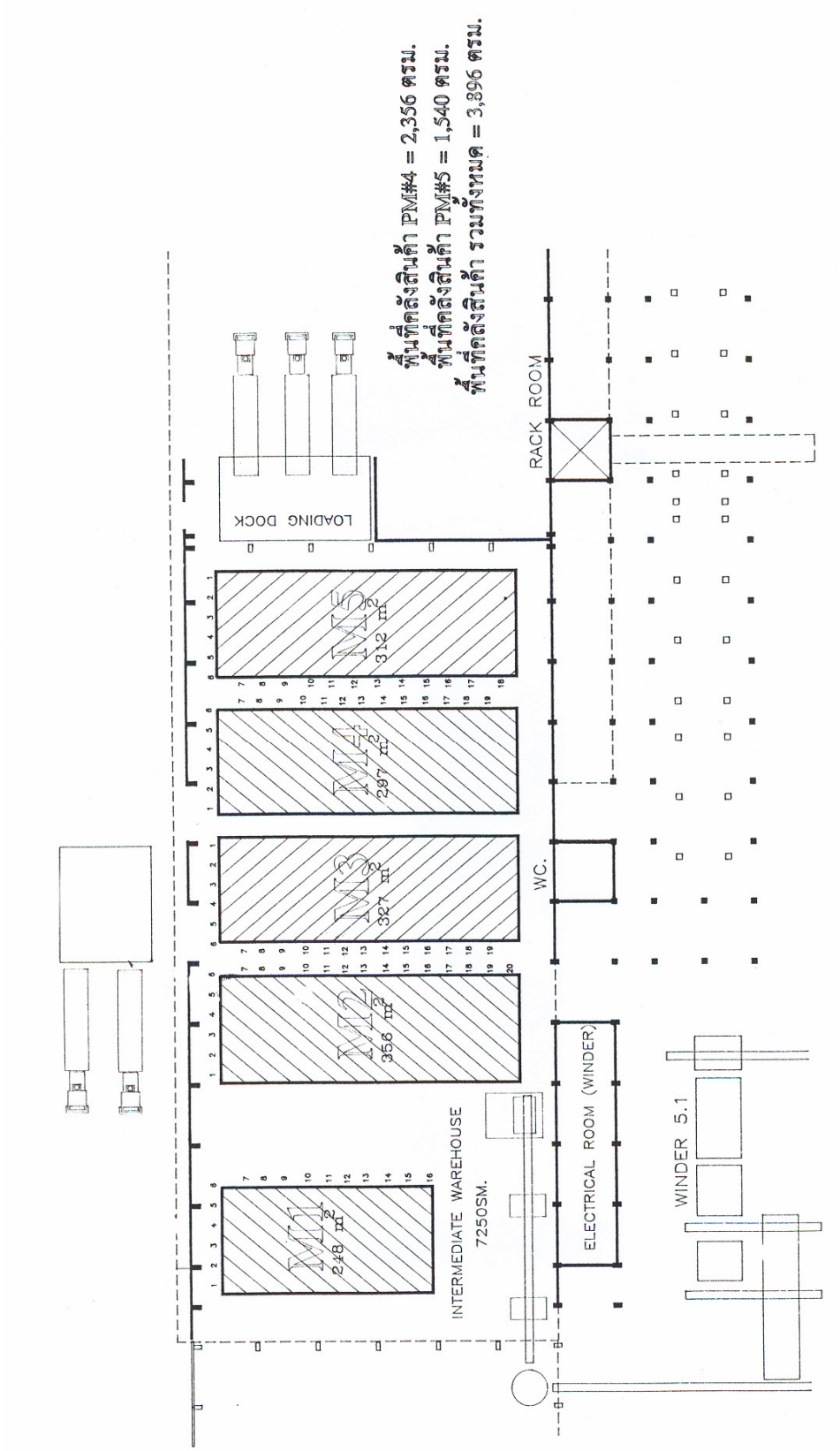


Figure 4.6 Export Zone Map

4.3.4 Warehouse Operation

From the conducting interview and warehouse operational observing it can be divided into 6 processes: Receiving, Put away, Checking and Relocation, Order picking, Returning to warehouse and Returning to production. As shown in figure 4.7.

Receiving Process: At the receiving process, staff will receive production planning report at least 3 days before receiving goods. The staff also receives goods 2 times per day at the 9.00 am and 2.00 pm everyday. Staffs will receive daily report of production to warehouse PM# (4, 5, 9) which was transfered to warehouse. Quality and quantity of production will be checked by staff, if it is acceptable, the product will be loaded into warehouse. As shown in figure 4.9.

Put Away Process: After the receiving process, the product will be moved from converting zone into warehouse by inventory layout report. This process involves goods identifying, barcode scanning, locations identifying and goods moving. The 3 numbers within material number, batch number and machine number will come to the condition of storage location. If staff receive product that the 3 numbers do not match product in warehouse, they will set the new lane for this product. As shown in figure 4.9, 4.11.

Checking and Relocation Process: Staff survey warehouse during 7.00 am. to 9.00 am. for finding free space and moving goods to the appropriate location everyday. There are checking and counting the quantity of goods and comparing between the quantity in warehouse and quantity data in SAP system by warehouse summary product report. If comparing result is error, they would determine the SAP report correct. The conditions of moving goods is that if any goods in the lane left less than 40 percent of total lane, they would be moved into another lane which provides the enough area. As shown in figure 4.8, 4.11.

Order Picking Process: Staff will receive picking list paper, find goods locations in the inventory layout report and write the location into picking list paper. The picking list paper is batch order picking group by car ID. The picking conditions uses the Fist In Fist Out (FIFO) concept by Material Number & Batch Number & Machine Number & entrance month. They have goods checking and correctly scan on loading to truck. As shown in figure 4.10.

Returning to warehouse Process: The customers would return goods to warehouse when goods are damaged or erroneous specification. As shown in figure 4.12.

Returning to Production Process: If the staff found the damaging goods that caused by the dampness or forklift, they would move them into the damage zone and back to the production department for reproduction. As shown in figure 4.13.

4.3.3.1 Work flow of warehouse processing

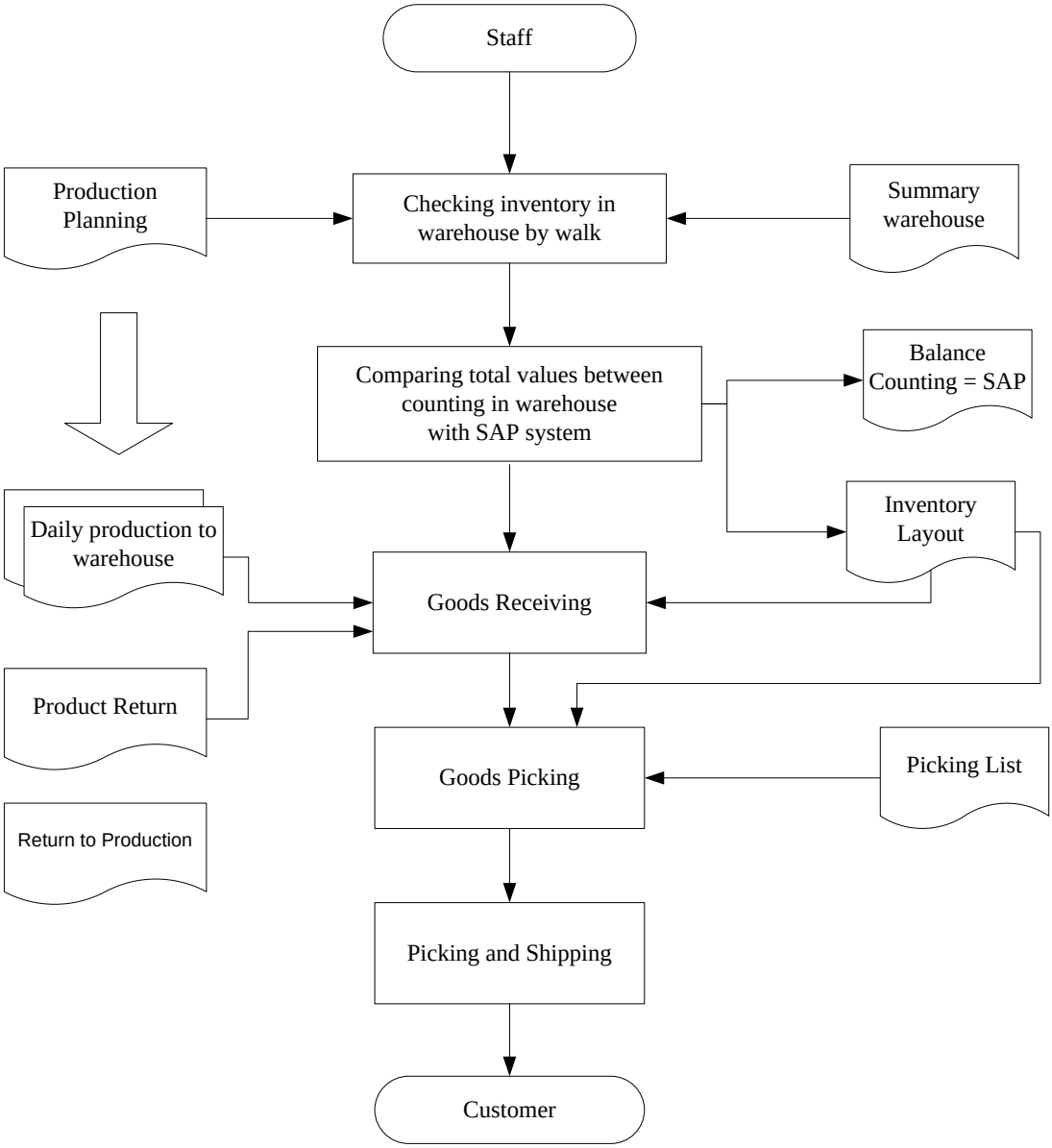


Figure 4.7 Warehouse processing flows

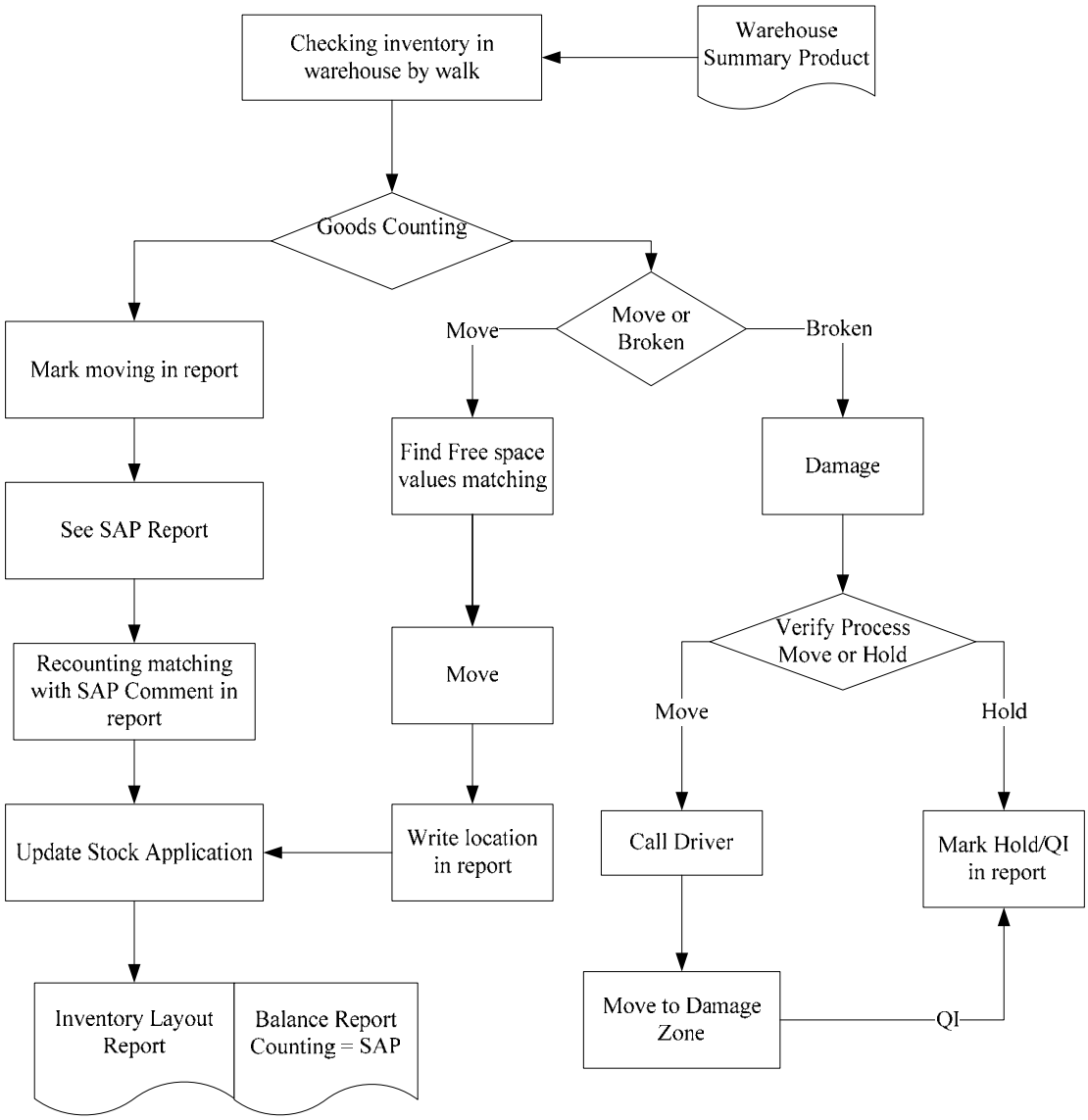


Figure 4.8 Checking warehouse work flow

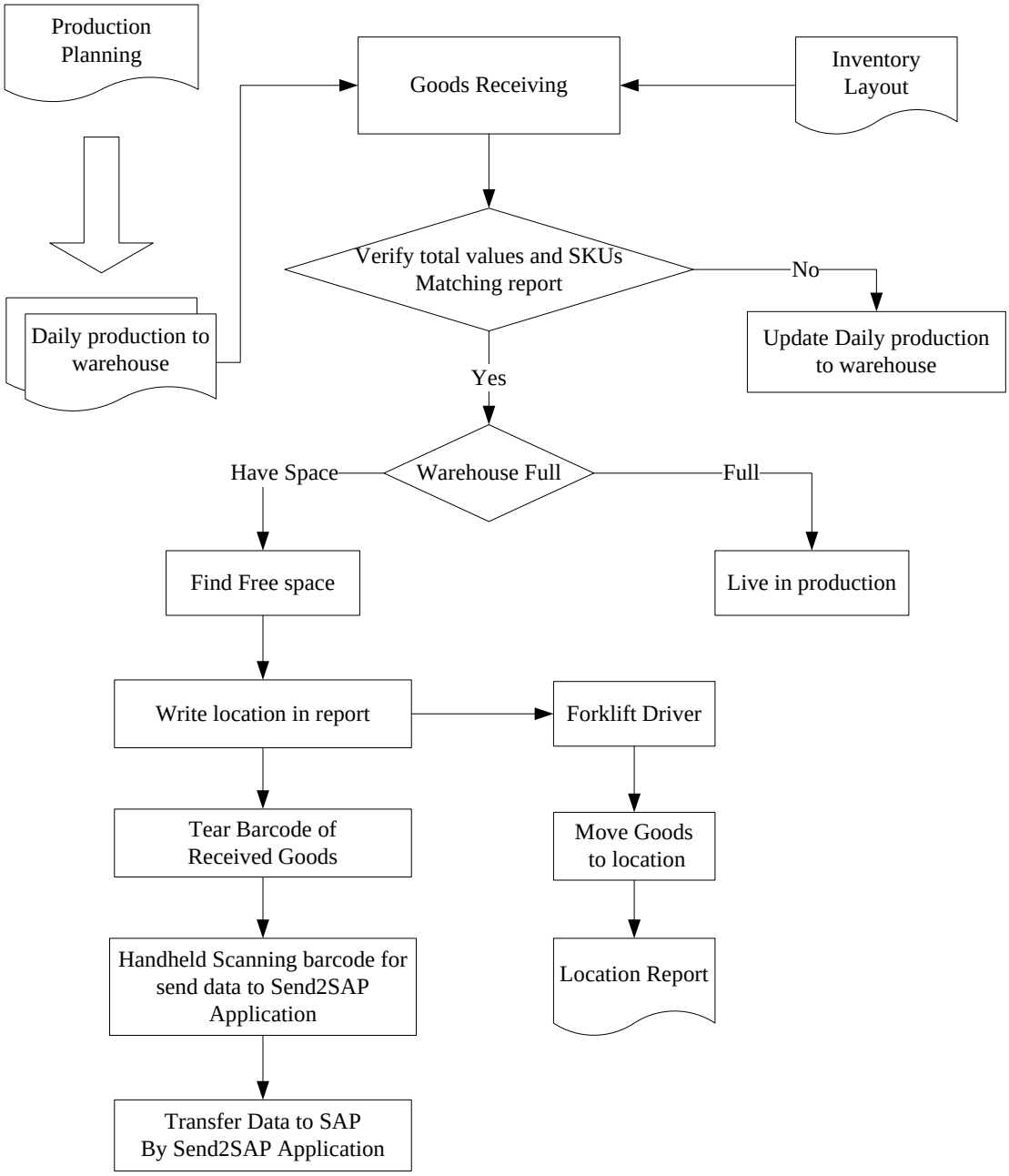


Figure 4.9 Goods Receive work flow

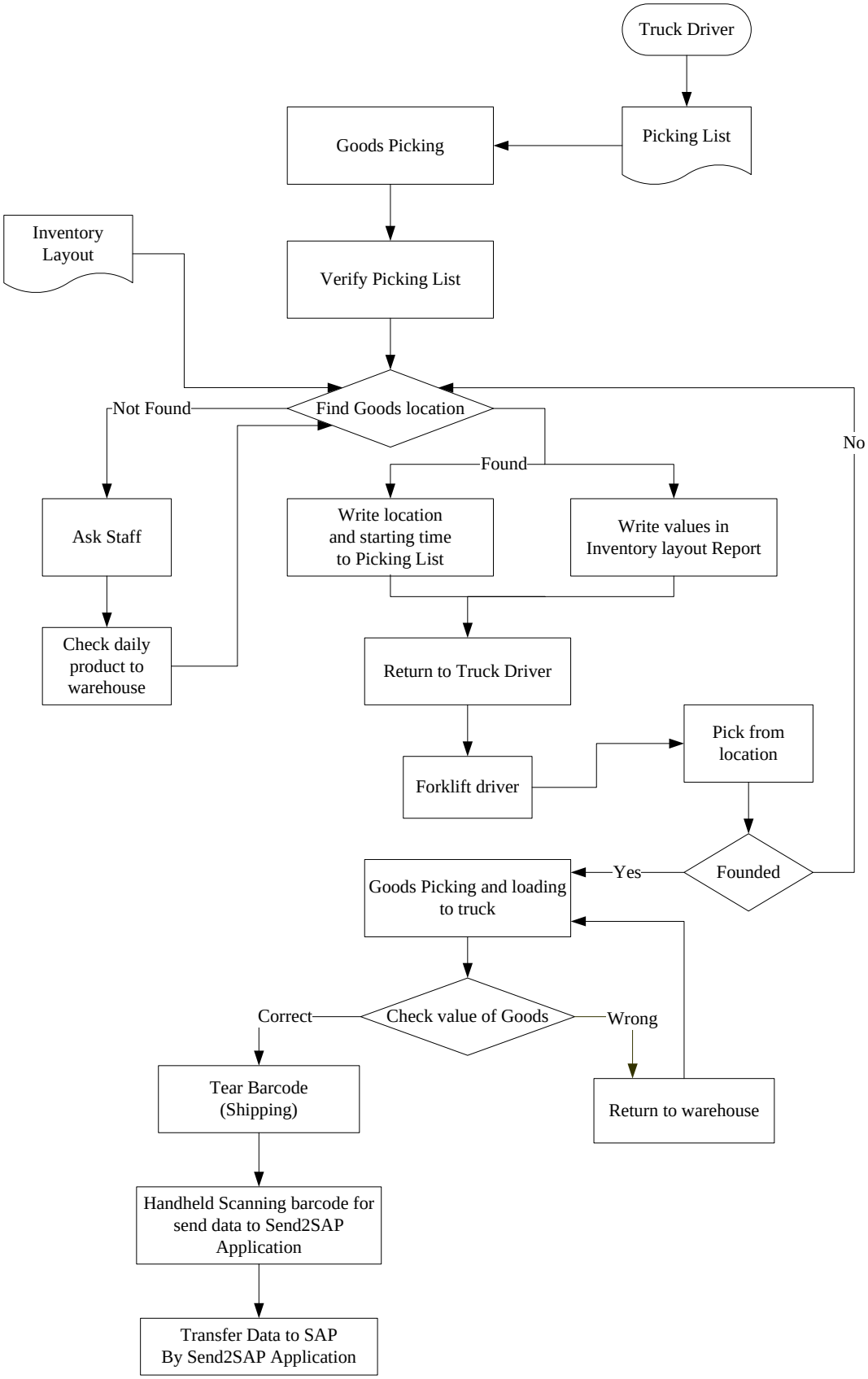


Figure 4.10 Picking & prepare shipping work flow

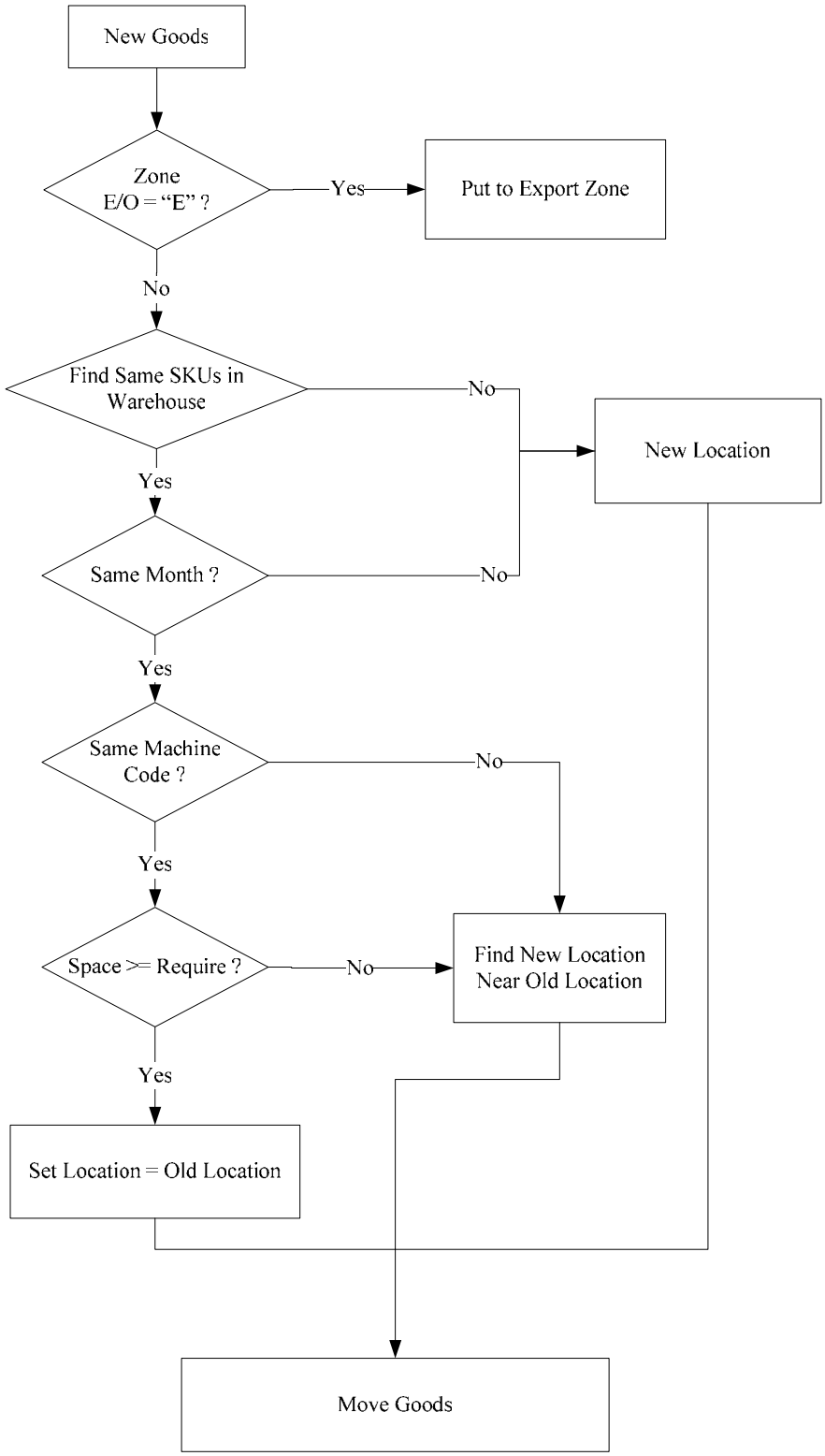


Figure 4.11 Location condition flow

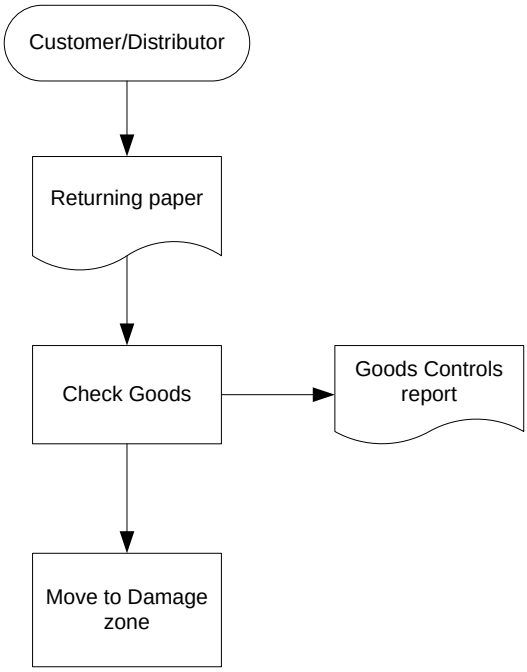


Figure 4.12 Return to warehouse

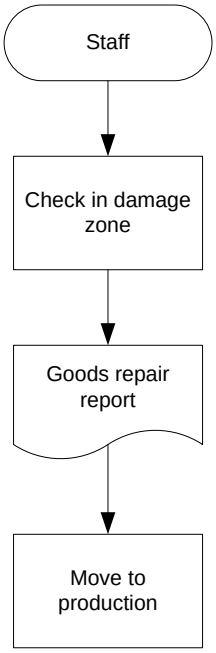


Figure 4.13 Return to production

4.3.3.2 System Information flow processing

The main system is SAP (System, Application, Production data processing). Operation of warehouse used handheld for recording the quantity of goods and goods information. Warehouse server under windows 2000 server supported handheld application and kept operation transactions. Server is connected with SAP on material data. After staff scanning barcode for goods receiving and goods delivery, they run Send2SAP program to data transfer to SAP system. Inventory application is stand alone application by Microsoft Access. It can not connect directly with SAP. Staff use export data function of SAP application and they are import data manual to inventory application.

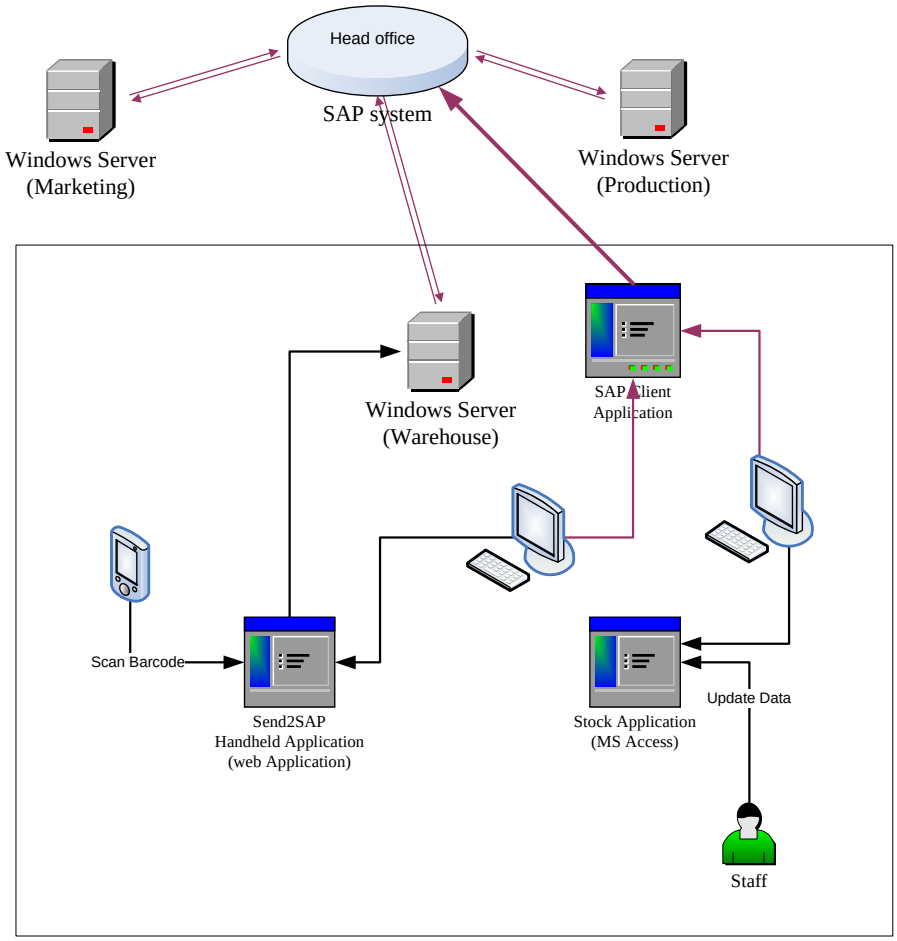


Figure 4.14 System Information Flow

4.4 Analysis and problem identification of the current system

From the interview, collecting sample document and observing operations Thai paper warehouse. Present SAP (System, Application, Products in Data Processing) is the main system of company to connect the Head Office. SAP provides a comprehensive range of enterprise software applications i.e. SD: Sale & Distribution, MM: Materials Management, PM: Plant Maintenance, HR: Human Resources. The company has only Materials Management module which is not included warehouse management system. The cost of each module is expensive. SAP wms can not provide demand of staff. As the result, the staffs build Inventory Application by Microsoft Access for recording the goods location. In the case study, the identification of problems and causes is the following;

4.4.1 Problem of Checking warehouse and relocation

1. Staffs spend 1-2 hours for warehouse checking and preparing the layout report. If staff plans for the goods moving, it will be reduce warehouse checking time.
2. Location specification has error while staff is telling forklift driver to move the goods.
3. The warehouse checking report made at night by Staff preparing for warehouse checking in the morning while staffs dally over to check quantity in warehouse on day.

4.4.2 Problem of Goods Receiving

1. Warehouse overflows, when the goods are overflow, staff will hold them in production section and move into warehouse after the warehouse has space.
2. Inventory layout report can not call free space that causes the difficulty to choose location decision.
3. Having goods searching error and calling position location that cause by staff does not update the goods receiving transaction.
4. Fast Picking Area can not be setting specification location.

5. In case of having new goods into warehouse. Staff must key a new data in the Stock Application because they can not use data from exist system.

4.4.3 Problem of Goods Picking

Because of searching SKUs and location in the inventory layout report have many SKUs and similarities that is difficult for searching and calling location error. The forklift driver has to return to the office and pick them again that is quite far from the office. Forklift driver increases picking time in order picking process per picking list paper.

4.4.4 Problem of Inventory Application

1. Inventory application can not transfer data from existing system: PLS, WHH, SAP.
2. Inventory application can not specify the exactly location on real time.
3. Inventory application can not see the free space data.
4. Inventory application can not see the historical data.
5. Inventory application can not see the statistical report.
6. Between SAP system and inventory application data has data conflict.

4.5 Concept for solving the problem

From the Analysis and problem identification of the current system, the researcher develops a prototype for warehouse management system to solve the problem. The warehouse management system will replace the Inventory application. It has specification as follows.

1. New system will support location management on graphic mode which can reduce warehouse checking time and make decision support for goods moving.

2. New system will support receiving, put-away transactions and goods status on real time which can reduce location assignment error and find free space for put-away.

3. New system has online report via intranet website to present the current warehouse status.

4. New system will support data transferring of existing system; it will reduce data redundancy and data conflict.

5. New system will support location decision for put-away and picking transactions. It will reduce time to make decision for location setting or searching and it will decrease the picking error of forklift driver.

6. New system will support the fast picking area.

CHAPTER V
RESULTS

5.1 System Analysis and Design

This section describes the analysis and detail design of the newly proposed warehouse management system. The chapter presents an overall structure of the system modules, system process and the details of system database design.

From the gathering, analysis and problem identification of the current system, there are functions of the new system as follows.

5.1.1 Functions of warehouse management system

The new system consists of 2 main functions: System function and Application function.

System Function

Import: Function of Import is the data importing from existing system on WHH Database and PLS Database which including the SKUs, Purchase Order and Production to warehouse.

Setting: Functions are the location preparation, goods description and user & security.

- Location: Users can build new block and lanes in a block.
- Goods description: Users can setting up number of pallet per column on each SKUs.
- User & Security: The authorization of the new system has 3 levels; administrator, user and driver.

Application Function

Put-away: Function of put-away would record the transactions of goods receiving into warehouse, location recommendation and location specification.

Goods moving: Function of goods moving, user can make the manual layout selection by location recommendation.

Goods Searching:

- Search by Production to warehouse Number.
- Search by Purchase Order Number.
- Search by SKUs

Picking: Function of picking would record the goods picking transactions and find goods location by purchase order number.

Paper Report

- Current warehouse layout report.
- Put-away & picking layout report.
- Receive daily report.
- Picking daily report.
- Damage report.
- Returning report.
- Hold product report

Web Report

- Lifetime of Goods in Warehouse.
- Daily comparison report.
- Summary inventory in warehouse group by zone.
- Summary inventory in warehouse group by round.

5.1.2 Operation of warehouse management system

From the analysis and design of the new system, there are 6 processes: Warehouse checking process, moving, Goods receiving and Put-away, Order picking, customer returning to warehouse and warehouse returning to production.

Warehouse checking process: Staff will import data from SAP system into WMS. Quantity in warehouse will compare data with SAP data. If the result of

comparison is error, staff must walk to check the warehouse by error report. They would update data in WMS application. If result of comparison is balance, they would prepare layout for goods relocation. As shown in figure 5.1.

Moving process: Staff will make decision for selecting the selected rows to move by graph that shows space information and goods in warehouse. The application will be shown location suggestion for move. The condition of selection the goods that are less than 40% of total in line. In application, they select line to move, look for the free space in the selected zone and it shows description of location on screen. Then application will lock location to move and print moving location report to forklift driver. As shown in figure 5.7.

Receiving and put-away process: In the goods receiving operation, staffs receive PM# 4, 5, 9 reports. They import data from PLS database by date-time and it displays on product list. Application getting data by Material number, Machine number, Quantity and zone and they go to goods receiving condition. This condition will check the fast picking zone. If SKUs is the popular order and it will be kept in this zone, application will find the free space for put-away. However if there is no space, it would query space automatically in normal zone or staff can make the manual selected layout. The basic conditions find the same goods in the warehouse. If the result of goods matching is true and it gets the location of goods, it will be searching free space near the getting location in warehouse. If there is the space, it would location to put-away. In case of goods matching is false, the application will be query free space in the getting zone and it would select location near the existing SKUs. In case of the getting zone is full, it would find location in the export zone. In the worst case export zone is full; it would hold them in the production zone as shown in figure 4.16. If staffs are dissatisfied on the application selected location, they can change layout by manual. After that staff will print layout report and lock layout for goods moving. If data is error, they can edit data before committing transaction. They scan barcode by handheld and commit data by Send2SAP application for transferring transaction to SAP as shown in figure 5.2-5.4.

Order picking process: Staffs receive picking list report from sale. They search D/P number on application. Application would query material number by D/P number and finding location by lot ascending. It would show order list and

picking location on screen. Staff can choose the automatic system or manual picking and print picking layout report. Application will start working time when printing report. It will stop at the barcode scanning by handheld and finish the moving. The application can select goods from locations both by automatic and manual. It detects lot and space of line for picking automatic. User can select goods by manual in recommendation line. As shown in figure 5.5-5.6.

Customer returning to warehouse process: Customer and Distributor may have damaged goods by shipping or any other cases. Staffs receive the returning paper from customer and distributor. Before staff receives goods, he would check the status and record the returning description. Application will choose location in the damaged zone. As shown in figure 5.8.

Warehouse returning to production: Staff will check in the damaged zone for repairing the damaged goods by the repairing report. They are update QI status on the application to record returning in to the production data. Application will update free location after the driver finished the move. As shown in figure 5.9.

5.1.3 An Analysis of system process

5.1.3.1 Work Flow Design

The flowchart is a schematic representation of an algorithm or a process. It is a visual representation about the sequence of the content in the new operations. A box is used to indicate the process step, a diamond represents a logical condition and arrows show the flow control as illustrated as follows:

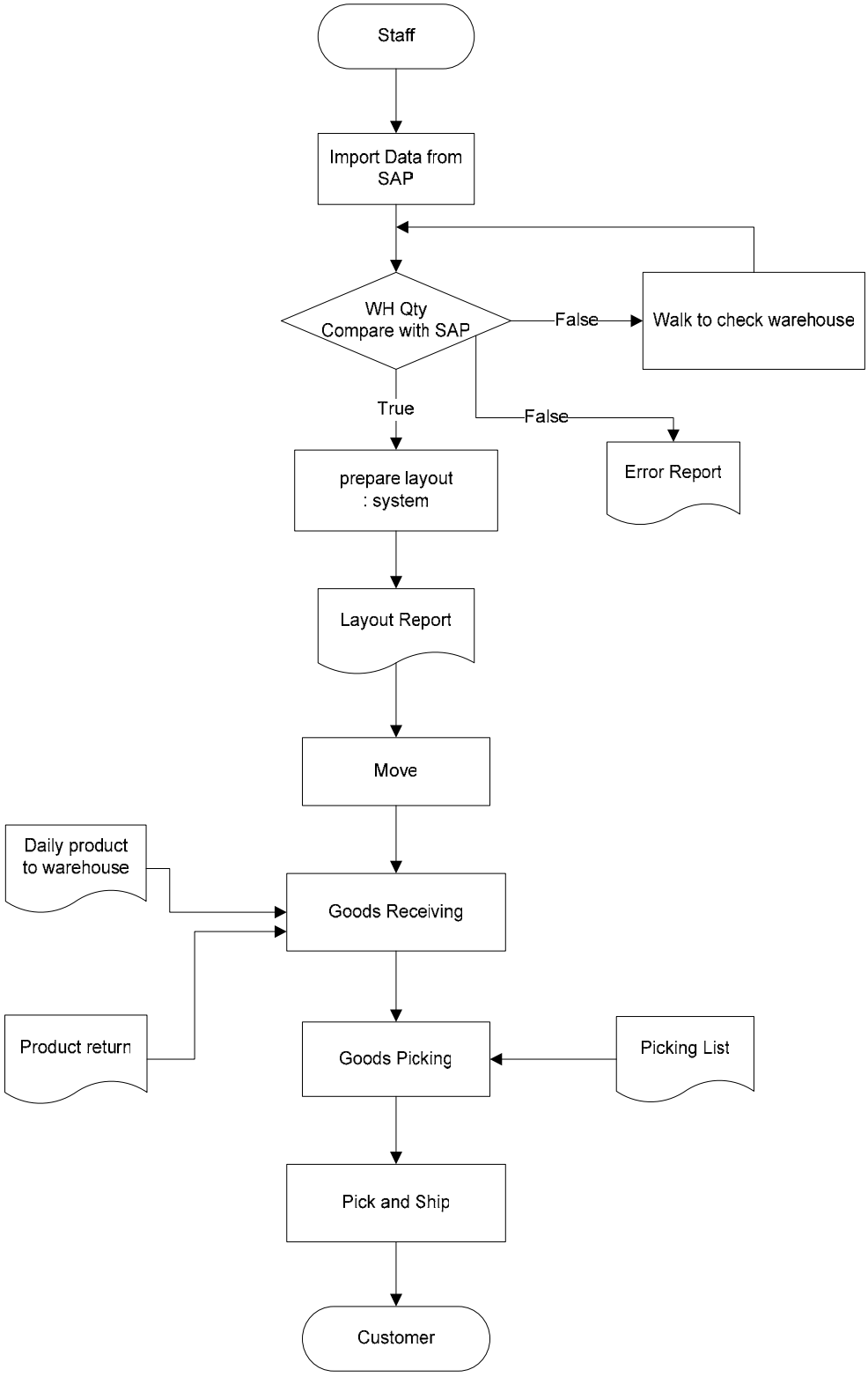


Figure 5.1 warehouse operation of the new system

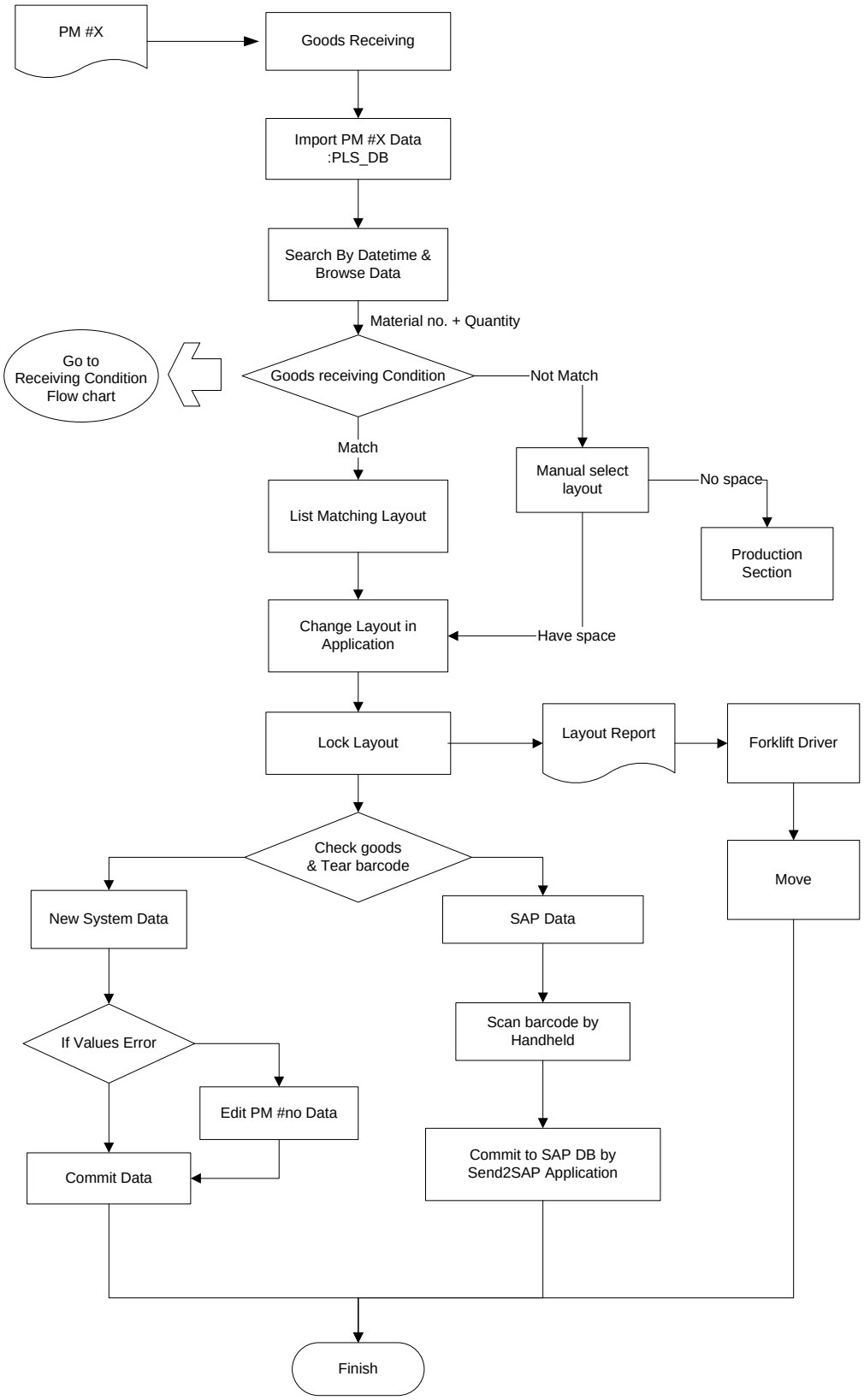


Figure 5.2 Goods receiving operation

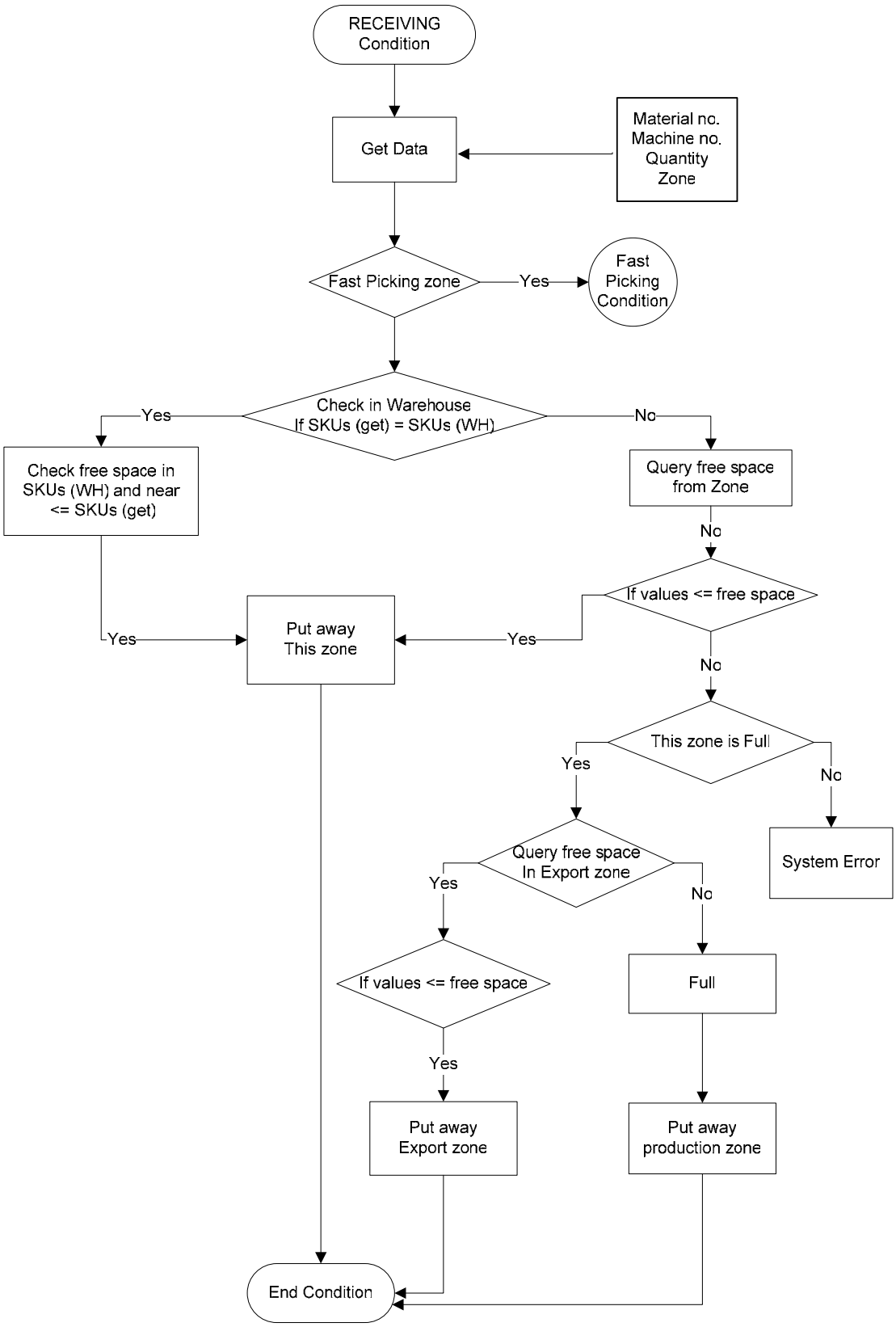


Figure 5.3 Goods receiving condition

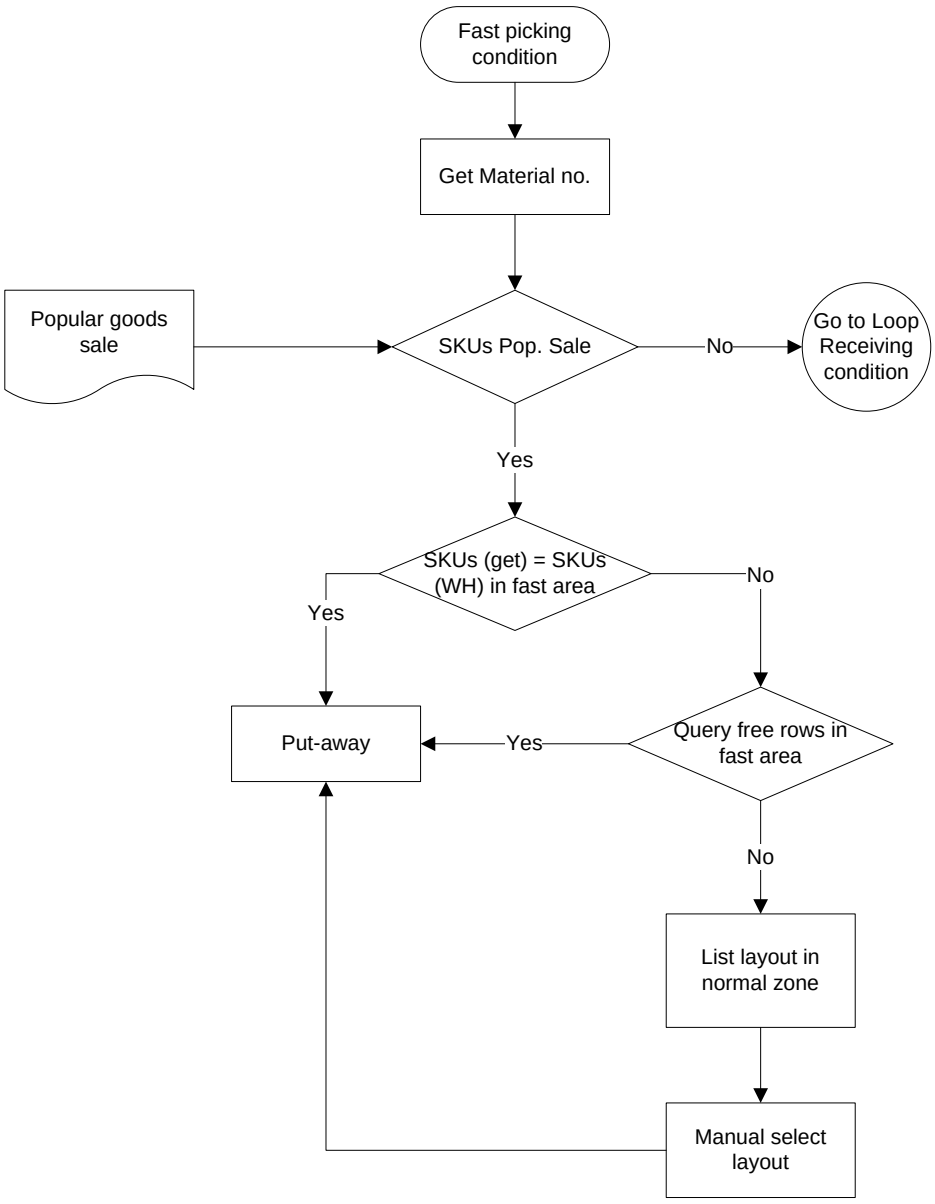


Figure 5.4 Put-away to fast picking condition

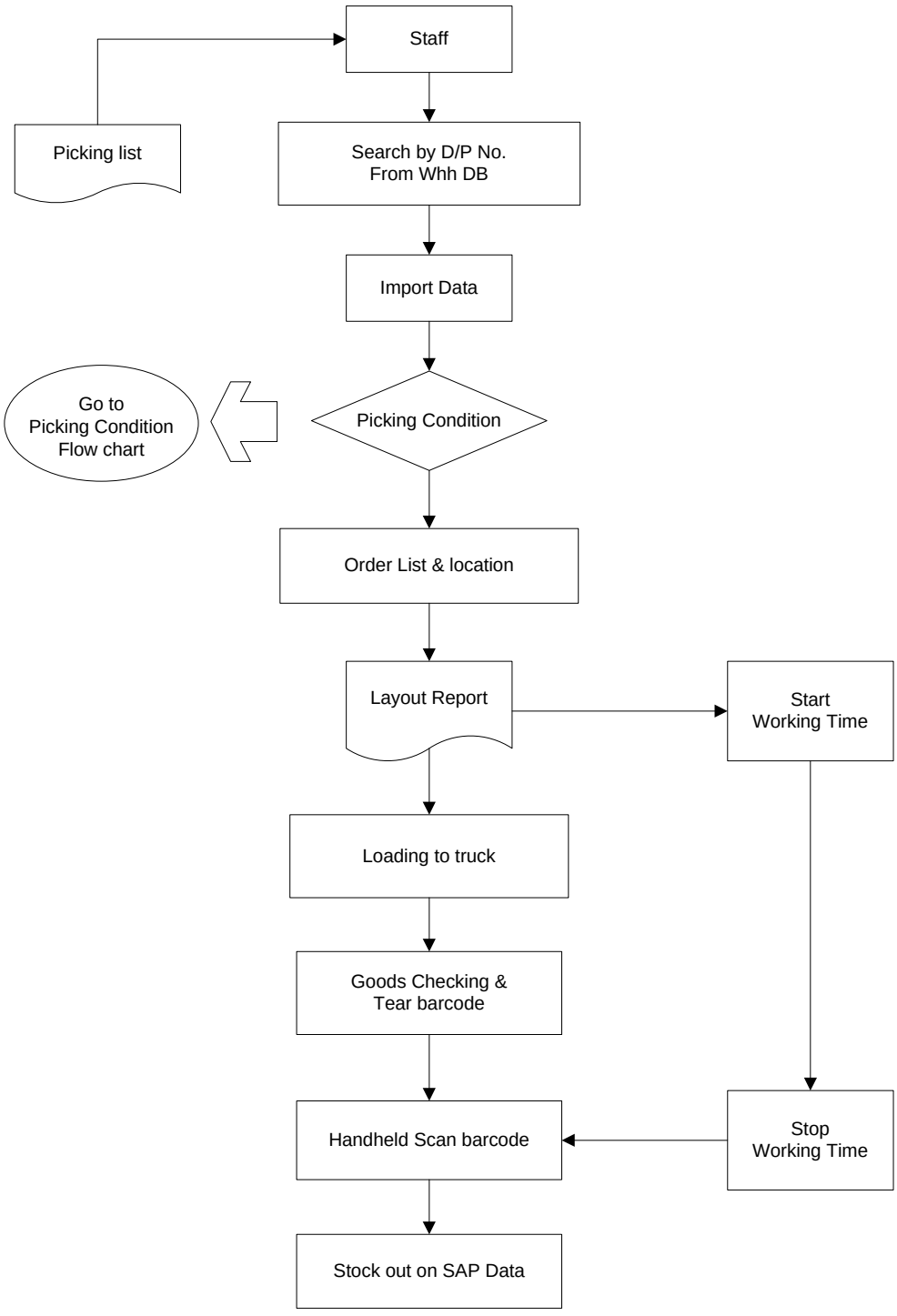


Figure 5.5 Goods picking operation

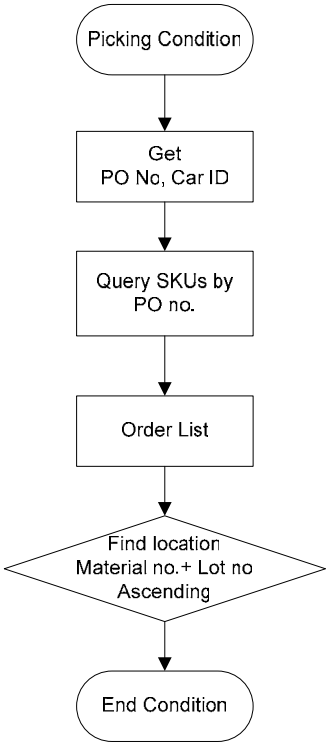


Figure 5.6 Goods picking condition

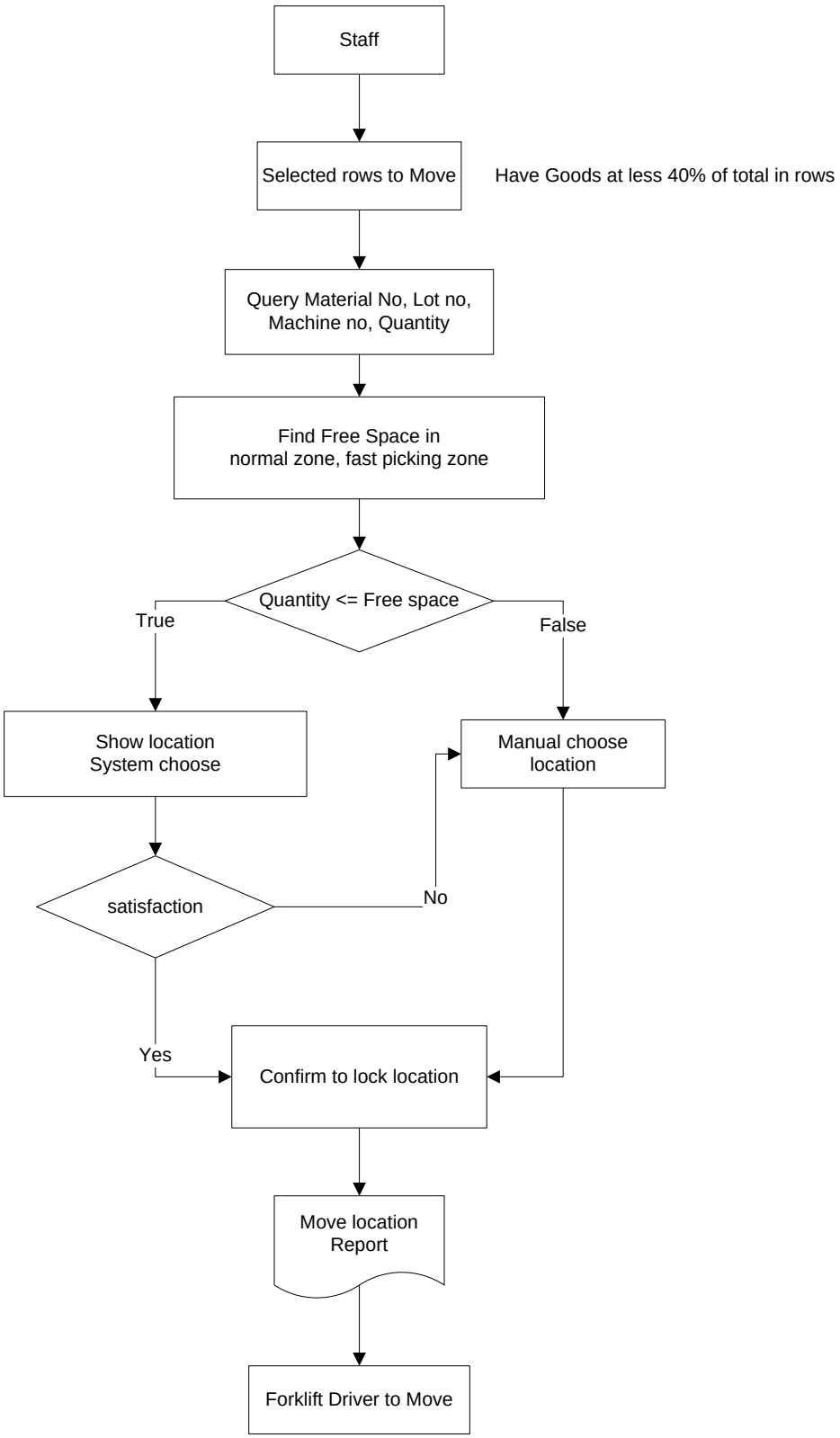


Figure 5.7 Relocation & Move operation

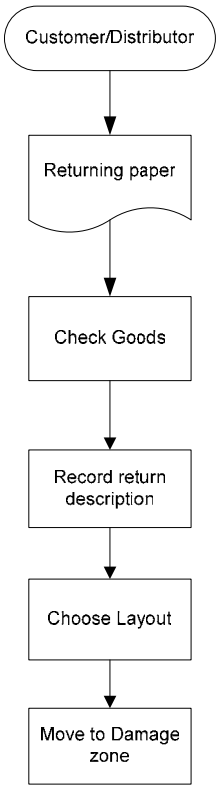


Figure 5.8 Customer returning Goods

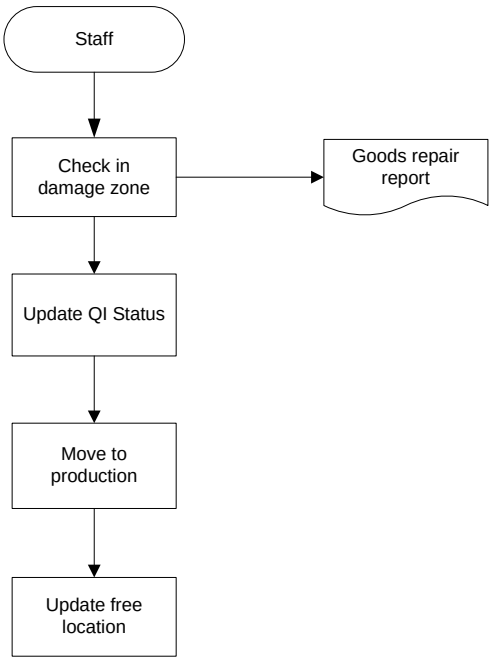


Figure 5.9 Warehouse returning to production

5.1.3.2 Data Flow Diagram

The data flow diagram enables the software engineer to develop models of the information and function domain. A Context Diagram is shown in Figure 5.10. It connects with central office, production section and warehouse section.

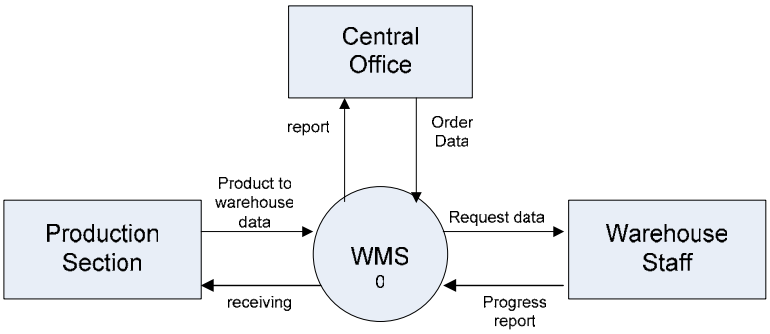


Figure 5.10 Context Level DFD

The level 0 DFD is shown in Figure 5.11. User is authorized by the security process, and then warehouse management process, location decision and statistic report, subsequently.

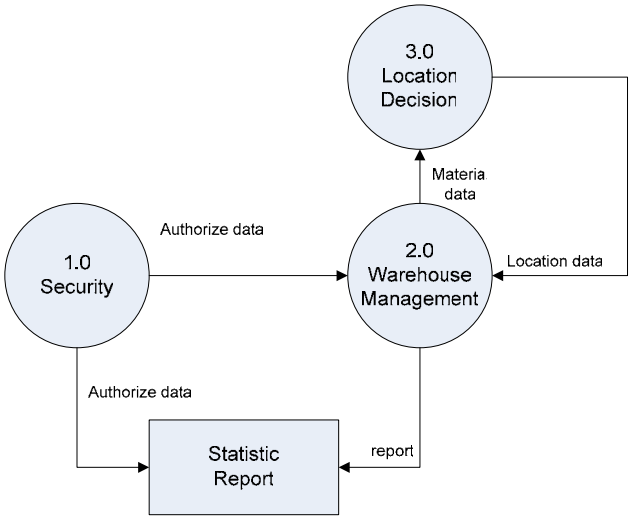


Figure 5.11 Level 0 DFD

The figure 5.12 is shown level 1 DFD of security process. The warehouse staff must be input username and password to verify and access the warehouse management and statistic report.

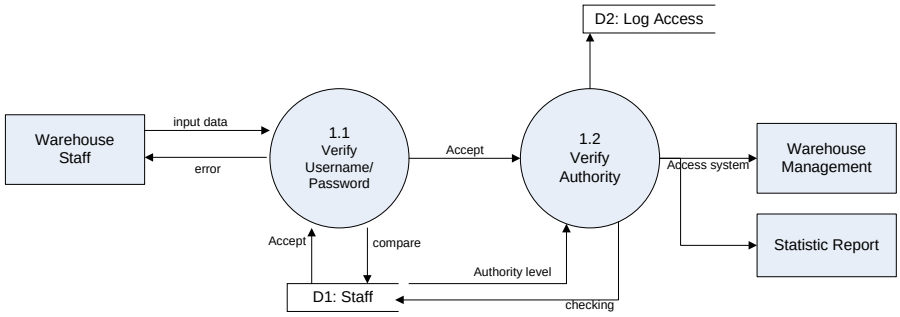


Figure 5.12 Level 1 DFD of security

The level 1 DFD of warehouse management is shown in Figure 5.13. It show warehouse data process in receiving, picking, returning goods, moving, location setting and account management.

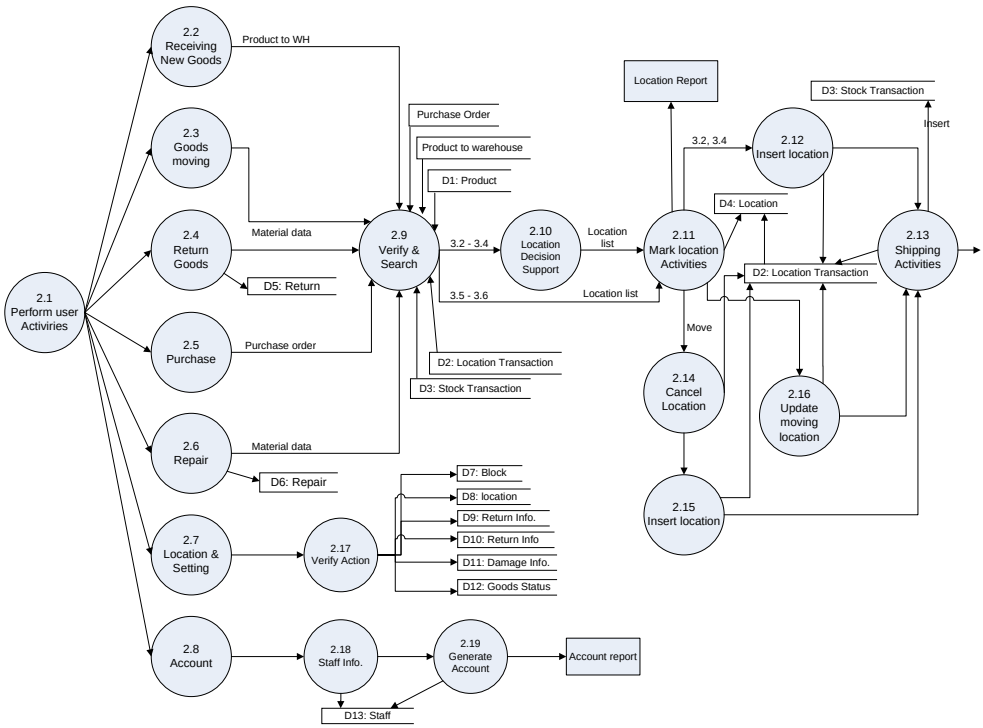


Figure 5.13 Level 1 DFD of warehouse management

5.1.4 A Database Design of Warehouse Management System

The focuses of database design will support warehouse operations and objectives. WMS making sure that it would meet user and system requirements. An Entity-Relationship (E-R) diagram is used for represent the representation of structured data. The complete normalized E-R diagram is shown in figure 5.14 and data dictionary is shown in Appendix A.

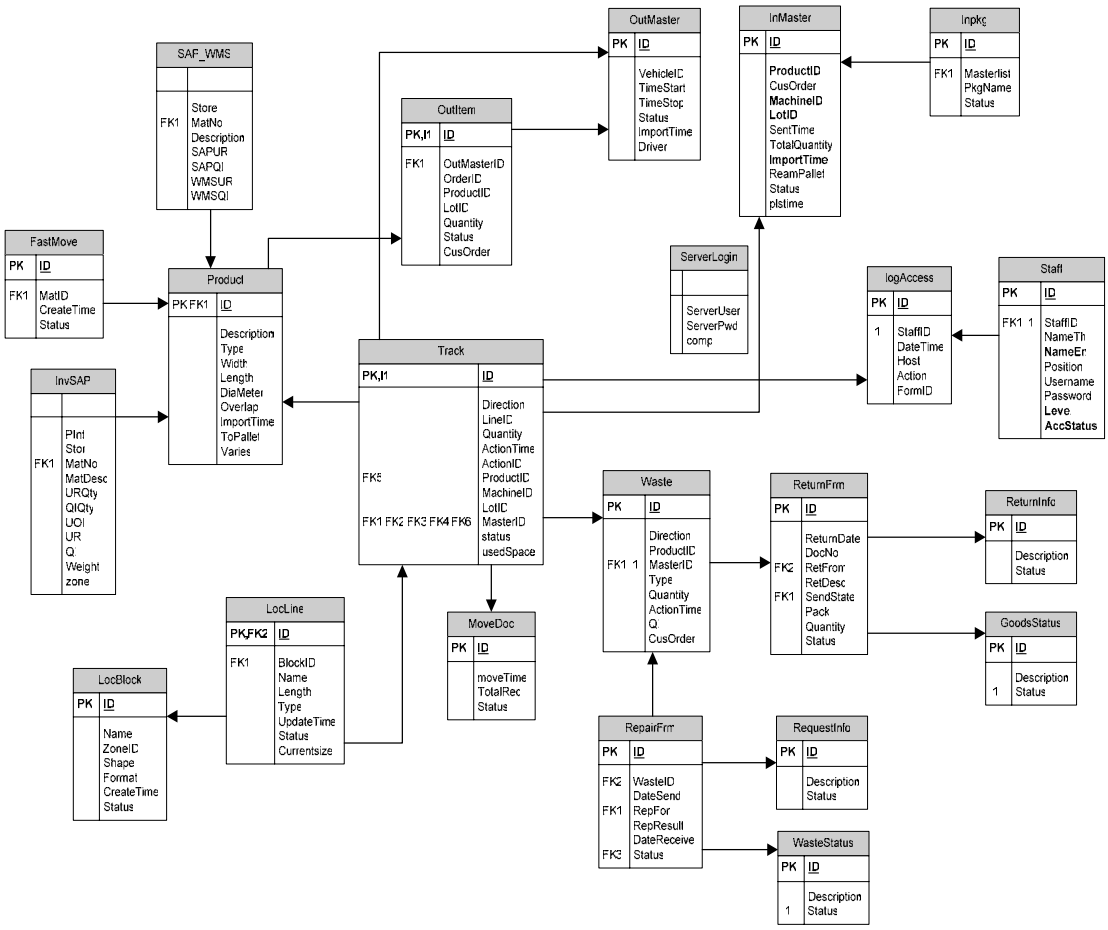


Figure 5.14 ER-Diagram of warehouse management system

5.1.5 User Interface Design

The part of users has 3 parts: administrator, operation and management user. The user interface will use a client-server application for administrator and operational user and web-based application for management user.

In the standard WMS screen including tree menu, list of pending form, graph to show the capacity of space by block.

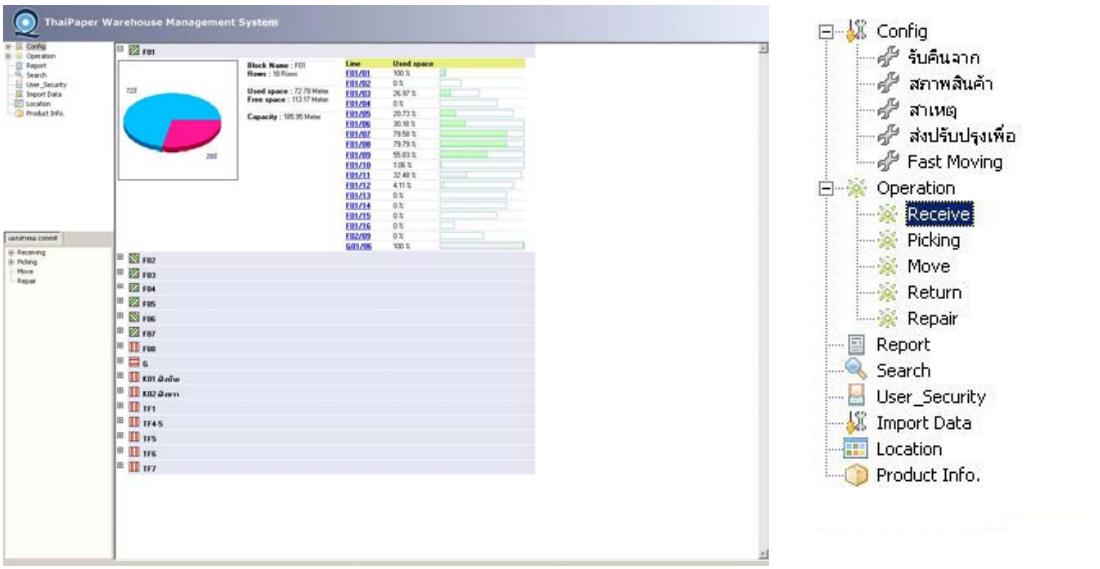


Figure 5.15 Standard WMS Screen

5.1.5.1 Main Menu

Main menu screen is showing the configuration, operation, report, search, user security, import data, location management and product information. Under the configuration menu is used for supporting configuration goods receiving, goods status, cause of goods damage, cause of remaking and fast moving. Under the operation menu is used for supporting receiving, picking, moving, returning, repairing goods. Report menu are showing summary reports and daily operation reports. Search menu is used for supporting goods searching on the condition of material number. User security menu is used for supporting account setting and authorization. Import data menu is used for supporting transfer daily SAP transaction data to WMS database. Location menu is used for supporting location management. Product information is used for supporting update description of products.

5.1.5.2 Part of administrator users

This feature is designed for supporting the configuration functions. Administrator can prepare location, setting goods description and account management. It is explained as follows:

Location management screen support creates block setting zone and the shape of block. In the line of block is setting length (meter), line type. It can enable or disable to use the line.

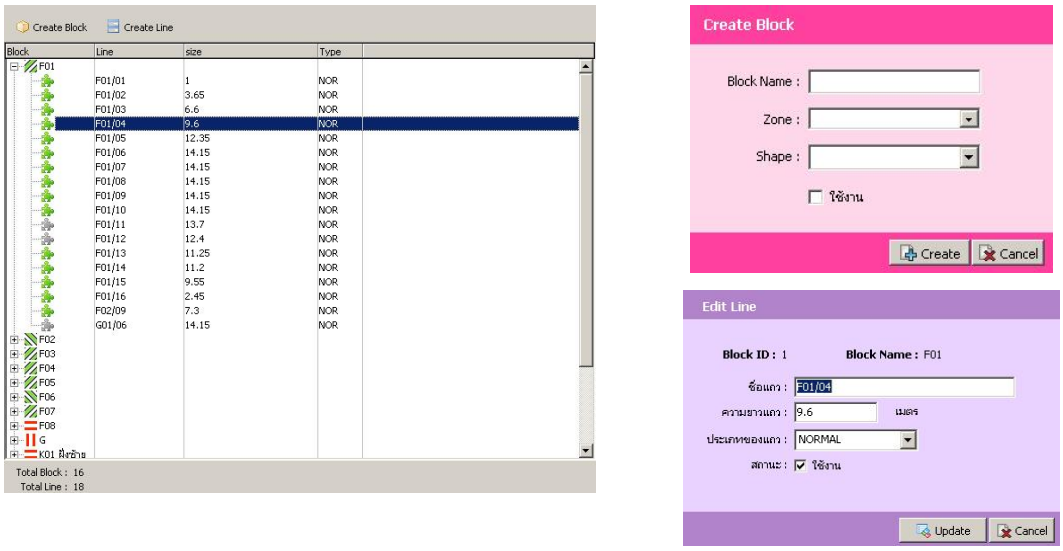


Figure 5.16 Location Management Screen

Goods management screen support to change the overlapping of goods that is not in the current warehouse.

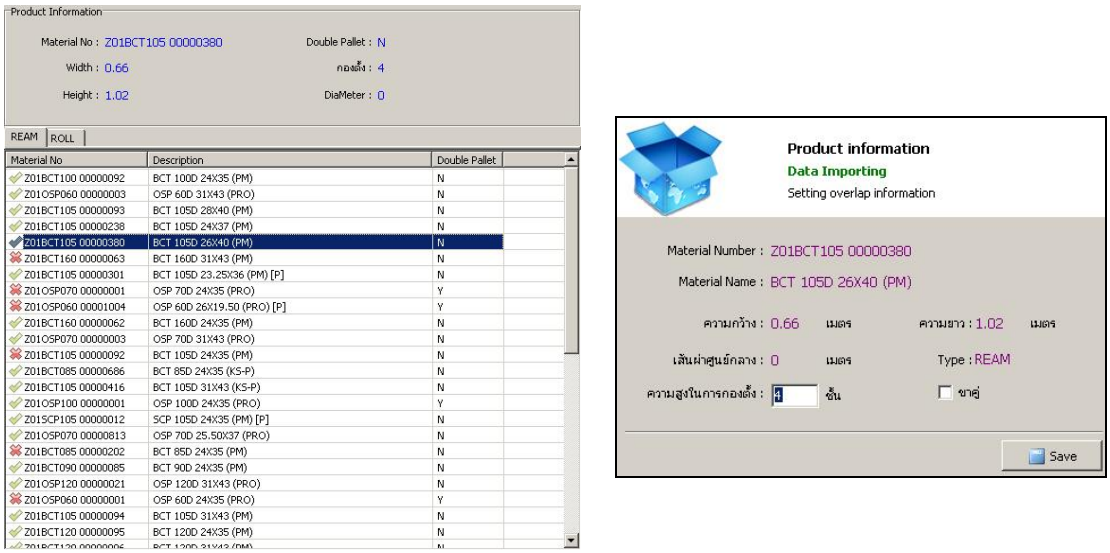


Figure 5.17 Goods Information Management Screen

Account management screen is designed for supporting in the adding, editing, deleting user account and authorizing user level.

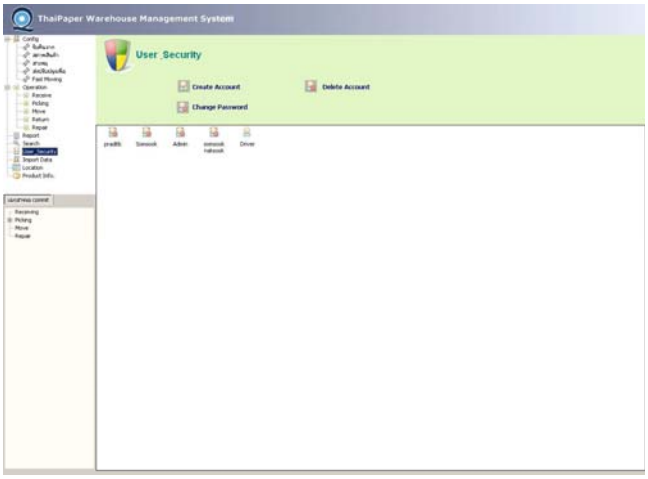


Figure 5.18 Account Management Screen

5.1.5.3 Part of operational users

This feature is designed for supporting warehouse operation to make it easy for receiving, put-away, picking and search location. It is explained as follows:

The goods receiving screen is used for the supporting domestic and export goods including reams and rolls paper. It can show line space and goods in line.

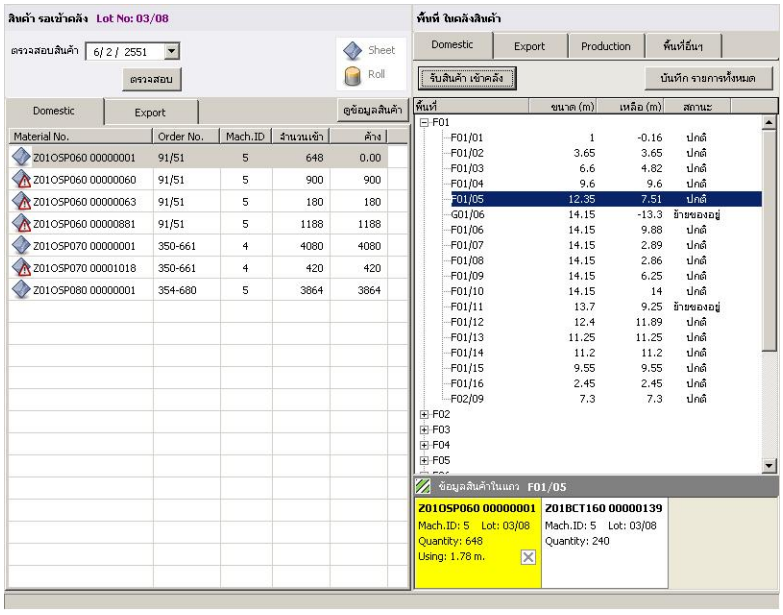


Figure 5.19 Goods Receiving Screen

Picking and shipping screen is used for supporting manual and automatic selecting goods by material number. It will track forklift driver and truck number.

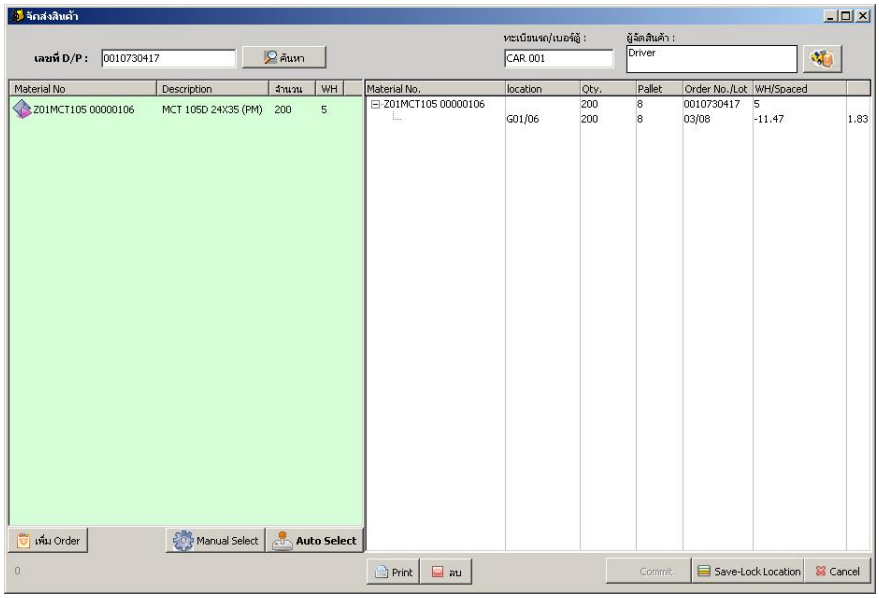


Figure 5.20 Picking and Shipping Screen

Move and relocation screen is showing the goods in warehouse including capacity of space. It can hold, enable, disable goods in line.

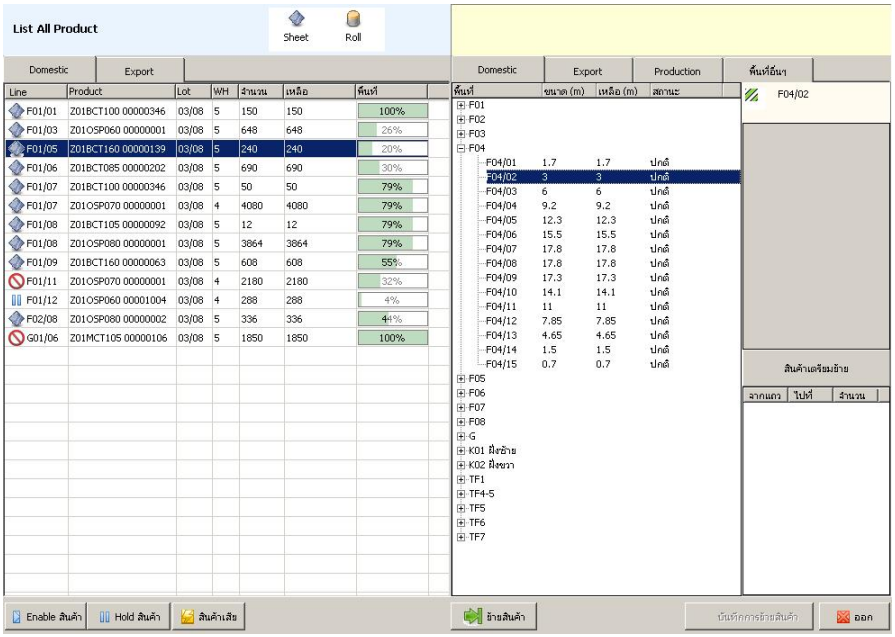


Figure 5.21 Move and relocation Screen

5.1.5.4 Part of management users

This feature is designed for commentating the on warehouse operation and annual reports.

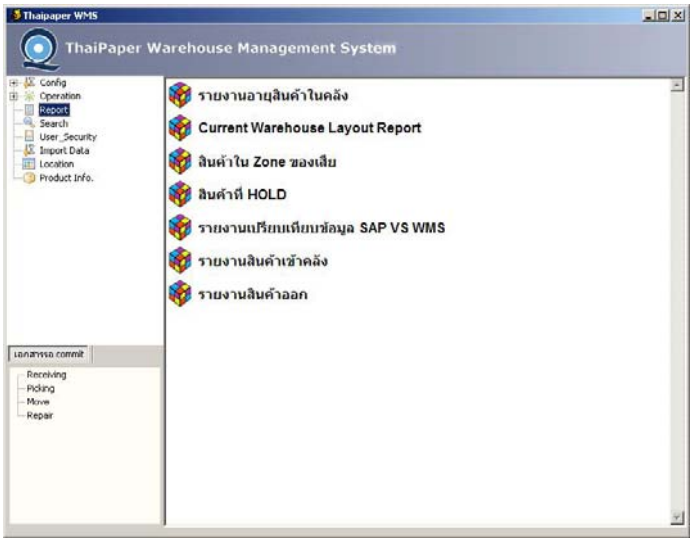


Figure 5.22 Summary Report Screen

5.1.6 Architecture of the new system

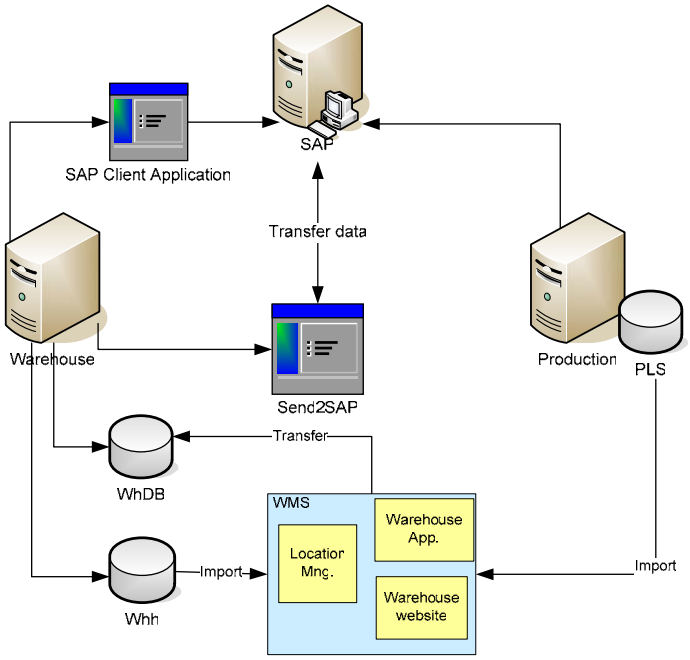


Figure 5.23 Architecture of the new system

WMS has 3 applications to support warehouse staff. 1) Location management support warehouse location and setting line. It makes new blocks and slide line in a block on line by meters. Staff is setting type of lane include normal, slow move, fast, damage. 2) Warehouse operation management support the operation of warehouse include receiving, warehouse checking and relocation, picking goods, customer return goods, warehouse return goods to production, search and report. In the receiving and picking goods, it import data on PLS database and WHH database. Warehouse operation management will import data in the operation of production to warehouse on production server. It connects WHH database on warehouse server for importing data in the operation of delivery and transportation. Customer returning records only transaction into the warehouse and return to production. It does not show location of lane but it shows only living zone. 3) Warehouse website summary report supports summary report of warehouse in daily comparison report, slow moving report and summary inventory report. It can see on handheld or laptop with wireless. WMS will keep transaction in WHDB database on warehouse server. It does not transfer data to SAP system because SAP client application will transfer data from warehouse server and production server to SAP system.

5.2 System Development

The development of new system has 3 parts: Database management, WMS Application and WMS website according to the design of the new system.

Database management is designed base on MSSQL Server 2000. It has 3 server to connect (PLS, WHH, WHDB) that WHDB is a main database. The PLS and WHH have read only data. WHDB will be tracking operation transactions, PLS selects goods for receive to warehouse and WHH selects goods for picking and shipping. WMS application development is base on Delphi 2007 and PHP language. WMS website shows result of operation, summary, and display capacity of warehouse by graph.

5.3 System implementation and testing

5.3.1 System Testing

Testing of the new system contains two techniques: system verification and validation.

5.3.1.1 System Verification

System verification is a process of ensuring the accuracy of each WMS functions. First, unit testing is the test of transact-SQL statement in the user interface and the accuracy of space calculation in each operation. In testing the accuracy of space calculation, the system would check the result from real product and real location to compare the number of product in line of the warehouse and WMS.

5.3.1.2 System Validation

System validation is a process of acceptant testing by presenting the WMS demonstration to the officers and asking them to use that demo. All functions pass in the acceptant criterions, which are user requirements and response time.

5.3.2 System Implementation

This phase is the windows server setting up including MSSQL Server for database server and IIS with PHP for web server together. In the next, create the table, set security into server and install web application file in virtual path. WMS must be installed in the client computer and connect by connection.ini file. Our system prototype is developed under the following environments.

5.3.1.1 Hardware Specification

- *Web and Database Server*

CPU	: Intel 2x Xeon CPU 3GHz or greater
Main Memory	: 1 GB or greater
Hard Disk	: 40 GB RAID 5
Monitor	: SVGA
Network Adaptor	: 1 GB Transfer

- *Coding and Client Testing*

CPU : Pentium IV 3.0 GHz
Main Memory : 512 MB
Hard Disk : 40 GB
Monitor : SVGA
Network Adaptor : 1 GB Transfer

5.3.1.2 Software Specification

- *Server*

Operating System: Microsoft Windows 2000 Server
DBMS : MS-SQL 2000
Web Server : IIS 5
Server Side Scripting: PHP 4.4.4

- *Development*

Operating System : Microsoft Windows XP
Programming Language : Delphi 2007 Developer
Editor : Crimson Editor 3.51
Web Browser : Microsoft Internet Explorer 6
Database Client tools : Enterprise Manager,
Query Analyzer

- *Client*

Operating System : Microsoft Windows XP
Web Browser : Microsoft Internet Explorer 6

5.3.3 System Evaluation

The main objective of evaluating the system is to collect the opinions from officers using WMS Application. The questionnaire contained 2 parts: profile and opinions of evaluators as shown in Appendix B, which are used for gathering the information which evaluated into 5 levels: Strongly Agree, Agree, Undecided, Disagree, Strongly disagree. There are five evaluators from users who are using

WMS. The decoding criteria value for evaluation is shown in Table 5.1. The result of system evaluation is shown in Table 5.2 - 5.3 and can be summarized as follows.

Table 5.1 The decoding criteria value for evaluation

Domain value	Meaning
1.00 – 1.50	Strongly disagree opinion
1.51 – 2.50	Disagree opinion
2.51 – 3.50	Undecided opinion
3.51 – 4.50	Agree opinion
4.51 – 5.00	Strongly agree opinion

Table 5.2 Questionnaire results from users using WMS

Question	Strongly Agree (%)	Agree (%)	Undecided (%)	Disagree (%)	Strongly Disagree (%)
1. Opinion about GUI					
1.1 Format of screen presentation and position of composition on application.	20	40	40	-	-
1.2 Appropriate of input screen	20	80	-	-	-
1.3 Appropriate background and text color	-	100	-	-	-
1.4 Appropriate menu position	40	20	40	-	-
1.5 Appropriate of warehouse image	-	80	20	-	-
Section Summary	16	64	20	-	-
2. Opinion about application system					
2.1 Suitability of current system	20	80	-	-	-
2.2 Step and instruction of current system	-	60	40	-	-

2.3 Convenience and rapidness of search data	40	20	40	-	-
2.4 Clearness to shown location of product	20	80	-	-	-
2.5 Clearness Information / document presentation	-	60	40	-	-
2.6 Correctness of current system	20	80	-	-	-
2.7 User friendly	40	60	-	-	-
2.8 Rapidness and usefulness of report	20	80	-	-	-
Section Summary	20	65	15	-	-
3. Opinion about system benefits					
3.1 Reduction of receiving and picking operation	20	80	-	-	-
3.2 Reduction of checking stock	20	80	-	-	-
3.3 Decrement step in current system	20	80	-	-	-
3.4 Reduction error of receiving and picking operation	40	60	-	-	-
Section Summary	25	75	-	-	-
Total result of WMS	20.34	68.00	11.67	-	-

Table 5.3 Questionnaire results from users using WMS (Continue)

Question	Mean	Satisfied Values
1. Opinion about GUI		
1.1 Format of screen presentation and position of composition on application.	3.8	Satisfied
1.2 Appropriate of input screen	4.2	Satisfied
1.3 Appropriate background and text color	4.0	Satisfied
1.4 Appropriate menu position	4.0	Satisfied
1.5 Appropriate of warehouse image	3.8	Satisfied
2. Opinion about application system		
2.1 Suitability of current system	4.2	Satisfied
2.2 Step and instruction of current system	3.6	Satisfied
2.3 Convenience and rapidness of search data	4.0	Satisfied
2.4 Clearness to shown location of product	4.2	Satisfied
2.5 Clearness Information / document presentation	3.6	Satisfied
2.6 Correctness of current system	4.2	Satisfied
2.7 User friendly	4.4	Satisfied
2.8 Rapidness and usefulness of report	4.2	Satisfied
3. Opinion about system benefits		
3.1 Reduction of receiving and picking operation	4.2	Satisfied
3.2 Reduction of checking stock	4.2	Satisfied
3.3 Decrement step in current system	4.2	Satisfied
3.4 Reduction error of receiving and picking operation	4.4	Satisfied
Total result of WMS	4.0	Satisfied

According to Table 5.2 – 5.3, the opinion about Graphic User Interface (GUI), 16% of the users are strongly satisfied, 64% of the users are satisfied, 20% of the users are undecided satisfied.

Result of the opinion about Application System, 20% of the users are strongly satisfied, 65% of the users are satisfied, 15% of the users are undecided satisfied.

Result of the opinion about System benefits, 25% of the users are strongly satisfied, 75% of the users are satisfied.

The total result of evaluation of warehouse management system (WMS) shows that 20.34% of the users feel strongly satisfied, 68% of the users feel satisfied and 11.67% of the users feel undecided satisfied. The mean shows that there are 4.0 users satisfy the WMS.

5.4 Maintenance of the New System

To maintain the WMS continually, having a developer team is necessary. The officers at computer section work as administrators. Their tasks are setting the location and user to use WMS.

5.5 Comparison of current system with new system

Operation	Current	New	Missing	Problem to Address
Daily Stock Checking				
	1. Walk to check the stock at 7-9 am. Everyday	1. Walk only comparing an error case	1. Staff spend 1-2 hours for warehouse checking	1. Auto checking error
	2. Compare the balance of stock in warehouse with SAP by report	2. Import SAP data and compare WMS data with error report	2. Double check	2. Build Importing data
	3. Move Broken or relocation by staff decision by walk	3. Have relocation layout planning	3. Location specification error	3. Support location decision and layout report
Receiving & Put-away				
	1. Receive PM#X Paper from production	1. Import receiving data	1. Inv.app can not see free space that cause the difficulty to choose location decision	1. WMS import receiving data from current system
	2. Quantity checking if error update PM#X	2. Can edit quantity data before committing the transaction	2. Having goods searching and call position error	2. Supporting location decision and layout report
	3. Find free space by walk and checking report	3. Show free space and order by priority of location		3. Having location planning before moving goods
	4. write location send to forklift driver	4. layout report for driver		
	5. Scan barcode	5. Scan barcode		

Operation	Old	New	Missing	Problem to Address
Picking & Shipping				
	1. Receive picking list	1. Import purchase order data	1. Difficult searching and having error in the calling location	1. WMS import purchase order data from current system
	2. Find location in inventory report and write in Picking list	2. Detect SKUs and select old Lots in warehouse	2. Double picking as the increasing picking time	2. Auto detect SKUs and location
	3. Send picking list to forklift driver	3. Layout report for forklift driver	3. Picking wrong product	3. Support picking time recorder
	4. Scan barcode and loading to truck	4. Scan barcode and loading	4. Delivery late	
Customer return to warehouse				
	1. Receive returning document from customer and distributor	1. Receive returning document from customer and distributor	1. Difficult searching and having error in the calling location	1. Auto detect location
	2. Checking Goods	2. Checking Goods		
	3. Hand writing in Goods controls report	3. Input returning goods description in WMS		
	4. Find location in inventory report and move to damaged zone	4. Auto location specification to damaged zone		

Operation	Old	New	Missing	Problem to Address
Return to production				
	1. Staff check goods in damage zone	1. Staff check goods in damage zone	1. Can not track status of goods	1. Support goods searching, show status and location
	2. Hand write goods repair report	2. Input goods repair description in WMS		
	3. Move to production			
Inventory Application				
	1. Inv.app input data by key in.	1. WMS importing data by PLS,WHH Database	1. Unable to transfer data from exist system and data conflict between SAP report.	1. WMS replace Inventory application
	2. Inv.app has only layout report	2. Support location decision	2. Unable show free space	2. WMS support location decision in real time
	3. Staff update stock data at night	3. Real time location	3. Unable show historical data	3. Show historical data on searching and website
		4. Have historical report	4. Unable show statistic report	4. Show statistic on website
		5. Have Statistic report		

CHAPTER VI
DISCUSSION

At the present, WMS is essential for management because it can support operation and solve problems. This application will succeed in the objectives. Moreover, User will accept new changes and satisfy to use it.

6.1 Problems During Development

The problems during development of the warehouse management system have 2 parts in the step of location measurement and the program installation.

1. From the gathering data, user have problems of location requirements and conditions as follows:
    - The phase of map screen can not slide the lines in block for showing the location of warehouse because it has the flexible degree; 45, 55, 60 90, 180. The system can not calculate correctly slide line in block.
    - It has special side style in fish bond. From the gathering data has four styles including left, right, vertical and horizontal.
    - The products have two SKUs in the line. It has gap about 1 pallet.

    All problems can be solved by cancellation the map to show the location and density of warehouse. This will make graph to show the percentile of space in 1 block.
2. In the test phase, having to wait authorization from the ITONE company to access servers.
3. Network is slow so the system is not smooth.
4. In the operation of receiving and picking the special products, there is no special product data in the database. This problem can be solved by special way to input data for process operation.

6.2 Tools in the Development

The system development life cycle (SDLC) is the framework of this research. Microsoft SQL Server 2000 is used for creating the system database. The visual-programming language, Borland Delphi 7.0 is used to develop the application because it has less system requirements, which is appropriate to the current computer specification. Web base technology is used for developing in to the map of WMS and summary report. It is easy to connect and show report.

6.3 Advantages

The advantages of the WMS are found and discussed as follow:

- The WMS can support location decision for operation and reduce time for decision making to choose the location.
- The WMS is client/ server architecture. User can use the system from any client in local area network.
- The WMS automatically select location for picking and shipping.
- Product checking can be done accurately and quickly.
- The WMS can supports many reports.
- Staff can forecast stock controlling.

6.4 Disadvantages

- The WMS can not show map location and not see the goods density.
- The WMS tracking is not smooth because the main data have conflict in customer order number. It can not compare between receiving and picking operation. Staff must use the manual for comparing data.

CHAPTER VII
CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The warehouse management system (WMS) for paper manufacturer is an application for tracking and deciding warehouse location of Thai Paper Company. The objective of WMS development is to serve the operation functions, i.e. Receiving, Picking, Relocation & moving, Returning and Repair.

The System Development Life Cycle (SDLC) is used as the basic of research methodology. Microsoft SQL Server 2000 RDBMS is used for creating the system database and collecting stored procedures. In regard of the visual-programming language, Borland Delphi 2007 and PHP are used to develop WMS application. Moreover, application will be tested by programmer and staff for system test.

The result of development is the WMS application, which provides better operation and management for a paper manufacturer business. This application can replace the old-application. It is a link of other database of warehouse. It can help the warehouse staff decreasing the operation time. Users accept the new changes and satisfy to use it. Thus the objective of the research is completed.

7.2 Recommendation

To increase the usefulness of the warehouse management system (WMS), the recommendations for further development are as follows:

7.2.1. WMS system should be merged the system in SAP, PLS, WHH together.

7.2.2. WMS system should be improved to be able to calculate automatically in receiving location.

7.2.3. WMS system should be improved the location suggestion.

7.2.4. WMS data can summarize goods report and support the management information system.

7.2.5. The WMS system should be improved to direct connection with SAP.

7.2.6. WMS data and Production data should be a real time transaction.

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APPENDIX

APPENDIX A
DATA DICTIONARY

Table	Attribute	Type	Width	Contents	Format	Req.	Key	FK Referenced
Product								
0	ID	Char	18	Material Number	Sheet/Roll_master.Material_no	Y	PK	
1	Description	Varchar	100	Name of Product	Material_master.Description_Eng	Y		
2	Type	char	1	Ream / Roll (S/R)	Sheet_master.width, Roll_master.width	Y		
3	Width	decimal	9,2	Meter Unit	Sheet_master.length			
4	Length	decimal	9,2	Meter Unit				
5	DiaMeter	decimal	9,2	Meter Unit				
6	Overlap	int	4	Count of turns		Y		
7	ImportTime	Smalldatetime		Import Time	getdate()	Y		
8	ToPallet	Char	1	ขาคู่				
9	Varies	int	4	+- Pallet				
InMaster								
0	ID	int		Auto Increment		Y	PK	
1	ProductID	Char	18	Link table -> Product	Sheet_amendment.Material_number	Y	FK	ProductID.ID
2	CusOrder	varchar	15	Customer Order	Sheet_amendment.Customer_order			
3	MachineID	char	1	Machine Number	Sheet_amendment.Department_number	Y	FK	
4	LotID	char	5	Lot Number	DD/YY	Y	FK	
5	SentTime	Smalldatetime		Date of Production to warehouse		Y		
6	TotalQuantity	Decimal	9,2	Count of Reams in lot		Y		
7	ImportTime	Smalldatetime		Import Time	getdate()	Y		
8	ReamPallet	Decimal	9,2	Ream per pallet		Y		
9	Status	Char	3	Input transaction status	NEW, CMP, CNC			
10	PlsTime	Smalldatetime		Time of pls table				
OutMaster								
0	ID	int		Auto Increment		Y	PK	
1	VehicleID	Varchar	20	Car / ContainerID				
2	TimeStart	SmalldateTime		Watch Start				
3	TimeStop	SmalldateTime		Watch Stop				
4	Status	Char	3	Picking status	NEW / ACT / CMP / CNC	Y		
5	ImportTime	SmalldateTime			getdate()	Y		
6	Driver	int	4	Driver				

Table	Attribute	Type	Width	Contents	Format	Req.	Key	FK Referenced
OutItem								
0	ID	int		Auto Increment		Y	PK	
1	OutMasterID	int		Link table -> OutMaster		Y	FK	OutMaster.ID
2	OrderID	Varchar	10	Order Number (D/P)	Delivery_item.Delivery_no	Y		
3	ProductID	Char	8	Link table -> Product	Delivery_item.Material_no	Y	FK	Product.ID
4	Quantity	Decimal	9,2	Number of Picking Goods	Delivery_item.Actual_Qty	Y		
5	Status	Char	3	Picking status	CMP / CNC / NEW	Y		
6	CusOrder	varchar	15	Customer Order				
LocBlock								
0	ID	int		Auto Increment		Y	PK	
1	Name	Varchar	20	Name of Location Block		Y		
2	ZoneID	char	1	Zone Identification	D: Domestic / E: Export / P: Production / X: Other	Y		
3	Shape	Varchar	200	Shape Coordinate of Block	L:Left / R:Right / F:Fish Bond / H: Herizontal / V: Vertical	Y		
4	Format	char	1	Point of Location to Zone		Y		
5	CreateTime	Smalldatetime		User Create Time	getdate()	Y		
6	Status	char	1	Block status	E: Enable / D: Disable	Y		
LocLine								
0	ID	int		Auto Increment		Y	PK	
1	BlockID	int		Link table -> Block		Y	FK	Block.ID
2	Name	Varchar	20	Name of line		Y		
3	Length	Decimal	9,2	Length of line		Y		
4	Type	Char	3	Normal / Fast Picking / Hold	NOR / FAS / HOL	Y		
5	UpdateTime	Smalldatetime		Type Update's Time	getdate(0	Y		
6	Status	Char	1	Line status	E: Enable / D: Disable	Y		
7	Currentsize	Decimal	9,2	Current size of line		Y		

Table	Attribute	Type	Width	Contents	Format	Req.	Key	FK Referenced
Track								
0	ID	int		Auto Increment		Y	PK	
1	Direction	Char	3	In Case	IN / OUT (-)	Y		
2	LineID	int		Link table - > LocLine		Y	FK	LocLine.ID
3	Quantity	Decimal	9,2	Count of Effective Action	Ream, Rolls	Y		
4	ActionTime	Smalldatetime		Tracking Time	getdate()	Y		
5	ActionID	Char	3	Track Action	**Get** PRD: Production MOV: Move MIX :Mix SKUs **Out** ORD: Customer Order WST: Waste Goods MOV: Move	Y		
6	ProductID	Char	8					
7	MachineID	Char	1					
8	LotID	Char	5	get Current Lot				
9	MasterID	int		Link table - > InMaster Link table - > OutMaster		Y	FK FK	InMaster.ID OutItem.ID MoveDoc.ID
10	Status	Char	3		RES/ CMP /CNC			
11	usedSpace	Decimal	9,2					
Waste								
0	ID	int		Auto Increment		Y	PK	
1	Direction	Char	3	In Case	IN / OUT	Y		
2	ProductID	Char	8	Link table -> Product		Y	FK	Product.ID
3	MasterID	int		Link table -> InMaster Link table -> ReturnFrm Link table -> RepairFrn	if from Warehouse if from Customer if send to Production	Y	FK FK	InMaster.ID OutMaster.ID Track.ID
4	Type	Char	2	Type of waste product	WH: Warehouse, CS: Customer, RT: Return	Y		
5	Quantity	Decimal	9,2	Count of effective action		Y		
6	ActionTime	Smalldatetime			getdate()	Y		
7	QI	Char	1		ส่งซ่อม N / Y			
8	CusOrder	varchar	15	Customer Order				

Table	Attribute	Type	Width	Contents	Format	Req.	Key	FK Referenced
MoveDoc								
0	ID	int	4					
1	MoveTime	Smalldatetime						
2	TotalRec	int	4					
3	Status	Char	3	NEW / CMP / CNC				
ReturnFrm								
0	ID	int		Auto Increment	Form No.	Y	PK	
1	ReturnDate	SmallDateTime		DateTime		Y		
2	DocNo	Varchar	10	Number of document		Y		
3	RetFrom	Char	1	Place of receiving	ที่เดียวกัน,ต่างสถานที่,ส่งรถไปรับ	Y	FK	ReturnInfo.ID
4	RetDesc	text	16	Return Description		Y		
5	SendState	int		Look of goods	ห่อปกติ,ห่อฉีกขาด,เปลือย,ตัดเจียร/ใช้งานแล้ว,...	Y	FK	GoodsStatus.ID
6	Pack	Varchar	20	Packing of goods	กระบะ,กระสอบ,...			
7	Quantity	int		Count of goods in reams		Y		
8	Status	Char	3	status	USE, CNC, CMP	Y		
RepairFrm								
0	ID	int		Auto Increment	Form No.	Y	PK	
1	WasteID	int		Link table -> Waste		Y	FK	Waste.ID
3	DateSend	SmallDateTime		Send Date		Y		
4	RepFor	int		Cause of repair		Y	FK	RequestInfo.ID
5	RepResult	int		Repair result		Y	FK	WasteStatus.ID
7	DateReceive	SmallDateTime		Receiving Date				
8	Status	Char	3	Status	USE, CNC, CMP	Y		
Log Access								
0	no	int		Auto Increment		Y	PK	
1	StaffID	Char	5	Link table -> Staff		Y	FK	Staff.ID
2	DateTime	SmallDateTime		Date/Time	getdate()	Y		
3	Host	Varchar	15	IP Address	TRIGGER	Y		
4	Action	Varchar	3	Activity	NEW : Create Staff LOG: Log on / OFF: Log off INS: Goods In / OUT: Goods Out MVI: Move In / MVO: Move Out RET: Return / REP: Repair	Y		
5	FormID	int		Waste.ID,InMaster.ID,OutMaster.ID				

Table	Attribute	Type	Width	Contents	Format	Req.	Key	FK Referenced
Staff								
0	ID	int		no		Y	PK	
1	StaffID	Char	5	Staff Barcode		Y		
2	NameTh	Varchar	100	Thai Fullname		Y		
3	NameEn	Varchar	100	English Fullname				
4	Position	Varchar	100	Position				
5	Username	Varchar	20	Username		Y		
6	Password	Varchar	20	Password		Y		
7	Level	Char	1	Level	1: Administrator, 2: Operationoal, 3:Worker	Y		
8	AccStatus	Char	1	Account Status	0: Unactive, 1: Active	Y		
FastMove								
0	ID	int				Y	PK	
1	MatID	Char	18			Y		
2	CreateTime	SmallDateTime				Y		
3	Status	Char	3		USE, CNC, CMP	Y		
ConfigInfo								
0	ID	int		Auto Increment		Y	PK	
1	Description	Varchar	200	Description		Y		
2	Status	Char	1	Status	0: Cancel, 1: Use	Y		
3	DataType	Char	3	Data Type	RET: Return, GST: Goods Status, WAT: Waste status, REQ: Request Info			
Inpkg								
0	ID	int				Y	PK	
1	Masterlist	Varchar	250	List of Master ID		Y		
2	PkgName	Varchar	50	Package Name				
3	Status	Char	3	Status	NEW, CMP, CNC	Y		

APPENDIX B

แบบสอบถามความคิดเห็นสำหรับผู้ใช้ ระบบการจัดการคลังสินค้า

<u>คำชี้แจง</u> แบบประเมินผลการใช้งานระบบการจัดการคลังสินค้า มีวัตถุประสงค์ในการสอบถามความคิดเห็นของผู้ใช้เพื่อนำไปประเมินประสิทธิภาพของระบบ และทำการปรับปรุงแก้ไขให้เหมาะสมต่อไป

ส่วนที่ 1 : ข้อมูลของผู้ตอบแบบสอบถาม

1.1 เพศ [ ] ชาย [ ] หญิง

1.2 ปฏิบัติงานตำแหน่ง.....

ส่วนที่ 2 : ความคิดเห็นจากการใช้ระบบการจัดการคลังสินค้า

โปรดทำเครื่องหมาย ✓ ในช่องว่างที่ตรงกับความคิดเห็น

ข้อคำถาม	เห็นด้วยอย่างยิ่ง	เห็นด้วย	เฉยๆ	ไม่เห็นด้วย	ไม่เห็นด้วยอย่างยิ่ง
1. ความคิดเห็นเกี่ยวกับการออกแบบระบบ					
1.1 ความเหมาะสมของรูปแบบหน้าจอ การจัดตำแหน่งส่วนต่างๆ บนหน้าจอ					
1.2 ความเหมาะสมของการป้อนข้อมูลบนหน้าจอมีความชัดเจน					
1.3 ความเหมาะสมของสีพื้นหน้าจอ ตัวอักษรและปุ่มต่างๆ					
1.4 ความเหมาะสมของเมนูการใช้งาน					
1.5 ความเหมาะสมของการแสดงภาพคลังสินค้า					
2. ความคิดเห็นเกี่ยวกับการทำงานของระบบ					
2.1 ความสอดคล้องกับระบบงานปัจจุบัน					
2.2 ขั้นตอนและวิธีการใช้งานของระบบ					
2.3 ความสะดวกรวดเร็วในการค้นหาสินค้า					
2.4 แสดงสถานที่ตั้งของสินค้าได้อย่างชัดเจน ถูกต้อง					
2.5 การนำเสนอข้อมูล และเอกสาร มีความชัดเจน					
2.6 การทำงานของระบบมีความถูกต้อง					
2.7 ระบบใช้งานง่าย					
2.8 ออกรายงานได้อย่างรวดเร็ว ตรงความต้องการ					
3. ความคิดเห็นเกี่ยวกับประโยชน์ที่ได้รับจากระบบ					
3.1 ลดเวลาในการนำสินค้า เข้า-ออก คลัง					
3.2 ลดเวลาการตรวจสอบคลังสินค้า					
3.3 การลดขั้นตอนการทำงานในระบบงานปัจจุบัน					
3.4 การลดความผิดพลาดในการจัดเก็บ-หยิบสินค้า					

APPENDIX C

USER DOCUMENTATION

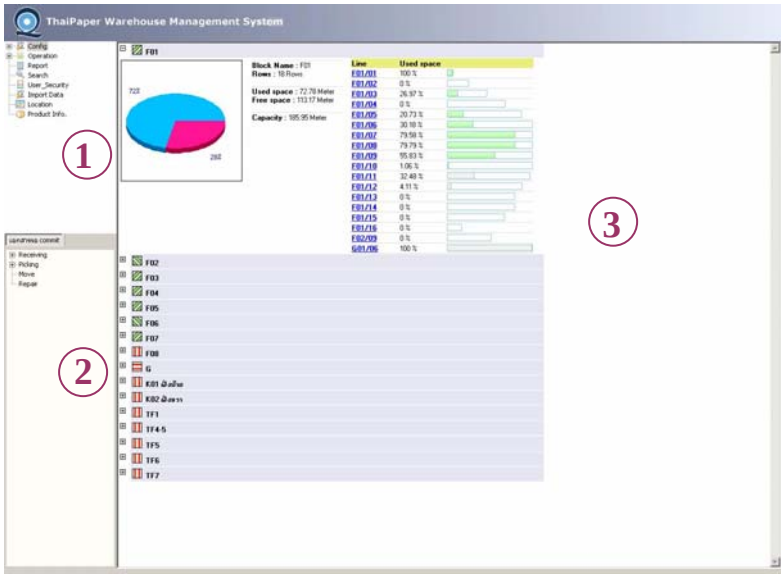
คู่มือการใช้งานระบบการจัดการคลังสินค้า กรณีศึกษาบริษัทผลิตภัณฑ์กระดาษไทย จำกัด

หน้าจอเข้าสู่ระบบ

จากรูปที่ ผู้ใช้จะต้องกรอกข้อมูล Username และ Password ที่ได้รับในช่อง Username และ Password

ส่วนประกอบของโปรแกรม

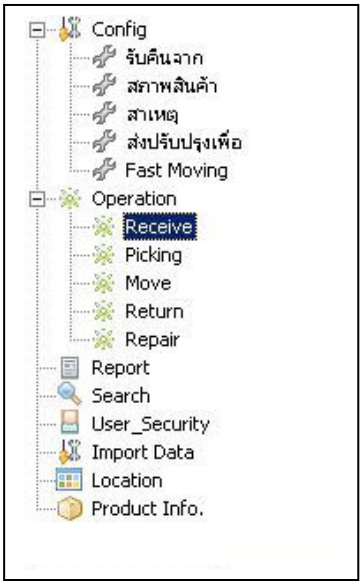
เมื่อผู้ใช้ทำการ Login เข้าสู่ระบบมาแล้วจะพบหน้าจอหลักซึ่งประกอบด้วย 3 ส่วนหลัก



1. เมนูหลัก
2. รายการสินค้าที่ค้างในระบบ
3. รายการสินค้าภายในคลังสินค้าทั้งหมด และกราฟแสดงสัดส่วนของสินค้าภายในคลังสินค้า

เมนูหลัก

เมนูหลักในระบบการจัดการคลังสินค้า ซึ่งประกอบไปด้วย



1. **Config** เป็นการกำหนดรายละเอียดข้อมูลเบื้องต้น ประกอบด้วย
   - รับคืนจาก
   - สภาพสินค้า
   - สาเหตุ
   - ส่งปรับปรุงเพื่อ
   - Fast Moving

2. **Operation** เป็นกระบวนการทำงานหลักของระบบฯ ประกอบด้วย
   - Receive
   - Picking
   - Move
   - Return
   - Repair

3. Report เป็นการพิมพ์รายงานสรุปสินค้าในคลัง และสถานที่ตั้งสินค้าต่างๆ

4. Search เป็นการค้นหาสินค้าจาก รหัสสินค้า, สถานที่ตั้ง, ...

5. User Security กำหนดสิทธิการใช้งานของระบบฯ

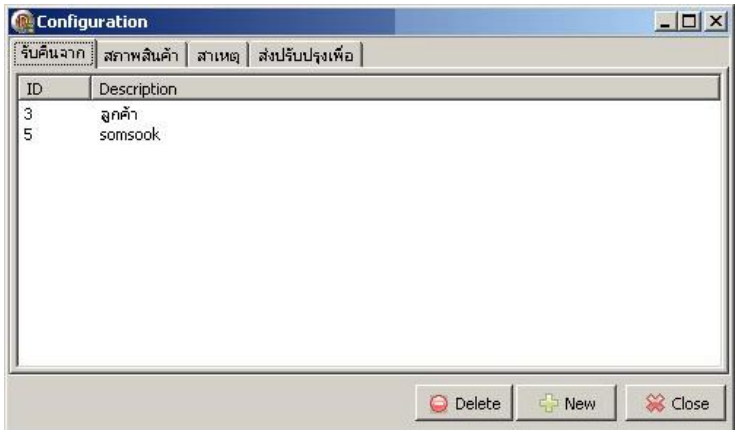
6. Import Data เป็นการดึงข้อมูลจากระบบ SAP เพื่อนำมาทำการเปรียบเทียบสินค้าในคลัง

7. Location เป็นส่วนของการจัดการพื้นที่ในคลังสินค้า

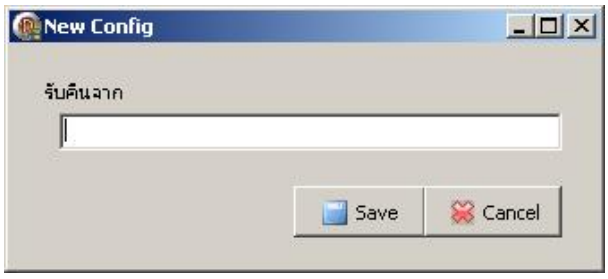
8. Product Information รายละเอียดสินค้าที่อยู่ในคลัง

Configuration Menu

เป็นการกำหนดรายละเอียดการรับคืนจาก, สภาพสินค้า, สาเหตุ, ส่งปรับปรุงเพื่อ โดยทั้งหมดนี้จะรวมอยู่ในแถบเมนู Configuration



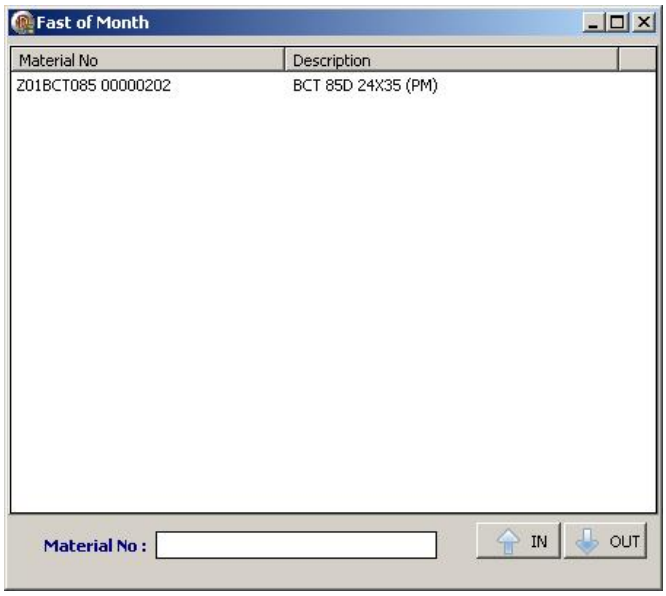
1. เพิ่มรายละเอียดการรับคืนสินค้าจาก โดยคลิกที่ New หลังจากนั้นใส่ข้อมูลในช่อง แล้วคลิก Save เพื่อทำการบันทึกข้อมูล



2. หากต้องการลบข้อมูลให้เลือกรายการที่ต้องการลบ แล้วคลิก Delete เพื่อทำการลบรายการ

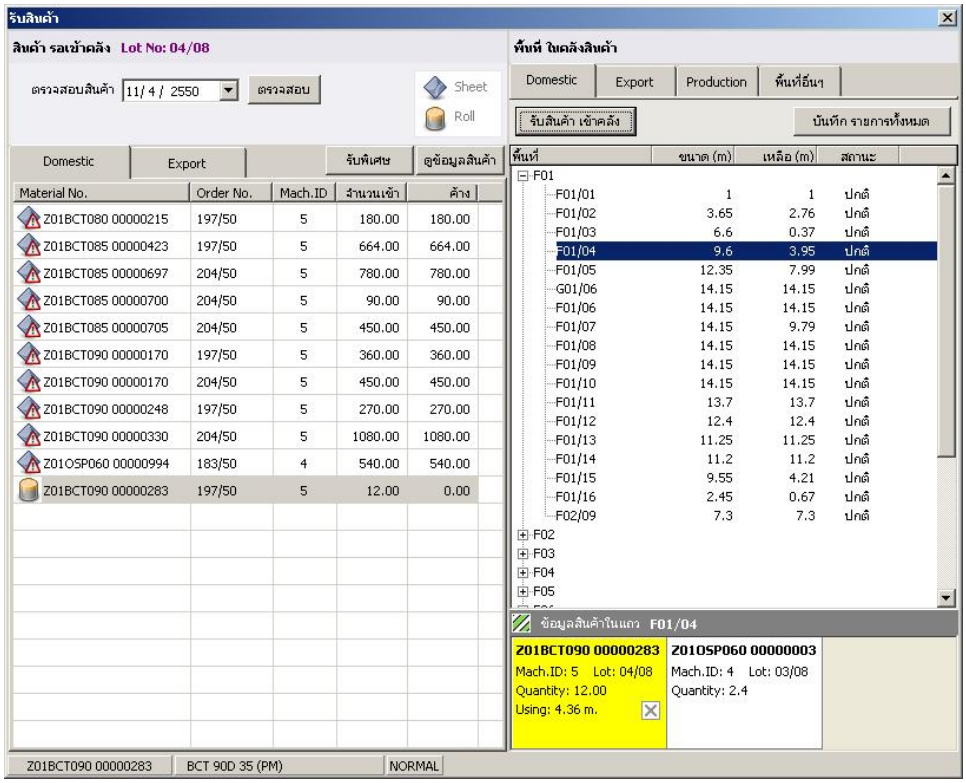
3. ในส่วนของสภาพสินค้า, สาเหตุของความเสียหาย, การส่งปรับปรุงเพื่อ มีขั้นตอนเหมือนกัน

Fast Moving Setting เป็นการกำหนดสินค้าที่มีการเข้า-ออก บ่อยครั้ง ซึ่งสามารถตั้งค่าโดยใส่รหัสสินค้า แล้วทำการคลิกปุ่ม IN เพื่อนำสินค้าเข้าสู่ Fast moving zone และทำการเลือกสินค้าแล้วคลิกปุ่ม OUT เพื่อยกเลิกสินค้า



Operations

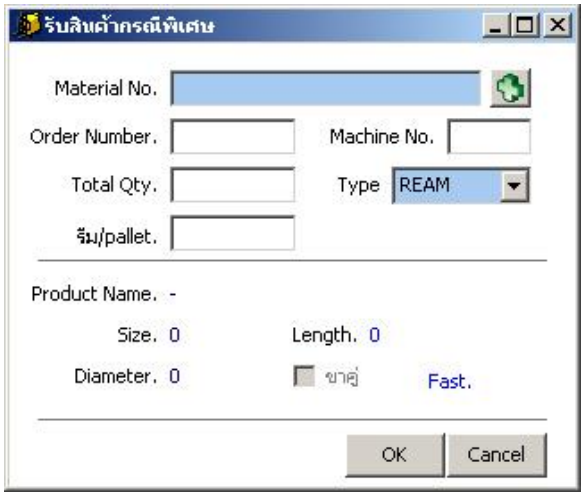
Receive: เป็นขั้นตอนการรับสินค้าจากฝ่ายผลิตเข้าสู่คลังสินค้า ในการนำสินค้าเข้าคลังตามขั้นตอนดังนี้



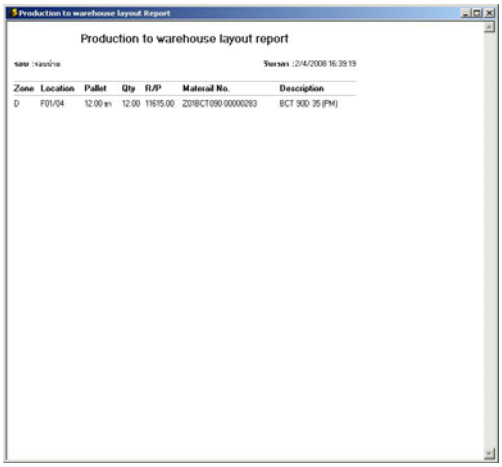
1. เลือกวันที่นำสินค้าเข้าคลัง เลือกปุ่มตรวจสอบ เพื่อทำการ list รายการสินค้าที่จะนำเข้าคลัง ซึ่งในรายการสินค้าจะแยกออกแบ่ง Domestic กับ Export รายการที่เป็นรีมจะแสดงในรูป
   a.  มีรายการสินค้าชนิดรีมในฐานข้อมูล
   b.  ยังไม่ได้มีการตั้งค่ารายการสินค้าชนิดรีม
   c.  มีรายการสินค้าชนิดม้วนในฐานข้อมูล
   d.  ยังไม่ได้มีการตั้งค่าสินค้าชนิดม้วน

   สามารถดูรายละเอียดสินค้าได้โดยเลือกสินค้า แล้วคลิ๊กปุ่มดูสินค้า
2. ทำการเลือกพื้นที่เพื่อวางสินค้าในแถบแสดงพื้นที่ในคลังสินค้า ซึ่งจะแบ่งตามโซนของคลังสินค้า แล้วคลิ๊กปุ่มรับสินค้าเข้าคลัง ซึ่งจะปรากฏเป็นแถบสีเหลืองทางด้านล่าง (ส่วนแถบสีขาวจะเป็นสินค้าที่มีในแถว) หากทำการเลือกสินค้าผิดให้คลิ๊กลบออกจากแถว

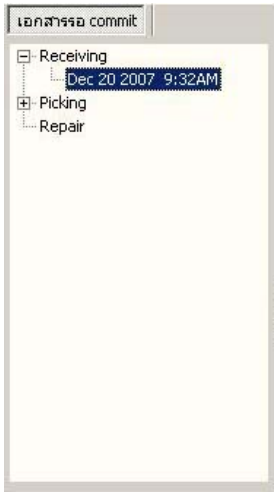
3. กรณีที่มีการนำสินค้าเข้าในกรณีพิเศษ ให้คลิ๊กที่ปุ่มเพิ่มสินค้านำเข้า จะปรากฏหน้าจอเพิ่มสินค้าและจำนวนที่นำเข้าคลังสินค้าด้วยตนเอง โดยไม่ต้องผ่านการยิงบาร์โค้ดหลังจากนั้นรายการที่ทำการตั้งค่าจะมาปรากฏในรายงานนำสินค้าเข้าคลัง และดำเนินการต่อไป



4. ทำการบันทึกรายการทั้งหมด เมื่อนำสินค้าเข้าครบแล้ว
5. ทำการ Print Layout โดยการคลิ๊กขวาในรายงานแล้วเลือก Print เพื่อให้คนขับต่อไป

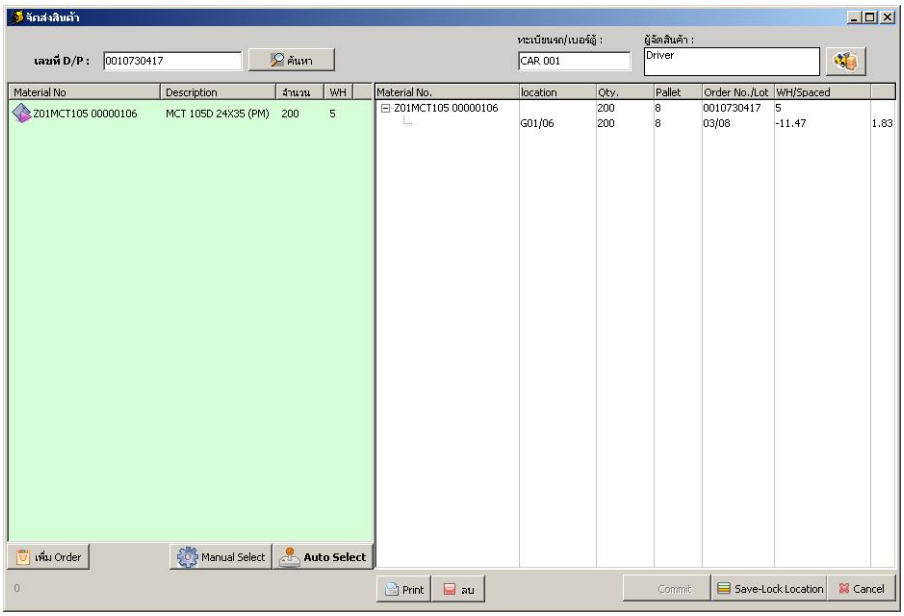


6. หลังจากที่ได้ทำการเคลื่อนย้ายเสร็จแล้วให้มาคลิ๊ก Submit Transaction ที่ จะเปิดหน้าที่เลือกสินค้าเข้าไว้มาให้เรา commit Transaction เพื่อจบ Transaction



Picking การจัดส่งสินค้า

1. เมื่อได้รับใบตั้งสินค้าให้ทำการระบุเลขที่ D/P, ทะเบียนรถ/เบอร์ตู้สินค้า, ผู้จัดสินค้า
2. ทำการเลือกค้นหาสินค้าที่จะจัดส่งจากเลขที่ D/P
3. เมื่อได้รายการสินค้าในใบตั้งสินค้าแล้ว ก็ให้เลือกแถวที่ต้องการนำสินค้าออกโดยผู้ใช้สามารถเลือกได้ทั้งแบบอัตโนมัติ คือให้ระบบทำการเลือกที่ตั้งของสินค้าเอง หรือเลือกที่ตั้งของสินค้าด้วยตนเอง รายการสินค้าพร้อมสถานที่ตั้งของสินค้าจะถูกแสดงในด้านล่าง

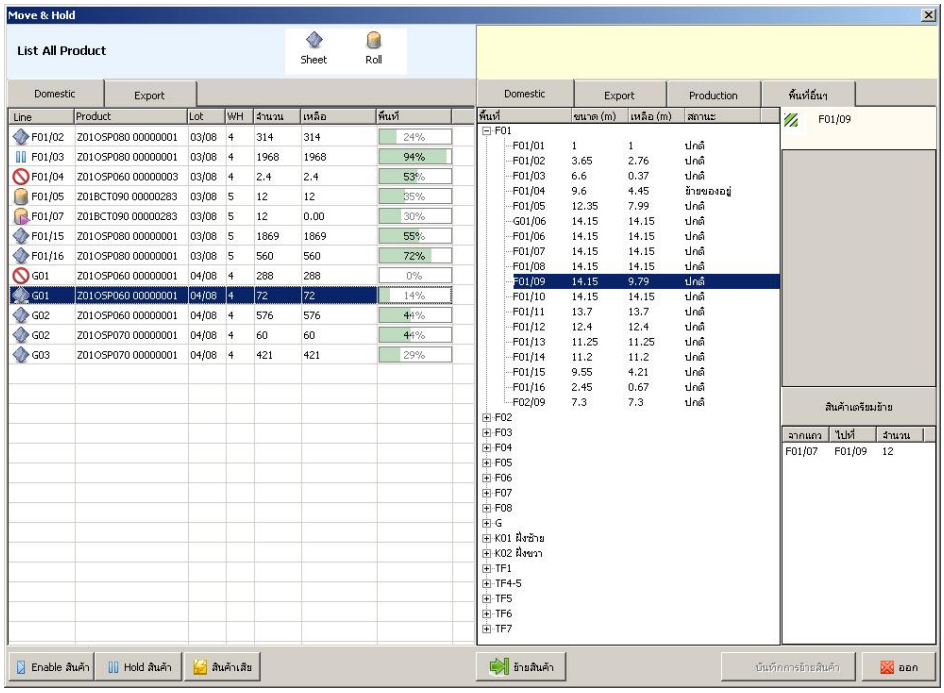


4. หากรายการที่เลือกมีข้อผิดพลาดให้คลิกปุ่มทำการแก้ไข เพื่อทำการแก้ไขต่อไป

5. ในกรณีไม่พบสินค้านำออก หรือมีการนำสินค้าออกในกรณีพิเศษ สามารถนำสินค้าออกได้เองโดยคลิ๊ก Manual Shipping เพื่อทำการเลือกสินค้าและจำนวนที่จะนำออกจากคลัง

6. เมื่อทำการเลือกสินค้าครบคลิ๊ก Save-Lock location เพื่อทำการ Lock และ คลิ๊ก Print Layout ต่อไป
7. เมื่อตั้งสินค้าเรียบร้อยต้องทำการ Commit Transaction เหมือนฝั่งรับสินค้า

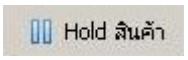
Move การเคลื่อนย้ายสินค้า

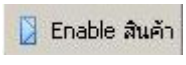


ในส่วนของการย้ายสินค้าภายในคลังสินค้า จะประกอบไปด้วย

1. การย้ายสินค้า 

จากแถวที่มีปริมาณสินค้าไม่เหมาะสมกับแถว เพื่อเป็นการเพิ่มพื้นที่การใช้งานให้มากขึ้น โดยการย้ายสินค้าจะต้องเริ่มจาก เลือกสินค้าในแถวที่ต้องการย้ายจากทางด้านขวามือ ซึ่งจะแสดงเป็นโซน และกราฟจะแสดงปริมาณสินค้าในแถวนั้นๆ แล้วทำการเลือกแถวที่ต้องการย้ายเข้าทางด้านขวามือ ซึ่งจะแสดงสินค้าที่มีอยู่ในแถวนั้นแถบขวาบนสุด แล้วกดปุ่มย้ายสินค้า รายการย้ายสินค้าจะไปปรากฏในแถบขวาล่าง เมื่อทำรายการเสร็จสิ้น กดปุ่มบันทึกการย้ายสินค้า
2. สินค้าเสีย 

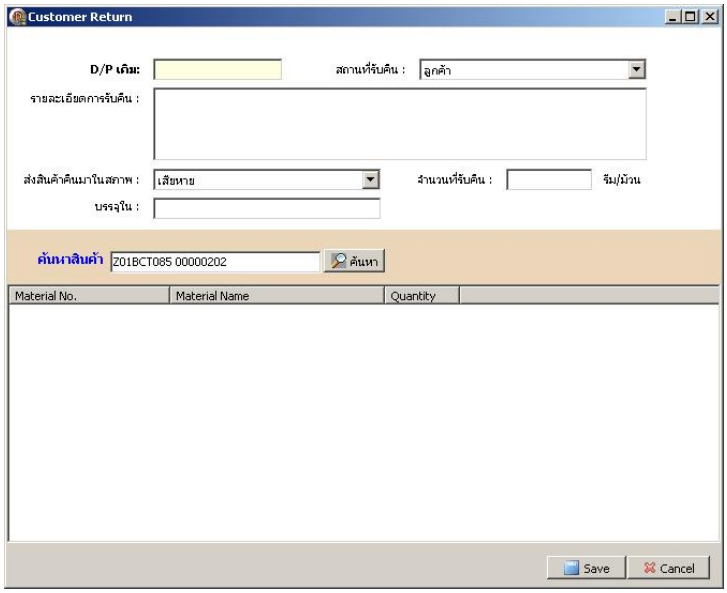
จากการเคลื่อนย้ายสินค้า จะเป็นการนำสินค้าในแถวนั้นย้ายไปที่โซนสินค้าเสีย
3. การระงับการขายสินค้าในแถวนั้นๆ 

ให้เลือกแถวที่สินค้านั้นต้องการระงับ กดปุ่ม Hold สินค้า เพื่อทำรายการ
4. ยกเลิกการระงับการขายสินค้า 

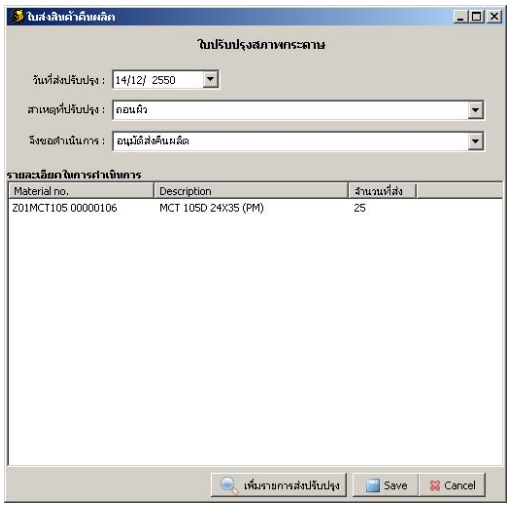
ให้เลือกแถวที่ทำการระงับไว้ แล้วกดปุ่ม Enable สินค้าเพื่อให้สามารถขายสินค้านั้นได้ต่อไป

Return การรับคืนสินค้าจากลูกค้า

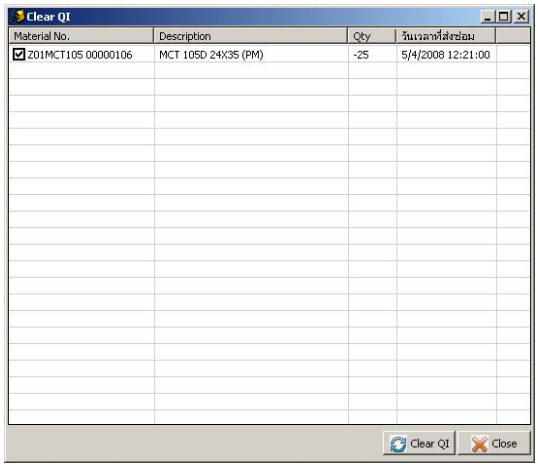
ในการรับคืนสินค้า จะต้องระบุเลขที่ D/P ในการจ่ายสินค้า และสาเหตุของการคืนสินค้า ซึ่งสินค้าที่รับคืนมาจะถูกส่งไปเก็บไว้ในโซนสินค้าเสีย เพื่อรอการดำเนินการซ่อมต่อไป



Repair (ใบปรับปรุงสภาพกระดาษ) ส่งสินค้าไปปรับปรุงที่ฝ่ายผลิต ซึ่งเป็นการนำสินค้าที่อยู่ในโซนสินค้าเสียมาปรับปรุง ซึ่งจะต้องระบุสาเหตุที่ส่งปรับปรุง, วิธีดำเนินการ และรายละเอียดการดำเนินการ กดปุ่มเพิ่มรายการส่งปรับปรุง เพื่อเลือกสินค้าที่ต้องการส่งปรับปรุง แล้วกดปุ่ม save

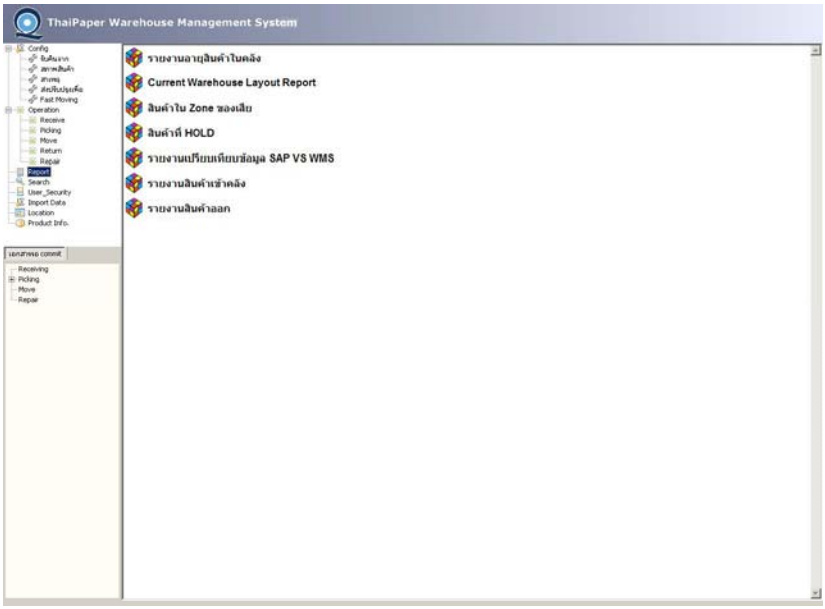


หลังจากทำรายการเรียบร้อยแล้ว เมื่อมีการส่งสินค้าที่ปรับปรุงคืนคลังจะต้องทำการ Clear QI เพื่อลบรายการส่งปรับปรุง



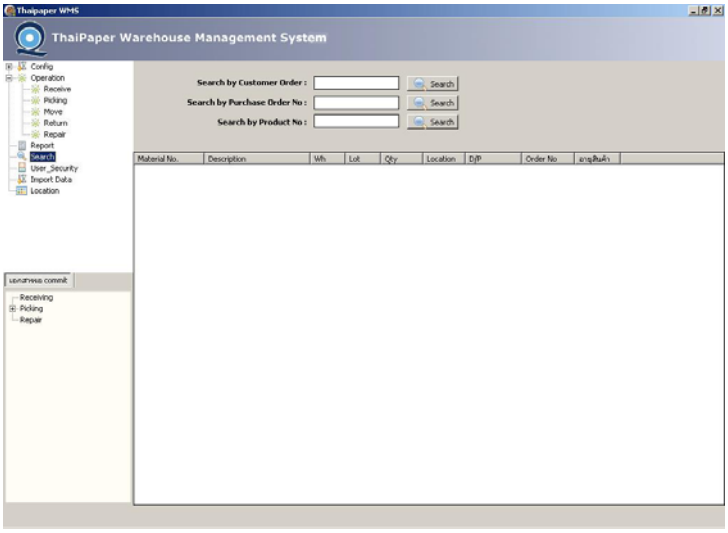
Report รายงานต่างๆ ประกอบด้วย

1. รายงานอายุสินค้าในคลังสินค้า
2. current warehouse report by zone
3. สินค้าในพื้นที่สินค้าเสีย
4. สินค้าที่ได้ทำการระงับไว้
5. รายงานการเปรียบเทียบสินค้าระหว่าง SAP กับ WMS
6. รายงานรับสินค้าเข้าคลัง
7. รายงานจัดส่งสินค้า



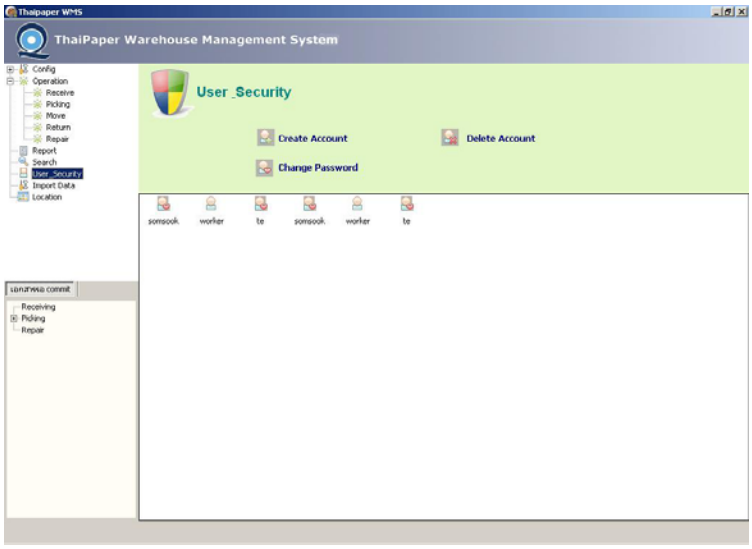
Search ค้นหาสินค้า จะแบ่งออกเป็น 3 ส่วน

1. Search by Customer Order
2. Search by Purchase Order No
3. Search by Product No



User Security จัดการผู้ใช้ระบบ ผู้ใช้ระบบจะแบ่งเป็น 3 ระดับ

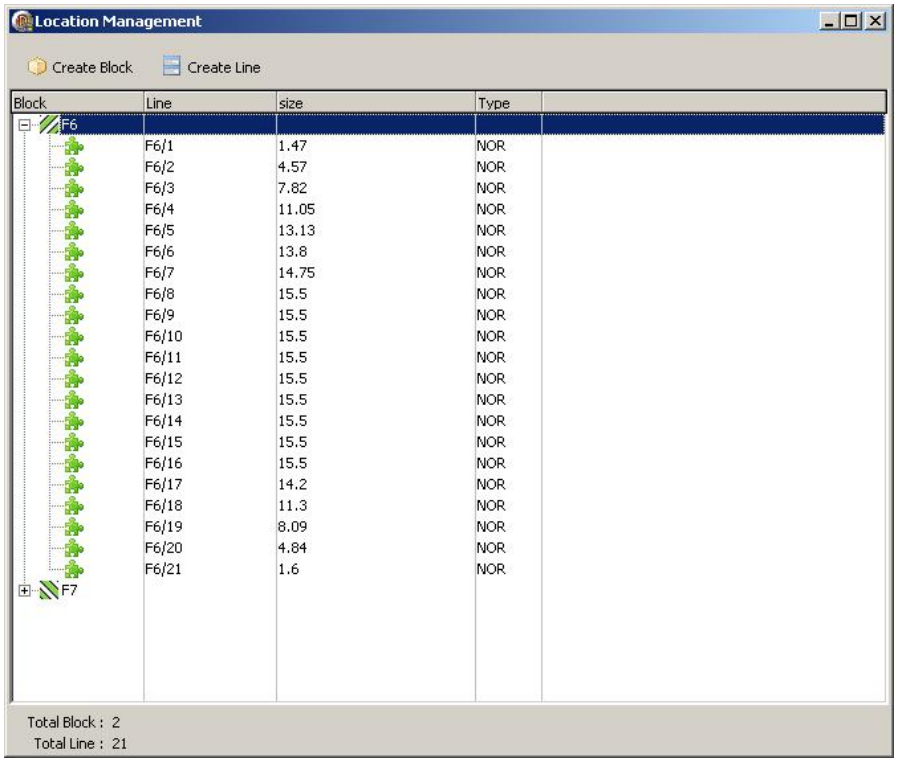
1. Administrator: สำหรับควบคุมผู้ใช้ระบบ สามารถใช้ระบบได้ทุกส่วน
2. Operation: สามารถใช้ระบบได้ทั้งหมด ยกเว้น user management
3. Worker: สำหรับคนขับรถ



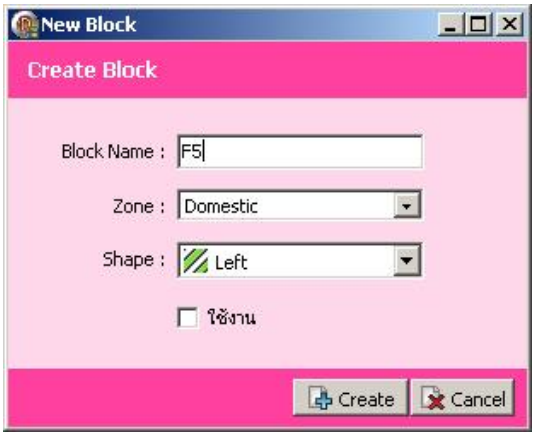
Create Account สร้างผู้ใช้ระบบ จะต้องระบุชื่อภาษาไทย, ภาษาอังกฤษ, ตำแหน่ง, username, password, ระดับการใช้งาน, user active เพื่ออนุญาติให้ใช้งาน แล้วกดปุ่ม create เพื่อสร้าง

Change Password เลือกที่ Account ที่ต้องการเปลี่ยน Password ระบุ password เก่า และ password ใหม่ที่ต้องการเปลี่ยน กดปุ่ม Change Password

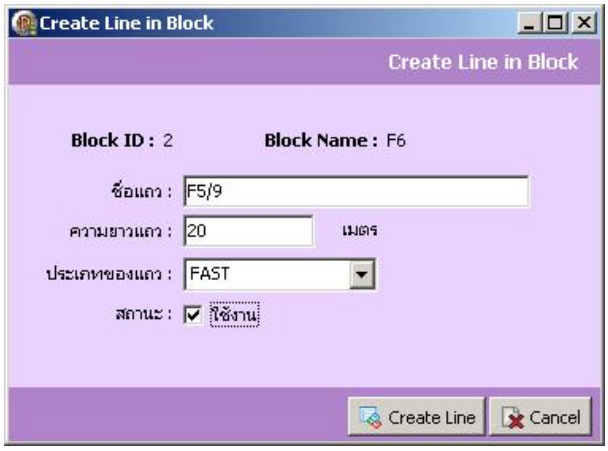
Location สร้างพื้นที่ในคลังสินค้า ในการกำหนดสถานที่จะแบ่งออกเป็น Block ซึ่งภายในจะมีแถวอยู่ ซึ่งจะมีลักษณะการเอียงคือ เอียงซ้าย, เอียงขวา, ตรง 90 องศา, ก้างปลา ซึ่งโปรแกรมจะแสดง ขนาดของพื้นที่ ชนิดของพื้นที่



New Block สร้างบล็อคเพื่อรองรับแถว ซึ่งจะประกอบด้วย ชื่อบล็อค, โซน, ลักษณะของแถว และการใช้งาน

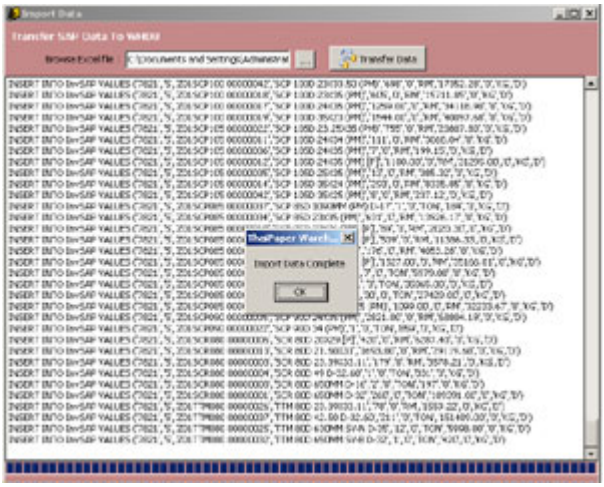


Create Line in block ในการสร้างแถวใน block จะต้องเลือกบล็อคที่ต้องการสร้างแถว กดปุ่ม create line และทำการระบุชื่อแถว, ความยาวแถว (เมตร), ประเภทของแถว, สถานะการใช้งาน กดปุ่ม create line อีกครั้งเพื่อ set แถว

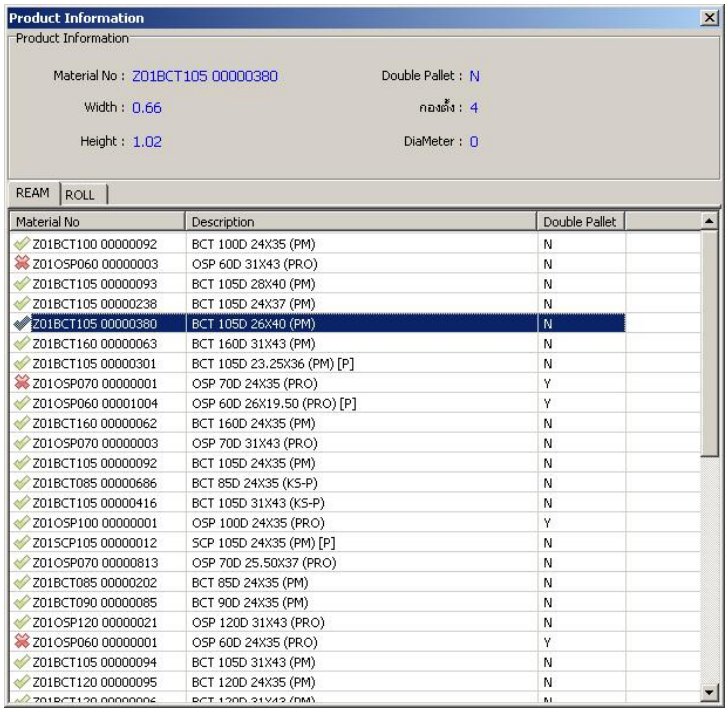


Import Data เป็นขั้นตอนการนำข้อมูลที่ได้จาก SAP เพื่อนำมาเปรียบเทียบกับข้อมูลในระบบ

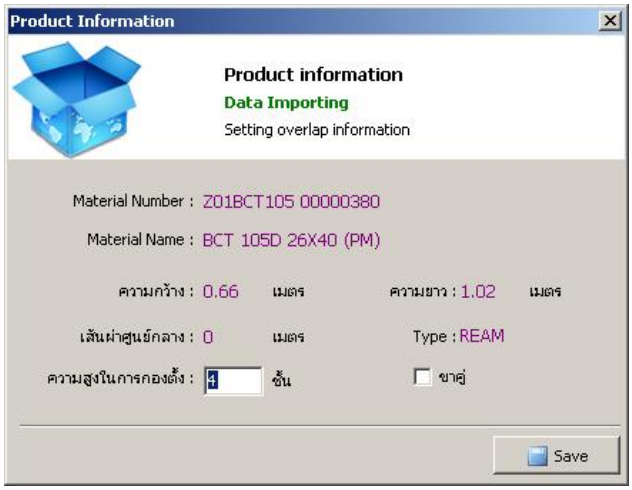
1. ทำการเลือก excel file ที่ได้จากการ export ข้อมูลจาก sap ที่ต้องการ import เข้าสู่ระบบ
2. กดปุ่ม Transfer data เพื่อทำการโอนถ่ายข้อมูล เมื่อทำการโอนข้อมูลเรียบร้อยแล้วจะขึ้นข้อความ Import complete
3. เมื่อทำการโอนข้อมูลเรียบร้อยแล้ว สามารถเข้าไปดูรายงานการเปรียบเทียบข้อมูลระหว่าง sap กับ wms ได้ที่เมนู report



Product Information เป็นส่วนของข้อมูลสินค้าที่อยู่ในระบบ ซึ่งจะบอกถึงลักษณะของสินค้า สัดส่วนการกองตั้ง



สามารถทำการแก้ไขได้หากสินค้าชนิดนั้นไม่ได้มีการกองตั้งในคลังแล้ว โดยการ double click สินค้าที่มีเครื่องหมายถูก และสามารถแก้ไขได้เพียงจำนวนการกองตั้ง และลักษณะการวางแบบขาคู่เท่านั้น



BIOGRAPHY

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