THE ANALYSIS OF A BUSINESS PROCESS FOR THE DEVELOPMENT OF AN INFORMATION SYSTEM FOR WAREHOUSE MANAGEMENT

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR
THE DEGREE OF MASTER OF SCIENCE
(TECHNOLOGY OF INFORMATION SYSTEM MANAGEMENT)
FACULTY OF GRADUATE STUDIES
MAHIDOL UNIVERSITY
2010

Thesis
entitled

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was submitted to the Faculty of Graduate Studies, Mahidol University
for the degree of Master of Science
(Technology of Information System Management)
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ACKNOWLEDGEMENTS

This dissertation was successfully done, which the researcher would like to contribute fully thanks to Asst. Prof. Rangsipan Marukatat, Assoc. Prof. Duangpun Singkarin, Dr. Thitikorn Limchimchol, Asst. Prof. Warakorn Charoensuk, and Asst. Prof. Charun Sanrach, who always dedicate their times to advise, recommend, and examine to modify until this dissertation has been completed.

The researcher would like to extend the honourable thanks to all lecturers in Technology of Information System Management program, Faculty of Engineering, Mahidol University, from pass to present who have taught the valuable things.

The researcher also would like to give sincere thanks to case study company where allowing the researcher to study and collect the data as well as providing valuable recommendation for this dissertation.

Finally, the researcher would like to express deeply thanks from heart and soul to parents, relatives, and all friends who stand beside every time and would like to dedicate time of success to them.

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ABSTRACT

This research was done to form and develop an information system for managing a warehouse, and to increase the working efficiency of a business procedure. Due to the fact that the original system was unable to specify the location of products in a warehouse, it caused errors in finding the products. As well, without having information linking to related departments, departments were unaware of purchasing information from customers in a timely manner.

This research, therefore, was done to focus on solving these problems by developing a warehouse administration system instead of using paper only, which lead to a reduction of the problems of storing and finding the locations of products. The newly developed system, in addition to solving inventory problems helped to solve the problem of receiving purchase orders from customers because it enabled the viewing of purchase orders via LAN lines to every department in real time. This lead to a reduction in waiting times.

The resulting warehouse administration system was able to fully and effectively facilitate the receiving, distribution, and the moving of products in inventory as well as to facilitate the order receiving operation process more conveniently and quickly. Using an analytical value stream mapping process to compare the time spent before and after the implementation of the order process and warehouse management, it was found that before implementation of the new system, it took 5 hours to process a purchase order through the order system, and merely 1.31 hours after implementation which was a reduction in time of 69.70%. For the physical movement of product in the warehouse, it took 4.10 hours before implementation of the new system and 1.05 hours after implementation, which was a reduction in time of 74.00%.

KEY WORDS: BUSINESS PROCESS/ INFORMATION SYSTEM/ WAREHOUSE MANAGEMENT/ SYSTEM DEVELOPMENT

116 pages

การวิเคราะห์กระบวนการทางธุรกิจเพื่อพัฒนาระบบสารสนเทศในการบริหารคลังสินค้า
THE ANALYSIS OF A BUSINESS PROCESS FOR THE DEVELOPMENT OF
AN INFORMATION SYSTEM FOR WAREHOUSE MANAGEMENT

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บทคัดย่อ

งานวิจัยนี้ ได้ออกแบบและพัฒนาระบบสารสนเทศเพื่อการบริหารคลังสินค้า และเพิ่มประสิทธิภาพในปฏิบัติงานของกระบวนการทางธุรกิจ ซึ่งระบบเดิมไม่สามารถระบุตำแหน่งที่ตั้งของสินค้าได้ จึงทำให้เกิดความผิดพลาดในการค้นหาสินค้า รวมทั้งไม่มีการเชื่อมโยงข้อมูลไปยังฝ่ายต่าง ๆ ที่เกี่ยวข้อง ซึ่งทุกฝ่ายไม่สามารถรับทราบข้อมูลในการสั่งซื้อจากลูกค้าได้อย่างทันที จึงทำให้เกิดความล่าช้าและเกิดเวลารอคอยที่ยาวนาน

งานวิจัยนี้จึงมุ่งเน้นในการแก้ปัญหาดังกล่าวโดยพัฒนาระบบบริหารคลังสินค้าแทนการจดบันทึกด้วยกระดาษ ทำให้ลดปัญหาในการจัดเก็บและค้นหาตำแหน่งของสินค้า ซึ่งระบบที่พัฒนาขึ้นมานั้นนอกจากจะแก้ปัญหาในเรื่องของคลังสินค้าแล้ว ยังช่วยแก้ปัญหาการรับคำสั่งซื้อจากลูกค้า เพราะระบบสามารถแสดงคำสั่งซื้อผ่านระบบ LAN ไปให้ทุกฝ่ายได้รับทราบอย่างทันทีทันใด จึงทำให้ลดระยะเวลาในการรอคอยลงได้

ผลจากการใช้ระบบบริหารคลังสินค้า พบว่าระบบสามารถเข้าไปช่วยในการรับ จ่าย ย้ายตำแหน่งของสินค้าที่อยู่ในคลังได้อย่างเต็มประสิทธิภาพ รวมทั้งยังช่วยให้กระบวนการทำงานในการรับคำสั่งซื้อเกิดความสะดวกและรวดเร็วยิ่งขึ้น จากการวิเคราะห์ผังงานสายธารคุณค่าเพื่อเปรียบเทียบเวลาก่อนและหลังการปรับปรุง พบว่าตัวชี้วัดเชิงปริมาณของกระบวนการใบสั่งงานก่อนการปรับปรุงใช้เวลาในการดำเนินงาน 5 ชั่วโมง เมื่อมีการปรับปรุงใช้เวลาในการดำเนินงาน 1.31 ชั่วโมง ซึ่งสามารถลดเวลาในการดำเนินงานได้ 69.70% และตัวชี้วัดเชิงปริมาณของการจัดการคลังสินค้าก่อนการปรับปรุงใช้เวลาในการดำเนินงาน 4.10 ชั่วโมง เมื่อมีการปรับปรุงใช้เวลาในการดำเนินงาน 1.05 ชั่วโมง ซึ่งสามารถลดเวลาในการดำเนินงานได้ 74.00%

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CHAPTER I
INTRODUCTION

1.1 Background and Problems statement

Logistics and supply chain management pays attention to the coordination of the business operations from the raw material sources to the consumers. Unity of the supply chain management can be achieved to benefit all of its members. However, there have been few adoptions of the logistic and supply chain management in the industrial or micro level. Importantly, in the industrial level logistics is not the transport management only. That is merely the management of the logistics outside the organization or the downstream management. What is needed is the internal logistics management, which the management of the resources within the organization. That starts from raw material procurement to material requirement planning, master production scheduling, production scheduling, inventory management, warehouse management, and distribution and transportation.

The study on the working system of the case study firm found that it still lacked the data linking system between sections and the limited distribution of data, causing the repetition of the operating processes and data transmission delay. It is inventory management still needed the product database management. Such deficiency caused the data loss and difficulty in product searching owing to the lack of efficient product location recording.

Accordingly, this research focused on the analysis over the business process in order to design the new system for the optimal flowing of data.

1.2 Objective

1.2.1 To form and develop an information system for managing a warehouse.

1.2.2 To increase the working efficiency of a business procedure.

1.3 Scope of Work

The study is to analyze business procedure so as to develop warehouse management information system. The study of working system can be divided as follows;

1.3.1 Warehouse Management System.

1.3.2 Order System.

1.4 Results

1.4.1 To integrate all kinds of knowledge into practicality such as in marketing, producing, industrialization. And the most important of all is computer science application into other activities.

1.4.2 To develop the work of product-industry section and increase service efficiency.

1.4.3 To guideline information system development for other managements.

1.4.4 The manufacture understand trends and principles in information using for warehouse management.

CHAPTER II
LITERATURE REVIEW

In this chapter will describe in seven main parts:

2.1 Warehouse and Inventory Management

2.2 Supply Chain Management

2.3 Database management system

2.4 Relational database

2.5 System Development

2.6 Technical Review

- 2.6.1 Integration DEFinition (IDEF)
- 2.6.2 Value Stream Analysis
- 2.6.3 Swim Lane
- 2.6.4 Elements of Data Flow Diagrams (DFD)
- 2.6.5 Data Modeling

2.7 Related Research

2.1 Warehouse and Inventory Management

2.1.1 Warehousing

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 (Coyle *et al*., 2003).

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 are movement and storage as shown in figure 2-1

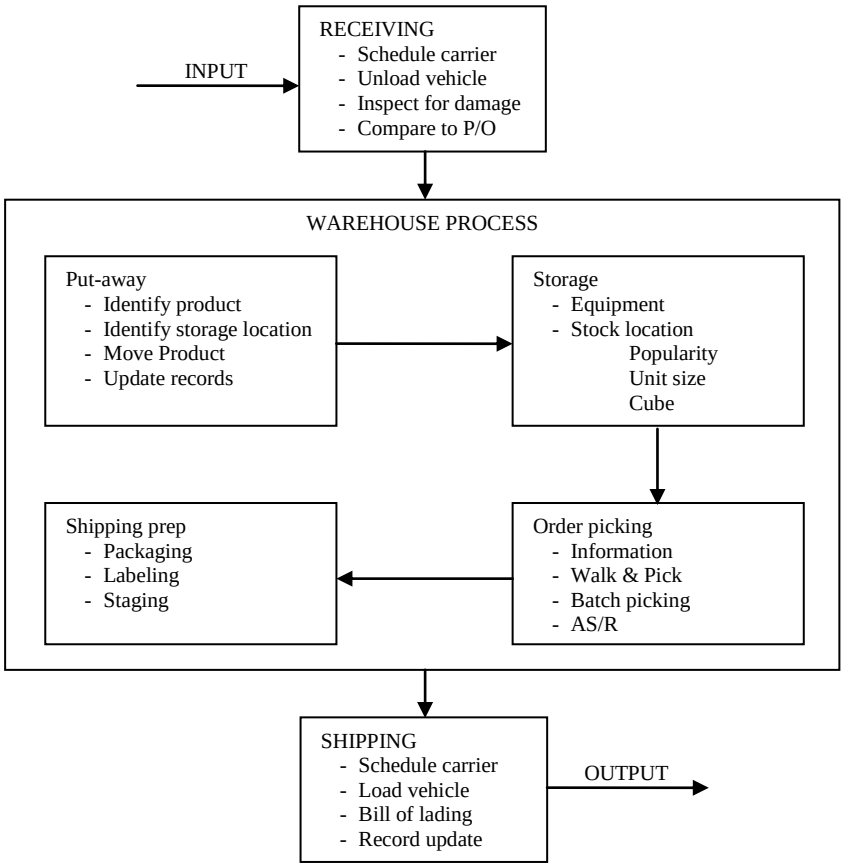


Figure 2-1 Warehouse operations are movement and storage

Receiving: At the receiving operation, this allows the warehouse to schedule receipt and unloading within the warehouse. Product will be inspected and any exceptions noted, 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 from the storage area the items ordered by the customer or manufacturing operation. The order information is given to the warehouse personnel on a pick slip. The AS/R process is an automated storage and retrieval materials-handling system that will do the picking process, when the order arrives at the shipping preparation area, the items are placed in an exterior (shipping) package or placed 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 because staged freight must be double handled. The trailer is likely to be scanned here to register its departure from the warehouse.

2.1.2 Inventory Management

In traditional supply chain warehouse and inventory management, an order is only the exchange of information, but information technology now allows one to share demand and inventory data quickly and inexpensively. The inventory management system is continued to consolidate and mature, with competition intensifying for the profitable upper end of the market, which will quickly become saturated (Cachon, 2000).

Wathers (1992) mentioned inventory is a list of the items held in stock. Stock consists of all the goods and materials stored by an organization. In addition, stock is a supply of items which is kept for future use. In general terms, inventory management policies should be aimed at lowering the holding costs through higher inventory rotation, but without triggering substantial stock-outs and backorders, caused by demand peaks and/or lead time delays.

Therefore, the optimal management of inventories is a primary objective to ensure that this allowance is made at minimum cost (Krautter, 1999). As a result, inventory has important implications for both the financial and the economic performance of the company. Therefore, inventory management is widely acknowledged that an optimal policy allows companies to achieve higher profitability levels (Bertolini and Rizzi, 2002). However, if stocks are not controlled properly the costs can become excessive and reduce an organization's ability to compete. Efficient inventory control then become a real factor in an organization's long-term survival. Figure 2-2 illustrates an inventory system.

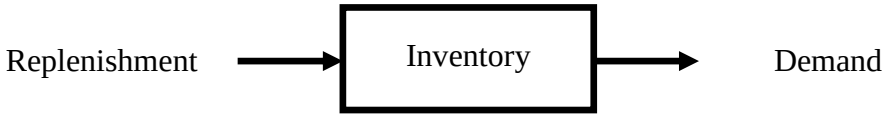


Figure 2-2 An inventory system

Inventory is generally considered to comprise of three main areas (Ballard, 1996):

a) A raw material and a component, the goods that are purchased by the organization.

b) Work in progress an item that has been partly manufactured and has had value added.

c) Finished goods, the completed product that is waiting for shipment to the customer.

It is important to realize that every organization holds stocks of some kinds. This stock will clearly have associated costs to cover tied-up capital warehouse

operations deterioration, etc. The main purpose of organization hold stock is to allow a buffer between supply and demand (Keong Ahmad, *et al*., 2005).

Wathers (1992) stated that all stock holdings incur costs. These typically amount to 25% of value held a year, but most organizations view this policy as necessary overhead which have to be carried to ensure continued smooth functioning. This necessity gives a general view of stocks as expensive but unavoidable. Generally stock holding costs are determined by number of factors and an appropriate objective is to minimize total costs rather than total stock.

The usual classification of stock holding costs significantly consists of unit cost, reorder cost holding cost, and shortage cost which are described as followed (Wathers, 1992):

2.1.2.1 Unit cost.

This is the price charged by suppliers for one unit of the item, or the cost to the organization of acquiring one unit.

2.1.2.2 Reorder cost.

This is the cost of placing a repeated order for the item and might include allowances for drawing up and order (with checking getting authorization, clearance, distribution and filing), computer time, correspondence and telephone cost, receiving (with unloading, checking and testing), supervision, use of equipment and follow-up.

In practice, the best estimate for a reorder cost might be found by dividing the total annual cost of the purchasing department (plus any other relevant costs) by the number of orders sent out.

2.1.2.3 Holding cost.

This is the cost of holding one unit of an item in stock for one period of time. The most obvious cost of holding stock is money tied up which either is borrowed (in which case interest is paid) or could be spent to other use (in which case there are opportunity costs). Other holding costs are due to storage space (supplying a warehouse, rent rates, heat, light, etc.), loss (due to damage, pilferage and

obsolescence) handling (including all movement, special packaging, refrigeration, putting on pallets, etc) administration (stock checks, computer updates etc.) and insurance.

2.1.2.4 Shortage cost.

If there is a demand for an item for which stocks have been exhausted and if replenishment takes a finite time then there is a shortage which usually has some associated cost. As a result, shortage cost includes loss of goodwill, loss of future sales, and loss of reputation. Shortages can be avoided if the lead time (between placing an order and getting the units in stock and ready for use) is short. The lead time occurs because of:

2.1.2.4.1 Time for an order preparation. When a decision is made to place an order, there is some delay before the order is ready to send to a supplier.

2.1.2.4.2 Time to pass an order to a supplier. This is the total time needed to get an order from an organization to a supplier.

2.1.2.4.3 Time at a supplier. This is the time needed for a supplier to process an order and prepare it.

2.1.2.4.4 Time to pass goods back from a supplier. This is the time needed to deliver an item.

2.1.2.4.5 Time to process delivery. This is the time taken between receiving the delivery and getting the goods available in the stock.

An inventory strategy and a decision become particularly important in businesses where inventory costs form a sizeable part of total marketing costs. The cost of holding inventories is justified by the benefit obtained which includes cheaper purchase prices, avoidance of stock outs smoothing of operations, and lover control costs. Thus, holding costs are incurred to achieve a reduction in costs of materials, ordering, and control systems (Inmon, 2005).

2.2 Supply Chain Management

Supply chain management (SCM) is a popular work since the end of 1980’s. Harland (1996) provided its definition as the integration of the main operations within the organization such as purchasing, production, sale and

distribution. Jone and Riley (1985) viewed supply chain as planning and control over the flows of all materials from suppliers to the manufacturer and from product distributors to consumer. Dekker and Van Gooer (2000) mentioned the definition interestingly that it was a process starting from raw material and component purchasing for manufacturing and assembling into finished goods until the product delivery to consumers. Cooper *et al*., (1997) extended its meaning to include the combination of the business processes from the end users reversal back to the raw material suppliers for the preparation and value addition of the products, the services and customer data. All definitions given by those scholars have indicated that supply chain management and logistics are closely integrated.

The meaning of supply chain however is wider and deeper than that of logistics. Logistics is the linked activities within organizations whereas supply chain is the overall activities ranging from purchases of raw materials, production, transport, product distribution to end users. Like the concept of Bechtel, Christian and Jayaram (1997), which compared supply chain to a fulfillment of the operations over the customer's demands to make connections and fulfilling the needs of other mediums of the entire system. Accordingly, supply chain has a wider scope than logistics. Some academicians believed that logistics is a part of supply chain as seen in the works of Rich and Hines (1997), which focused on the operations within an organization that has the managerial processes among sections or external operations that are the relationships between customers and suppliers. Chopra and Meindl (2001) opined that supply chain was the entire directly and indirectly intralinked process to fulfill the demands of the customers and does not deal with the manufacturer and suppliers only but also carriers, warehouses, retailers and customers. Ganeshan and Harrison (2007) added that supply chain is a network of the facilities and options of the product distributions or raw material procurement services and processing of those raw materials into components during the production and finished goods including the distribution of the finished products to customers

Mentzer (2001) mixed the definitions of various scholars and concluded that supply chain is a systematic mixture of the old and modern business operating strategies within a company and of every business in the supply chain to improve the operating performance for long term and throughout the supply chain line. In

conclusion, supply chain is the combination of the business processes that cover from the raw material suppliers into the industrial business system to the end users, which simultaneously includes the transfers of the informative data service products as well that is the value addition of the products and presentation of those data to the end users.

This research studied the operating process of the case study firm(s) and discovered that its/their operating characteristics were in line with the supply chain procedure. Hence, the newly developed system was designed to suit those operating natures not only for inventory control purpose only but also for various processes related to the products.

2.3 Database management system

Patt and Adamski (1994) defined that a database is a structure which houses information about multiple types of entities, as well as relationships among entities. A database management system (DBMS) is the software package that manages a database, define, create and maintain the database. In addition, DBMS provides controlled access to database through the use of security policy.

Furthermore, some advantage of using DBMS are to reduce redundancy and inconsistency share data among users, obtain more information from the same data, enforce integrity constraints provide backup and recovery, and increase programmer productivity. Because of these advantages, many organizations have considered using a DBMS to gain their best advantages and handle their large-scale data efficiently.

The most influential early effort to create standard system architecture was the implementation of ANSI/SPARC architecture ANSI/SPARC divided database-centric systems into three model: the internal or physical, conceptual, and external or view. The diagram is illustrated on Figure 2-3

2.3.1 The external or view level

The external level is concerned with the way the data is viewed by an individual user. The external level consists of many different external views of the database. Each external view describes the part of the database that a particular user

group is interested in and hides the rest of the database from that user group. In addition, different views may have different representations of the same data.

2.3.2 The conceptual level

The conceptual level represents the logical structure or all relations that are stored in the database. The conceptual level concentrates on describing entities, attributes relationship, constraints, semantic information on data security, and integrity information. Also, the conceptual level supports each external view containing any data that is available to a user has to be contained in or derivable from the conceptual level.

2.3.3 The internal or physical level

The internal level has the structure of storage and retrieval. In addition, the internal level specifies the real structure of the database, including indexes, storage representations, field order character sets. Moreover, this level has to ensure adequate performance.

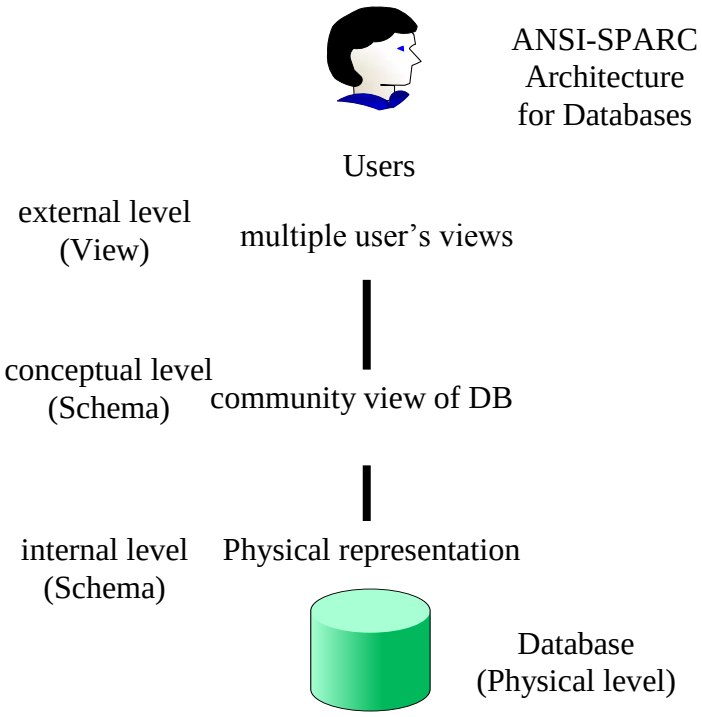


Figure 2-3 The tree-level architecture of database system

The objective of the three-level architecture is to separate the three schemas independently from the others. The architecture results in system that is resistant to physical modification and/or conceptual structure refinement. Instead of having to rebuild the entire system for every change to a storage structure, one would just change the database storage structures without affecting the entire systems or integrity (Muller, 1999).

DBMS provides tools and features that are used to manage data as described below (Bennett *et al*., 2001):

a) Data definition language (DDL). The DDL is used to specify the data is held in a database management system and the structures that are used to hold it.

b) Data manipulation language (DML). The DML is used to specify updates and retrieval of the data in the DBMS.

c) An integrity constraint. A constraint is specified to ensure that the integrity of the data is manipulated.

d) Transaction management. This feature guarantees that all activities have been successfully committed to the storage. Otherwise the system will roll back to all data to the initial state.

e) Concurrency. This feature is to ensure that performance will decline as little as possible when there us a large number of users accessing the database at the same period.

2.4 Relational database

Ramakrishnan and Gehrke (2000) stated that a relational is a database that maintains a set of separate related files (tables), but combines data elements from the files for queries and reports when required. The concept of relational database was developed in 1970 by Edgar F. Codd whose objective was to accommodate a user's ad hoc request for selected data. The standard user and application program interface to a relational database is the structured query language (SQL). SQL is the standard language designed for relational database and provides DDL and DML capabilities.

The relational database management system (RDBMS) is a database management that is based on the relational model to define, manipulate, and query the

data in the database, expressed as a string of characters for a relational system, the concept of relational integrity, and normalization (Bostrup, 2002; Chaterjee, 2005).

2.5 System Development

The methodology to develop the system is based on the iterative and incremental development. Iterative and incremental development is a cyclical software development process developed in response to weaknesses of the more traditional water fall model (Larman and Basill, 2003). One advantage of using this methodology is the iterative development which is able to evolve and refine of a system through multiple iterations, with cyclic feedback and adaptation as core drivers to converge upon a suitable system. The Figure 2-4 describes the phases in software development.

Figure 2-4 The iterative and incremental development (Kruchten, 2003)

This research developed the system upon the study over the system development life cycle (SDLC) and the water fall model including the incremental model to understand the system development principles. Each model contains similar operating methods as those of Kruchten. To produce the system, those principles hence were applied in 4 following stages: 1) the study and analysis of current business process, 2) system design, 3) system development and 4) system test and evaluation.

2.6 Technical Review

2.6.1 Integration DEFinition (IDEF)

IDEF (Integration DEFinition) was developed by the U.S. Air Force's Integrated Computer Aided Manufacturing (ICAM) project in the late 1980's. There are many different IDEF methods. Each method is useful for describing a particular perspective of an enterprise. The major IDEF methods in use are functional or activity modeling (IDEF0), information modeling (IDEF1), data modeling (IDEF1x), process description capture (IDEF3), object oriented design (IDEF4), and ontology capture (IDEF5) (Mayer, Painter, deWitte 1992). Although IDEF2 was intended to be used as a dynamic modeling method for simulation, the numerous simulation tools commercially available have supplanted this method. The modeling methodologies used in this paper are IDEF0 and IDEF3. These two methods best facilitate a structured approach to system model development and review and the creation of a corresponding discrete-event simulation of the system. Both of these methods utilize a subordinate principle of abstraction called decomposition (Rumbaugh et al. 1991), which is the breaking down of each box (activity) into more detail in a continuous manner until the greatest level of detail is achieved. (Marca and McGowan 1988)

2.6.1.1 IDEF 0

There are five elements in the IDEF0 functional model as shown in Figure 2-5. The activity (or function) is represented by the boxes; inputs are represented by the arrows flowing into the left hand side of an activity box; outputs are represented by arrows flowing out the right hand side of an activity box; the arrows flowing into the top portion of the box represent constraints or controls on the activities; and the final element represented by arrows flowing into the bottom of the activity box are the mechanisms that carry out the activity (Marca and McGowan 1988, Mayer 1992).

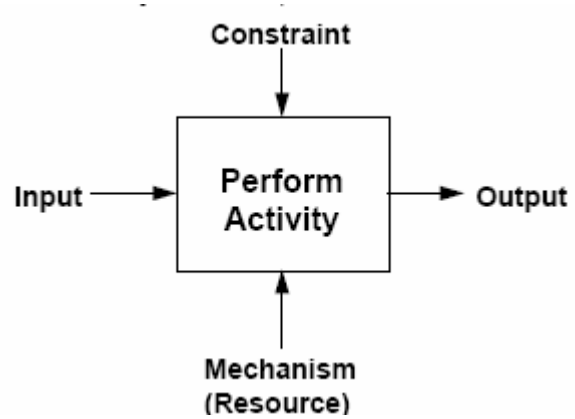


Figure 2-5 Model of IDEF0

2.6.1.2 IDEF3

The IDEF3 Process Description Capture Method (Mayer, Painter, deWitte 1992) consists of process flow diagrams and elaboration diagrams. Only the process flow diagrams were used to feed the simulation model. IDEF3 uses a rigid syntax that eliminates model ambiguity. The basic elements of IDEF3 process descriptions used in this research are Unit of Behaviors (UOBs), Junctions, and Links. A Unit of Behavior describes the actual process detailed in the box. Links connect the boxes and describe the relationship between the various UOBs. Junctions explicitly describe the logic of multiple links either coming together or spreading apart. Two examples of junctions are decision points or entities branching into parallel flows of process steps. An example of an IDEF3 model with UOBs, links and various types of junctions is shown in figure 2-6.

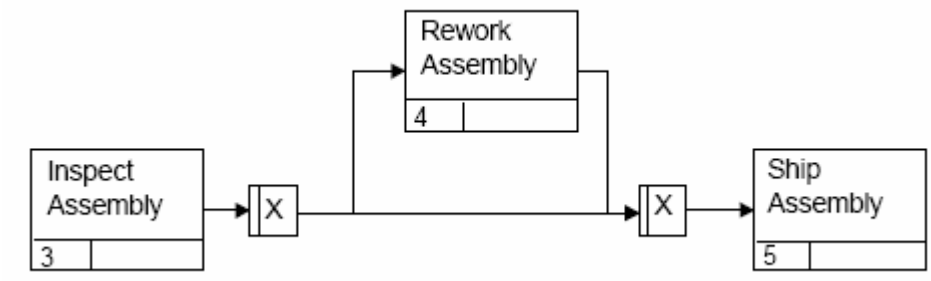


Figure 2-6 Model of IDEF3

2.6.2 Swim Lane Diagram

Swim Lane diagrams are essentially process maps. It provides a means of integrating steps in a process with the information and people involved. The "swim lane diagram" was originally developed by Lynn Shostack for use in designing services. It is basically enhanced flowcharts that incorporate additional information such as people involved, points of interaction, means of contact, and flow of information. The sample of Swim Lane Diagram is show in figure 2-7.

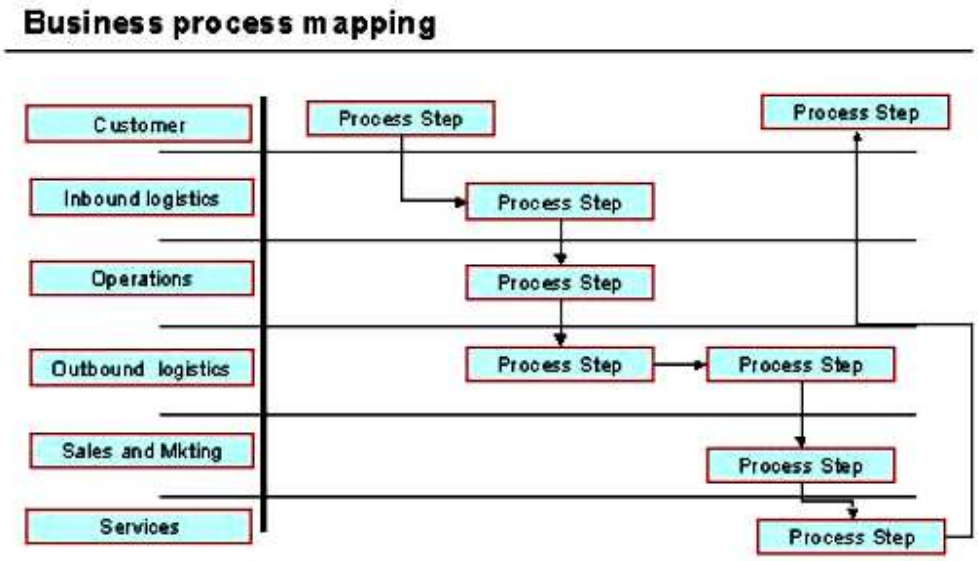


Figure 2-7 Swim Lane Diagram

2.6.3 Value Stream Analysis

The case study firm's current operating system has not only focused on the good quality manufacturing but also wanted the flexible operating system. The value flow analysis accordingly is made on the flows of the data of the work orders and the inventory management process and hence serves as a guideline of the analysis of the works or activities in the supply chain so that the value adding and the non – value (ie.waste) making stages can be identified. That serves as a method of time reduction or non-value stuff removal from the products and the supply chain.

2.6.3.1 7 Wastes

Wastes are frequently found in the production process and cut down its efficiency and efficacy like long manufacturing time, low quality products, and high costs. Plenty of concepts to decline those wastes have emerged. Mr. Shiego Shingo and Mr. Taiichi Ochon invented Toyota Production System with the objectives of removing the 7 following wastes.

1) Wastes from overproduction.
2) Wastes from inventory.
3) Wastes from transportation.
4) Wastes from motion.
5) Wastes from processing.
6) Wastes from delay.
7) Wastes from defect production.

2.6.3.2 Supply-Chain Works Classification

The works within supply chain can be classified under the Value Stream Management concept, which considers the work value as main issue and was invented by Yasuhiro Moden (Monden, 1993). The idea is to eradicate or reduce the non-value making activities. Yasuhiro divided the works in the supply chain into 2 main types: the materials flow and the information flow.

2.6.2.2.1 Material Flow

a) Non Value Adding (NVA) refers to the activities that add the no value activities that needs to be erased out such as waiting time, piling of products during production without immediate link into the following manufacturing process or the repetitive similar working / activity.

b) Necessary but Non Value Added (NNVA) is the wastes or no value activities that may have to be permitted to arise in the production procedure such as walking for long distance to fetch a part or raw material and the moving of instruments and equipment during the production process. Limiting those no-value works requires big change like drawing-up of plant layout with respect to the production process. Such work cannot be carried out promptly.

c) Value Added (VA) is the activity that makes values in the eyes of the customers. VA is one necessary activity for working quality like entering correct data into computer and the experts or specialists' consideration on the data as per laws (in case of issuance of new products), etc.

The 7 Value Stream Mapping Tools under the Value Stream Management (Hines, 2000) are involved with the 7 aforementioned wastes. Each tool is selected in compliance with the results of the survey on the no-value or waste making activities in the organization. The tools shown in Table 2-1 are useful to improve the internal process of the supply chain.

2.6.2.2.2 Information flow

a) Non Value Added (NVA.) is the activities which are not increased the value added in term of information flow or document works and classified as "Type Two Muda" by Womack and Jones (1996: 20), who defined NVA. As a Pure waste that should be set the goal to quickly terminate, for example: documents storing in document box and etc.

b) Necessary but Non Value Added (NNVA.) is the activities which are not increased the value added but necessary to perform or the activities that cannot be avoided. It is the action to solve the limitation of technology or system examined, which Womack and Jones (1996: 20) called as "Type One Muda." For example: documents movement between department. These activities should be investigated the long term planning for terminating or reducing them.

c) Value Added (VA.) is the activities which can be created value added in customer's point of view. VA. Is the necessary activities for quality of work for example: keying the correct information in computer, consideration about information regarding to law and regulation done by specific specialists (in case new product launching) and etc.

Table 2-1 Seven Value Stream Mapping tool

Mapping Tool/Waste Structure	1.Process Activity Mapping	2.Supply Chain Response Matrix
1.Overproduction	L	M
2.Waiting	H	H
3.Transportation	H	
4.Inappropriate Processing	H	
5.Unnesscessary Inventory	M	H
6.Unncessary Motion	H	L
7.Defect	L	

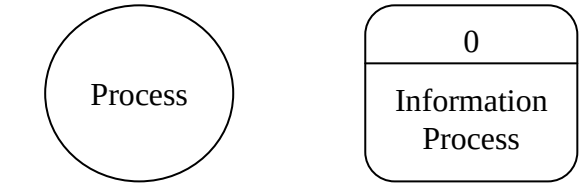
H High correlation and Usefulness M Medium correlation and Usefulness

L Low correlation and Usefulness

2.6.4 Elements of Data Flow Diagrams (DFD)

A data flow represents incoming of data to a process or outgoing of data (or information) from a process. A data flow is also used to represent the creation, reading, deletion, or updating of data in a file or database. There are four type of symbols in the DFD language (processes, data flows, data stores, and external entities), each of which is represented by a different graphic symbol (Dennis and Haley, (2000). There are two commonly used styles of symbols, one is developed by Charis Gane and Trish Sarson and the other is developed by Tom Demarco and Ed Yourdon. Both styles are equally popular; some organizations use Gane and Sarson style and others use DeMarco and Yourdon style.

A process (Figure 2-8) is an activity or a function that is performed for a specific business reason. Processes can be manual or computerized, and every process has a name that start with a verb and end with a noun. The name should be short but contain enough information so that readers can easily understand exactly what it means. In general, each process performs only one activity. So most system analysts avoid using the word and in process names because it suggests that process performs several activities.

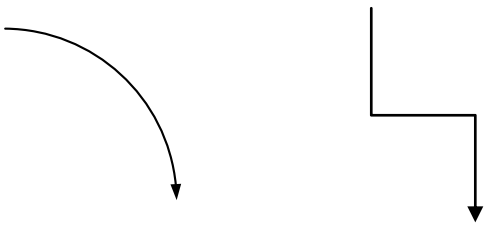


Yourdon / Constantine Gane / Sarson

Figure 2-8 Process

Every process has a unique identification number, a name, and a description, all of which are noted in the CASE (computer-aided software engineering) repository. Descriptions clearly and precisely describe the step and detail of the processes; ultimately they are used to guide the developers who need to computerize the processes. More detail will be added to the process description as more information is learned throughout the analysis phase.

A data flow (Figure 2-9) is a single piece of data, or a logical collection of several pieces of information. Every data flow has a descriptive name that is a noun, and a description. Typically, the description of a data flow will list exactly what element the flow contains. For example, the patient information data flow can list the patient name, address, and phone number as its elements.



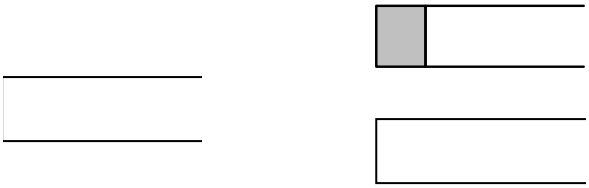
Yourdon / Constantine Gane / Sarson

Figure 2-9 Data Flow

Data flow are the glue that holds the processes together. One end of every data flow will always come from or go to a process, with an arrow showing the direction into or out of that process. Data flows show what inputs go into each one

output data flow because if there is no output, the process does not do anything Likewise, each process usually has at least one input data flow because it is difficult if not impossible to produce an output without any input.

A data store (Figure 2-10) is a collection of data that is stored in a file or a database. Similar to processes, every data store has a descriptive name, which is a noun, an identification number, and description. Data stores are the starting points of the data model, and are the principal link between the process model and the data model.



Yourdon / Constantine Gane / Sarson

Figure 2-10 Data store

A data flow coming out of a data stores indicate that information is retrieved from the data store and data flow going into a data store indicates that information is added to the data store indicates that information is added to the data store or that information in the data store is changed. Whenever a process update a data store, both the data coming from the data store and the data written back into the data store.

All data stores must have at least one input data flow, unless they are created and maintained by another information system. Likewise, they usually have at least one output data flow. In case that the same process both stores data and retrieves data from a data store, there is a temptation to draw one data flow with two separate data flows.

An External Entity (Figure 2-11) is a person, organization, or system that external to the system but interact with it. Every external entity has a name and a description, A key point to remember about an external entity is that it is external to the system but may or may not be part of the organization

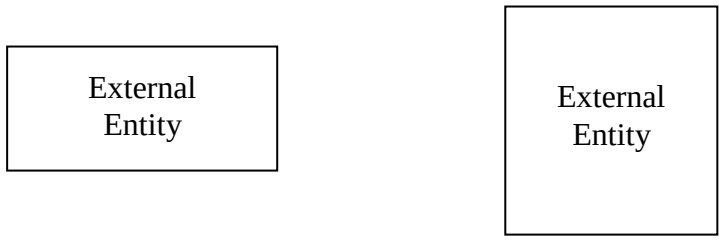


Figure 2-11 External Entity

A common mistake is to include people who are part of the system as external entities; the people who execute processes are part of the processes and are not external to the system. A person who performs a process is often described in the process description but never on the DFD itself. However, a person who uses information from the system to perform other processes or who decide what information goes into the system is documented as an external entity.

The working principle of DFD could lead the researcher to make application in the designing of the software of the new system thanks to the use of the data flow diagram as the process model for the analysis and designing of the system structure that can be applied with the advanced computer language. The data flow diagram can indicate the relationships between the processes and relevant data, hence making known the origins of the data, the destination of the data flow, the places of the data storage, and the events arising to the data on course of the flows.

2.6.5 Data Modeling

Data modeling is a graphical and textual representation of analysis that identifies the data needed by an organization to achieve its mission functions, goals, objectives, and strategies, and to manage and rate the organization. A data model identifies the entities, domains (attributes) and relationships (or associations) with other data, and provides the conceptual view of the data and the relationships among data.

2.6.5.1 Entity – Relationship Model

The Entity-Relationship (ER) model is a way to unify the network and relational database views. Simply stated the ER model is a conceptual data model that views the real world as entities and relationships. A basic component of the model is the Entity-Relationship diagram which is used to visually represent data objects. Since Chen wrote his paper the model has been extended and today it is commonly used for database design For the database designer, the utility of the ER model is:

- it maps well to the relational model. The constructs used in the ER model can easily be transformed into relational tables.
- it is simple and easy to understand with a minimum of training. Therefore, the model can be used by the database designer to communicate the design to the end user.
- In addition, the model can be used as a design plan by the database developer to implement a data model in specific database management software.

ER Notation

There is no standard for representing data objects in ER diagrams. Each modeling methodology uses its own notation. The original notation used by Chen is widely used in academics texts and journals but rarely seen in either CASE tools or publications by non-academics. Today, there are a number of notations used, among the more common are Bachman, crow's foot, and IDEFIX.

All notational styles represent entities as rectangular boxes and relationships as lines connecting boxes. Each style uses a special set of symbols to represent the cardinality of a connection. The notation used in this document is from Martin. The symbols used for the basic ER constructs are:

- *Entities* are represented by labeled rectangles. The label is the name of the entity. Entity names should be singular nouns.
- *Relationships* are represented by a solid line connecting two entities. The name of the relationship is written above the line. Relationship names should be verbs.

- *Attributes*, when included, are listed inside the entity rectangle. Attributes which are identifiers are underlined. Attribute names should be singular nouns.

- *Cardinality* of many is represented by a line ending in a crow's foot. If the crow's foot is omitted, the cardinality is one.

- *Existence* is represented by placing a circle or a perpendicular bar on the line. Mandatory existence is shown by the bar (looks like a 1) next to the entity for an instance is required. Optional existence is shown by placing a circle next to the entity that is optional.

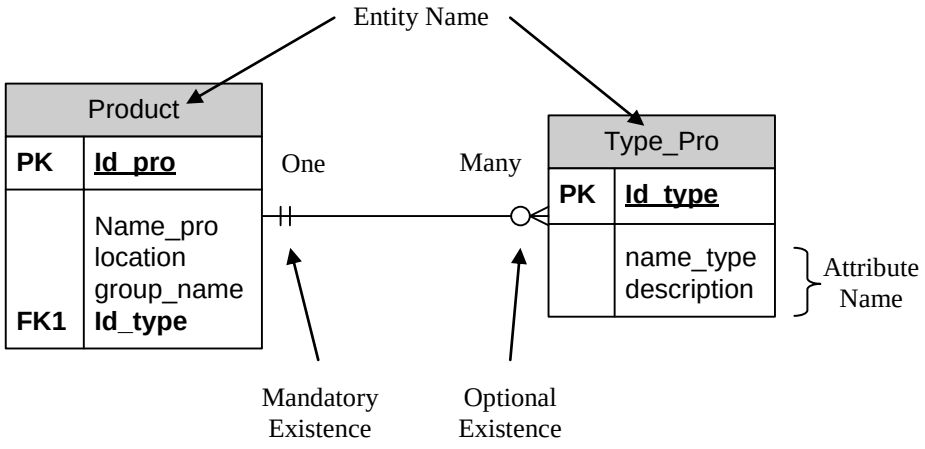


Figure 2-12 Example of ER Model

2.7 Related Research

The research on the information system development for inventory management or the applications of the information system for the supply chain management indicated that the efficiency of the inventory management needs the studies on related processes that range from receipt of customers' purchase orders, production, deliveries, etc. Integration can be made only when coordination arises with all parties regardless of being the suppliers, manufacturing factors, producers and customers. The continued yet fast flows encourage more efficient and effective operations despite the fact about the organizational communication problems and working redundancy. Those problems however can be solved nowadays with the aids of the information flowing tools. The management over the supply chain data flows is

needed and the use of information technology that consist of computer, hardware, the networking system and software including the e-commerce system for all activities are inevitable inside and outside the organization to create fastness and accuracy.

The research of Charu Chandra and Sameer Kumar (1998) indicated that the successful supply chain management adopted in the textile industry needs quick and accurate responses. That can be achieved under the use of SCOR Model (Supply Chain Operations Reference Model) to administer the working systems and data sharing and integration between members of the supply chain, which are the raw material suppliers, manufacturers and customers. Likewise, the research of Sakchai Kongkiat and Witthaya Sauraruedamrong (2001) used the SCOR Model to manage the supply chain so as to generate the working framework of the purchasing system with the aim to adjust its efficiency and the reduction in raw materials cost and to bring about the cooperation and relationships among those concerned.

The supply chain management also helps inventory operations and cuts down costs to lowest. Marilyn M. Hwlms, Lawrence P. Ettkin and Sharon Chapman (2000) issued the research that supported the use of forecast in the supply chain operations. The working of various companies like Eastman Chemical, Reynolds Aluminium, WalMart, Ocen Spary and Heineken have already utilized the forecasts to manage the chain supply, resulting in the decrease in the inventory volume and waiting time of the raw material purchase and the increase in the cooperation between the manufacturers and raw material suppliers. This is because the forecast of the future manufacturing volume can project the raw material quantity to be needed and hence lead to the cooperation of all parties. The research of Footlik R. B. (2004) attempted to improve the inventory system by using the product storage technique that kept similar or related or associated products in the same place and in groups as classified by product movement frequency. In addition, Albenson K. and J. Aylen (2003) believed that the forecast of the inventory faced uncertainty because the inventory was a significant variable of the overall output of the country and thus the forecast of the inventory volume change was important to the output management. Albenson K. and J. Aylen thus made the Error Correction Model to forecast the inventory change. Principally, the real inventory and output volumes shift along season. The analysts hence need to use the real inventory and output data of each period to build the

forecast model of the inventory production demand. Harry K.H. Chow et al (2006) conducted the research that applied the RFID system in the logistics process, part of which is related to the inventory system. Using the RFID system in the inventory process can make the real time data for further result processing of the inventory system management. The real time data acquired make known the movements, the entry and exit time and the volume of the past or current products including their whereabouts. The RFID Passive Tags Readers can be installed at the entries and exits of the storage places in each part of the warehouse including the forklift vehicles. The RFID system can also track down the current status of the employees' operations about their work start and finish time as well as their current status.

The middle part of the supply chain is the manufacturing that uses various techniques to handle the supply chain to promote production efficiency. Research of Narasri Thawornkul and Witthaya Suharitdamrong (2002) which applied the Value Stream Mapping (VSM) with the operations of the supply chain in a bid to seek for necessary and unnecessary (i.e. waste) production and activities, the latter of which are to be removed so as to quicken and make the producing and other operations more efficient. The research of Panithat Suriyathanaphat et al (2003) and Sitthiphorn Chanchalermphorn (2005) applied the SCOR Model to build the operating process model and to analyze the problems of the business processes so as to find the overall operating results and their problems. The research also applied the Process Activity Mapping under the Value Stream Principle to analyze the flows of the informative data in the process(es) to see the waste or no value adding activates, which could lead to the problem analyses and solutions to enhance the supply chain operations. In addition, the research of Sitthiphorn Chanchalermphorn (2005) also adopted the Definition for Function Modeling (IDEF0) to exhibit the flows of the operational planning process from the study on the operations using SCOR Model. His research also sought the operating process improvement solutions by using PERT/CPM and 5W-1H to make analysis and erase the no-value adding activities by utilizing the Process Activity Mapping. It discovered the ability to reduce the leading time of the operating planning, which is a technique to administer the supply chain and amereolate the efficiency indices of the SCOR Model and the product delivery to customers. Todd Hannel, Dorothea Kuettner and Tom Phelps (2002) used the supply

chain management in the CD Rewriter production process at Hewlett Packard, which resulted in the faster delivery modes thanks to a more proper location of the corporate central warehouse center for raw materials and product sale as it was approximate to that of the raw materials suppliers. That helped cut down the time of production process from raw material delivery to the manufacturing completion to 8 days instead of 126 days. It also reduced the delivery and inventory storage expenses as well as the cycle time of the products, hence rolling out products to the market faster. Hewlett Packard accordingly gained advantages over the competitors and made better coordination on work division and data transmission between the raw material suppliers, producer and customers and could find more proper location of the inventory warehouse center for the transport of raw materials from suppliers to the manufacturer and the deliveries of products from the producer to the customers. That is a technique to make the supply chain flow smoothly.

The supply chain management however may face the scarcity of the caliber manpower with know-hows on supply chain management and data communicating technology in the chain itself (raw material suppliers, producer and customers) as seen the research of Remko I. Van Hoek, Robina Chatham and Richard Wilding (2002). The research made study on the needs of organizations for human resources with correct knowledge in supply chain management. The solution, the research pinpointed, was the correct education on supply chain for the corporate manpower to bring about the optimum flows of the supply chain and the efficient inventory management in the warehouses.

CHAPTER III
MATERIALS AND METHODS

3.1 Step of Research Methodology

This research is the analysis of business process to develop the information in the warehouse management emphasizing on the data transition to other groups. Any kind of data that are analyzed for development derive from an interview of several sectors involved including the practical observation by which the developed working system will apply the data of some of Ink Company as the case study. The step of system development is divided into 4 as shown in figure 3-1. The detail of each step is as follows;

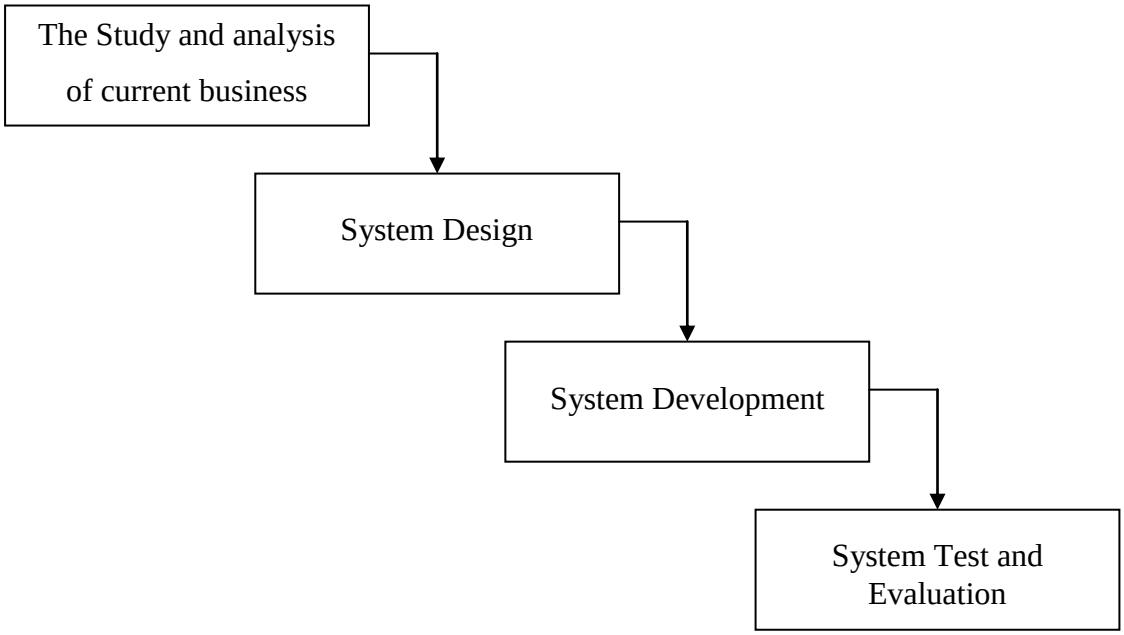


Figure 3-1 Steps of Research Methodology

3.1.1 The Study and analysis of current business process

The research is the study of present working process so as to show the activity flow that is happening and is the analysis of working process by using Integration Definition for Function Modeling (IDEF0) and showing swim lane diagram starting from receiving order from customers including activities until the step of goods production as well as goods export from the company.

3.1.2 System Design

System modeling is taking the result obtained from analyzing present process as database for keeping information. Modeling will begin from parts of instruments and other technology, developed computer program, data model, data flow diagram, output design and user interface.

3.1.3 System Development

At this step, there will be writing and computer program development. The instrument employed at this step is computer language writing program. The technique employed is to take working process and data flow diagram to modify as working process of the program, thereafter taking chosen real data to test to the system as well as preparing handbooks and training real users of the system.

3.1.4 System Test and Evaluation

The system should be tested before practicality by investigating real data to system working process called Beta testing technique. If there is an error for the test, then reviewing the step of system development. After the system is already tested, then there will be the system install for practicality. During the system development, the system test should be made and hardware and network communication tools should be prepared. Prepare to put practical system program and application program, then new working system should be operated later. The system evaluation use the Value Stream Mapping.

3.2 Research Tools

3.2.1 Hardware used for application development

- Database Server

CPU	: Intel 2x Xeon CPU 3GHz or greater
Main Memory	: 1 GB or greater
Hard Disk	: 120 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	: 80 GB
Monitor	: SVGA
Network Adaptor	: 1 GB Transfer

3.2.2 Software used for application development

- Server

Operating System	: Microsoft Windows XP
DBMS	: Microsoft SQL Server 2005

- Development

Operating System	: Microsoft Windows XP
Programming Language	: Microsoft Visual C# 2005
Editor	: Visual Studio.Net 2005

- Client

Operating System	: Microsoft Windows XP

3.3 Time schedule for this study

Table 3-1 Gantt chart of research time

Activities	Month									
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
The Study and analysis of current business process	→									
System Design		→								
System Development				→						
System Test and Evaluation							→			

CHAPTER IV
A CASE STUDY ON INFORMATION GATHERING

4.1 Overview Organization of Business

The case study-firm, with approximately 105 staff**,** that has carried out its business for 16 years, registered with 60 million bath fund. Concerning the operation within the organization, there are seven departments such as;

1) Personnel department

2) Accounting and financing department: accounting department and financing department

3) Sales and marketing department: sales department and marketing department

4) Production and planning department: research and products development department and production planning department

5) Production department: production department and quality assessment department

6) Warehouse department: material warehouse department and ready-made warehouse department

7) Transportation department

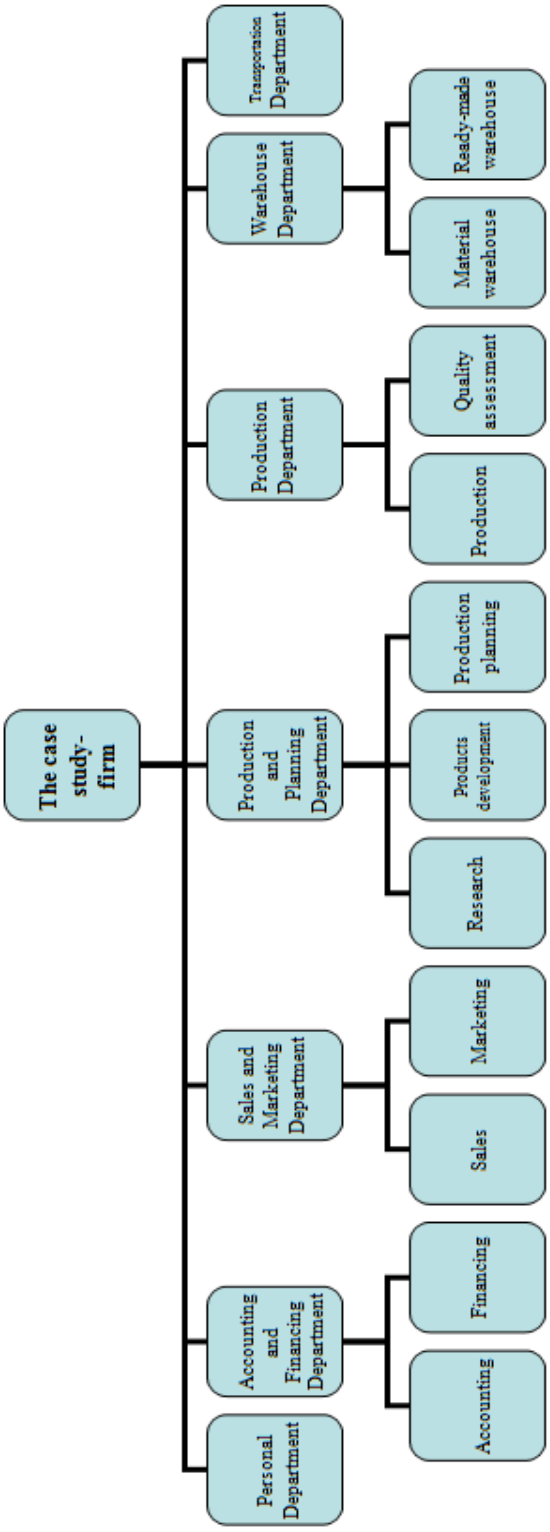


Figure 4-1 Organization Chart of Case Study

4.2 Current Business Process

4.2.1 Supply Chains Structure

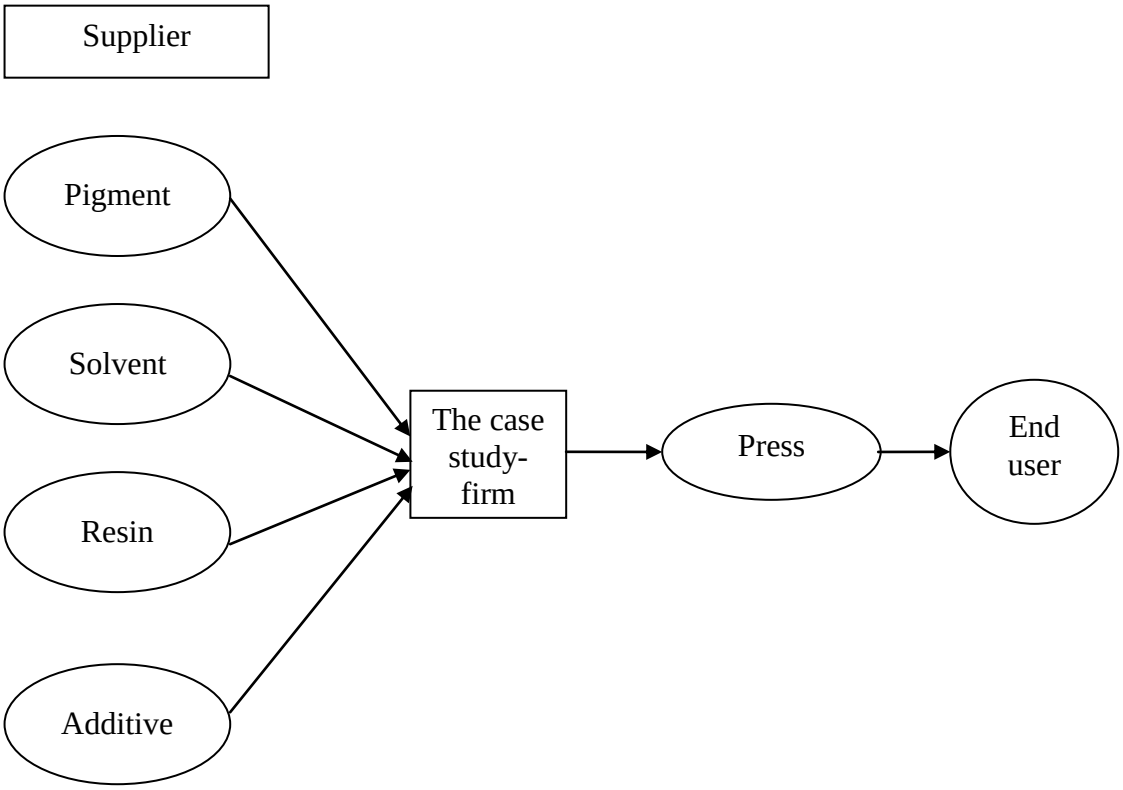


Figure 4-2 Supply Chain Structure

4.2.2 Purchase Order

The operation begins with purchase call from customers by which the sales department will receive purchase order through a call, fax or else the staff of the firm directly comes out for the purchase from customers. Thereafter the sales department will assess code of the registered goods so as to record into the purchase order receipt. However, the accounting department will open purchase order in Auto Flight Program. Then the sales department will release 4 orders (copy included). Next step, the whole order will be continually sent through the planning department, the production department and the warehouse department as well as the transportation department. After receiving the order the planning department will check goods remained in which the planning department will inquire the data of goods remained from the warehouse

department if there are goods ordered by customers, if any, the warehouse department will fill in the data in the Auto Flight Program and know that which pallet goods are stored in and how many the remaining of goods are there in the warehouse. The planning department will send the remaining back to the sales department and transport in the next day by the sales department will release invoice attached to the order to bring goods from the warehouse department and transport to customers. By the transportation, there will be fixity that by which route goods will be sent by the gathering of the planning department, the production department, the warehouse department and the transportation department at 15.00 p.m. for each day. In case of no goods stored in the warehouse, the planning department will release production order and fill in the data in the Microsoft excel program, and then fix the production timetable of each day arranging according to a queue sent to customers and transportation route. In the production, each production will have approximately 700 kilograms per a ton. Having finished the production formula the planning department will send the production data to the production department. Having produced goods the production department must have the quality assessment of goods before sending them to customers.

4.2.3 The warehouse structure

The warehouse structure must have the area for goods storage approximately 204 square meter. Goods storage can be divided into 2 zones; ready-made zone and material zone. Each zone will be kept in pallet and can show goods storage as shown in figure 4-3. At each pallet, storage will be sub-divided into rack. If there is the abundant of goods storage in the pallet, there must be extra-charge according to the pedestal which is called spared pallet that is able to show warehouse layout map in figure 4-4

Figure 4-3 Goods storage in pallet and rack

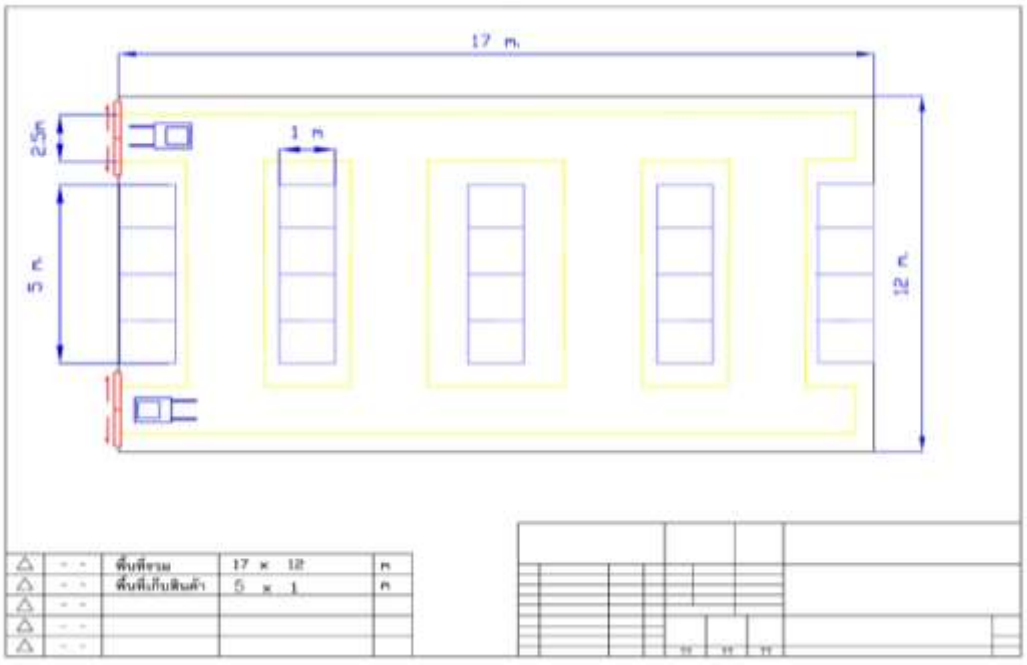


Figure 4-4 Map of warehouse

4.2.4 Warehouse Operation

In the warehouse operation, there will be no any ready-made program. Therefore, any operation concerning goods can be made by filling data on paper whether it will be goods receipt into the warehouse, request or payment or transfer position in storing goods by employing code in dividing and storing goods. But goods finding will be found from recorded list on paper by reading carefully code of any goods.

4.3 Logistics mapping

4.3.1 IDEF (AS-IS)

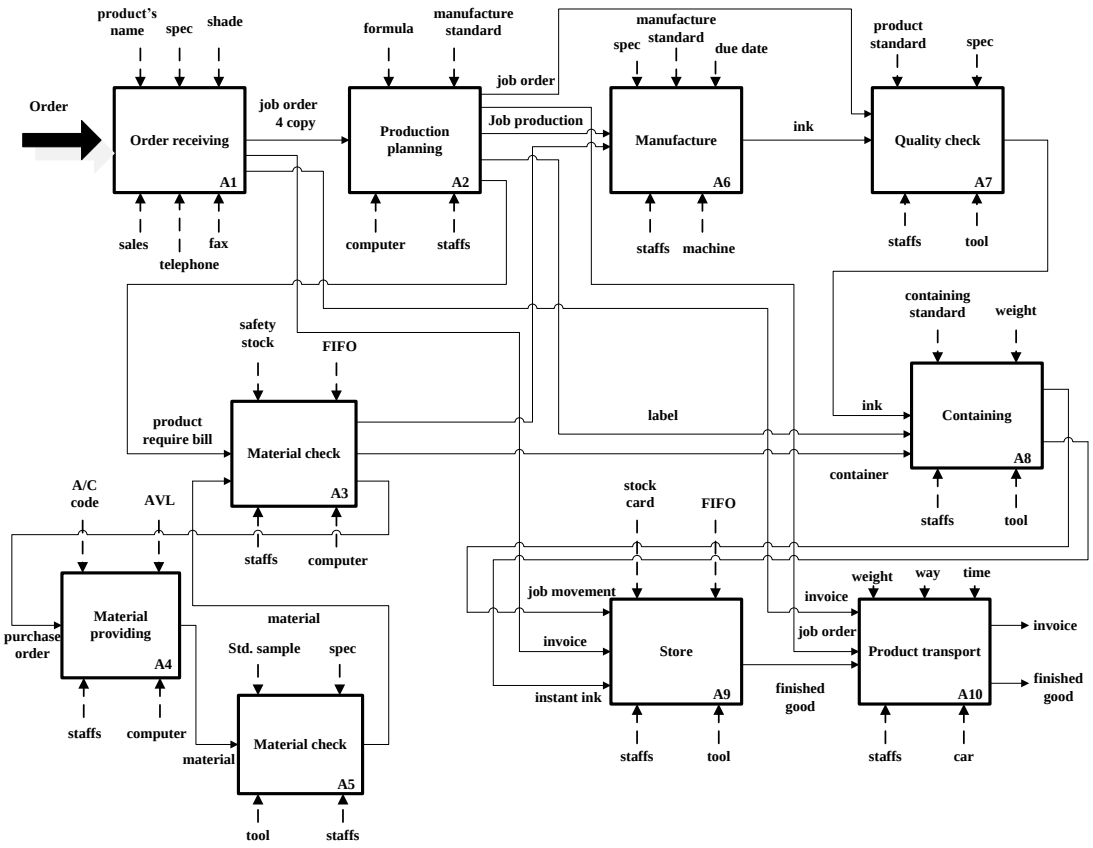


Figure 4-5 IDEF0 As-Is working process

From the study and analysis of the present working process of the case study- company, it can show the working process according to IDEF0 diagram as in figures 4-5 - 4-9. From figure 4-5, it is found that it contains with several steps as follows;

Order receipt, production planning, production, quality assessment, material checking, material finding, material assessment, containing, storing and transporting. All processes start from;

4.3.1.1 A1 the step of purchase order: customers will order goods by which the sales department will receive purchase order through the call, fax or else the company staff will directly come out for purchase order from customers, thereafter the sales department will assess ordered goods by fixing code to each kind of goods so as to record onto purchase order receipt, then the sales department will release 4 copy to the production planning department.

4.3.1.2 A2 the step of production planning: as the planning department receives all 4 copy from the sales department, it will distribute working order to the warehouse department, the quality assessment department and transportation department. After receiving order, the planning department will assess the amount of goods by enquiring data of goods amount from the warehouse department if there are goods ordered by customers, if no any, the planning department will release production order filling data in the Microsoft excel program so as to calculate material usage and to make formula calculation to the production department.

4.3.1.3 A3 the step of material checking: in case of no goods in the warehouse, there must be prepared material and material checking available to production power.

4.3.1.4 A4 the step of material finding: if there is no material in the warehouse, there must be prepared material through supplier.

4.3.1.5 A5 the step of material checking: in case of no goods, there must be prepared material and material checking available to production power.

4.3.1.6 A6 the step of production: the production department will produce according to formula received from the production planning department

by which the production department will receive material from the warehouse department.

4.3.1.7 A7 the step of quality assessment: this step will also involve with the production department, this step will go on after finishing production and the quality assessment department will release COA list to customers.

4.3.1.8 A8 the step of containing: as the production department has produced and quality assessment has been completely examined, next is the step of containing.

4.3.1.9 A9 the step of ready-made goods storage: as the production department has already contained goods and sent to the warehouse department for further ready-made goods storage.

4.3.1.10 A10 the step of transportation: the transportation department will transport goods according to the amount ordered by customers, thereafter, there will be transportation to customers again.

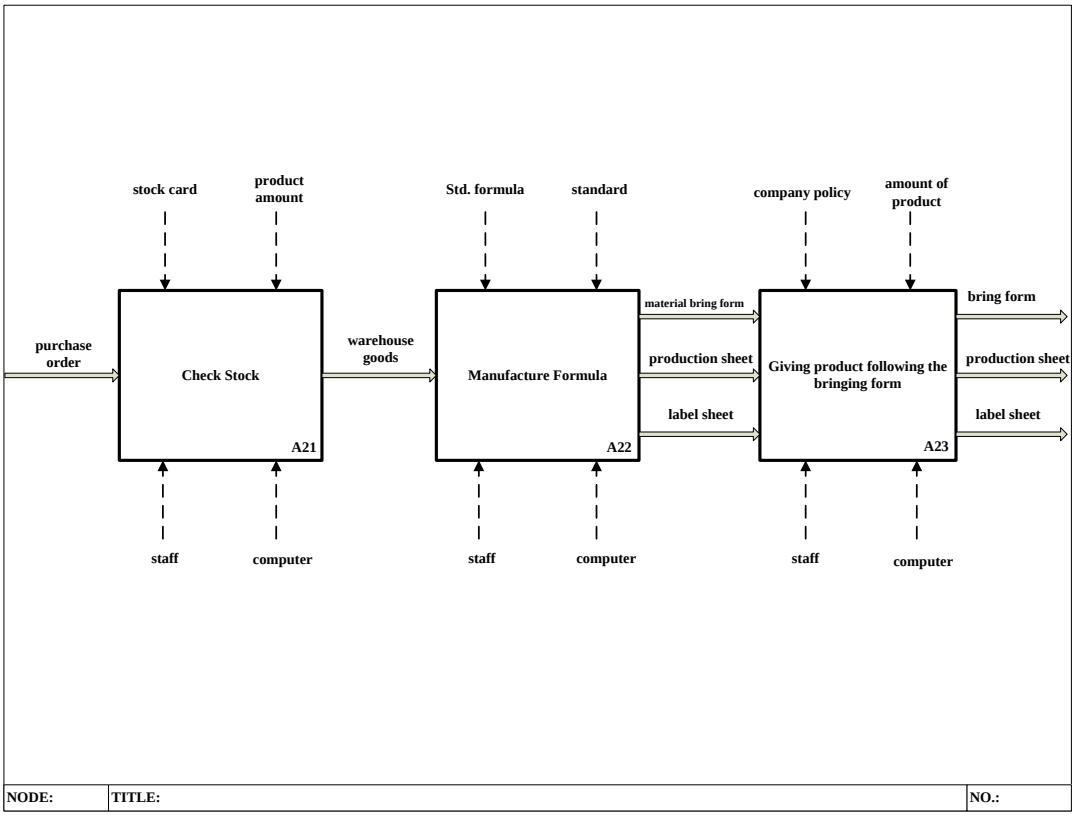


Figure 4-6 IDEF0 Production planning process

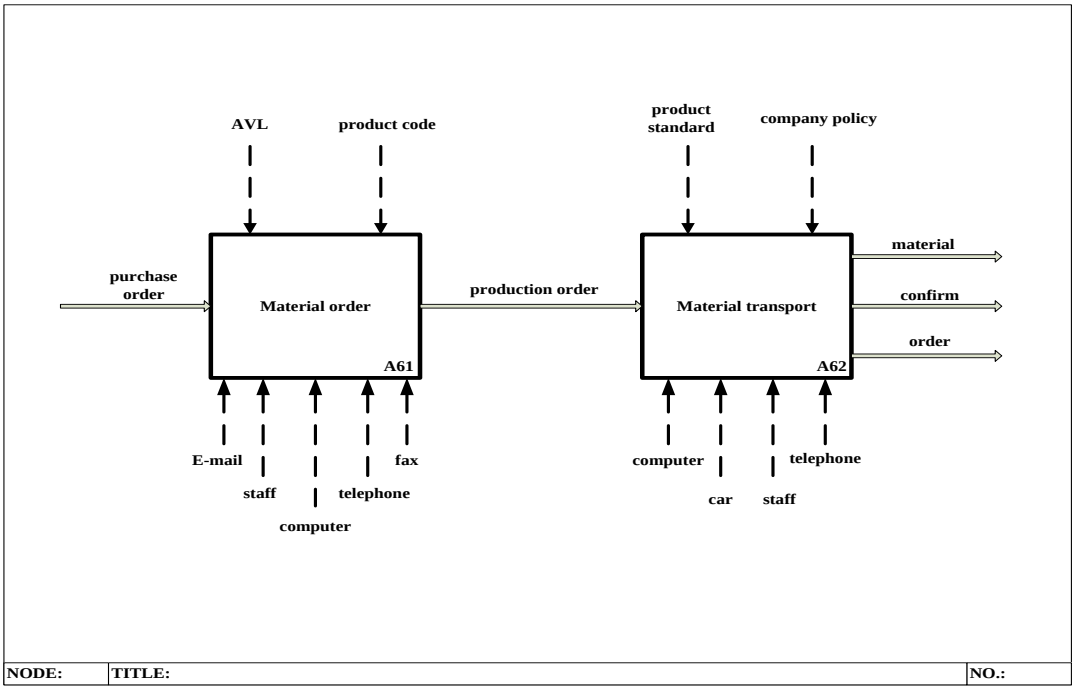


Figure 4-7 IDEF0 Raw material preparation process

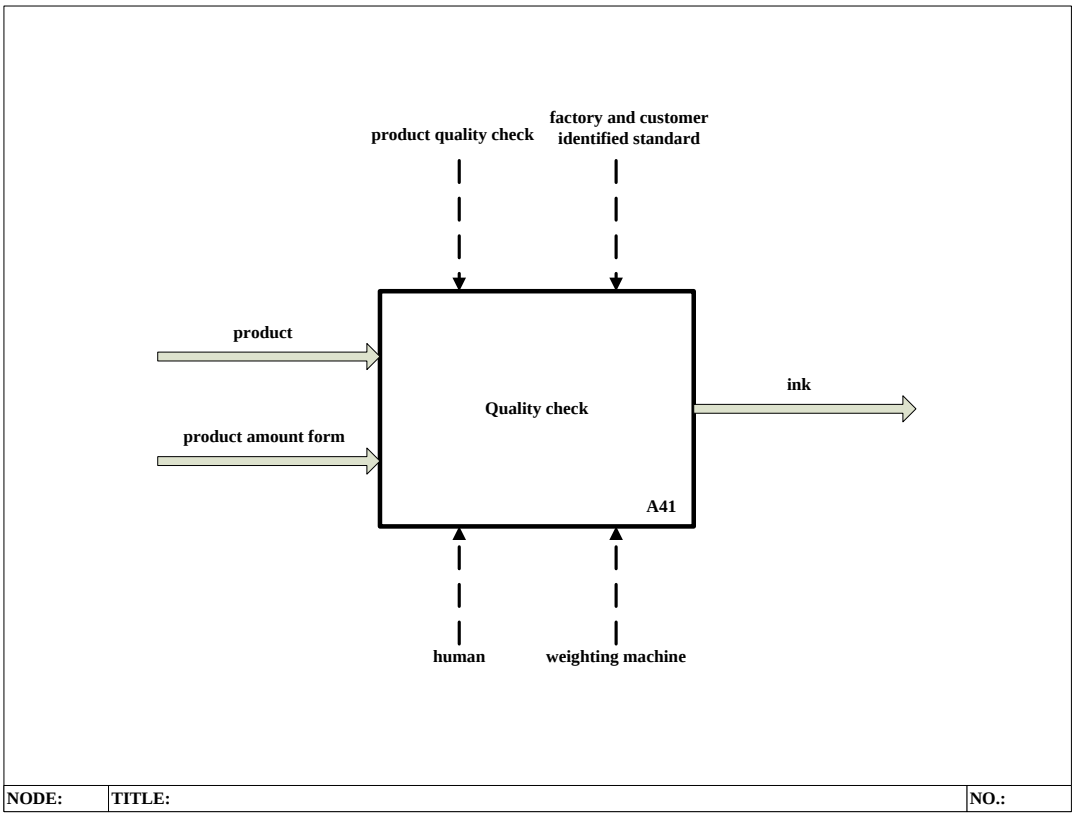


Figure 4-8 IDEF0 Quality assessment process

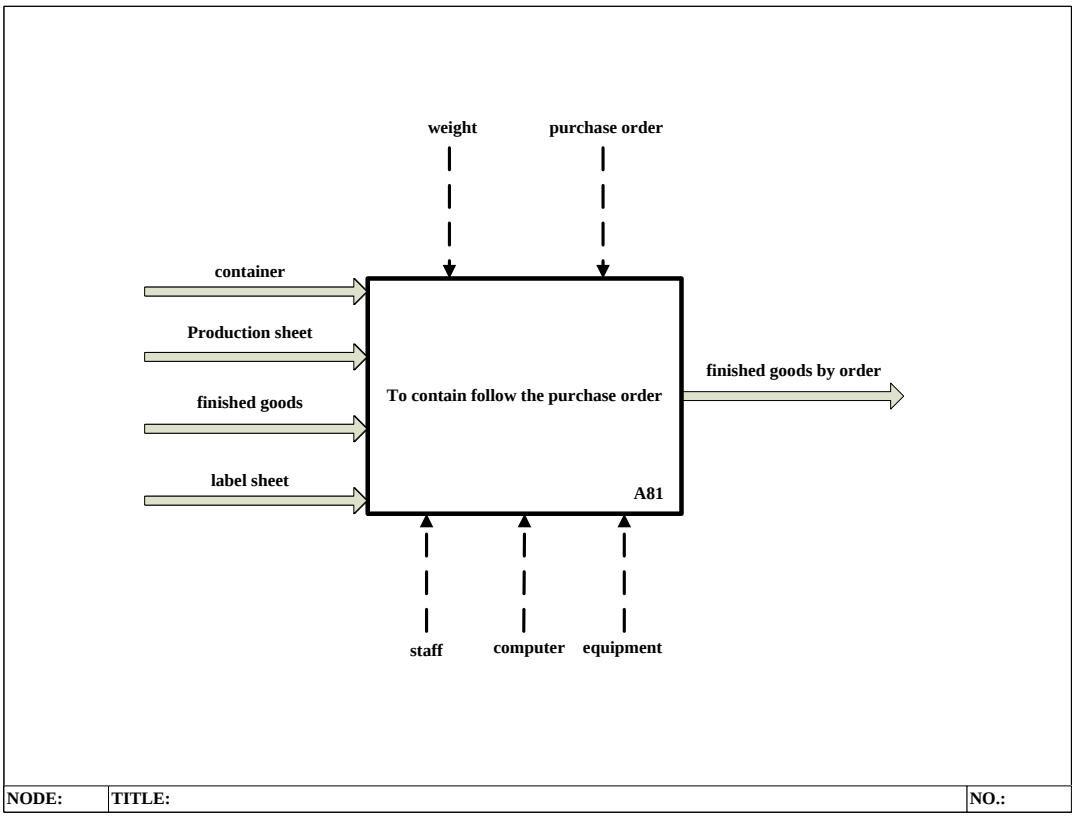


Figure 4-9 IDEF0 Packaging process

Each activity will have information linkage and all processes rather complicated because of the transition of several orders. Other than the demonstration of the step of operation with IDEF0, the step of operation of the swim lane can be also demonstrated as shown in figure 4-10. The swim lane diagram will show all processes like the IDEF0 diagram will, but the Swim Lane diagram will add particularly the flow of working processes more clearly and pictorially.

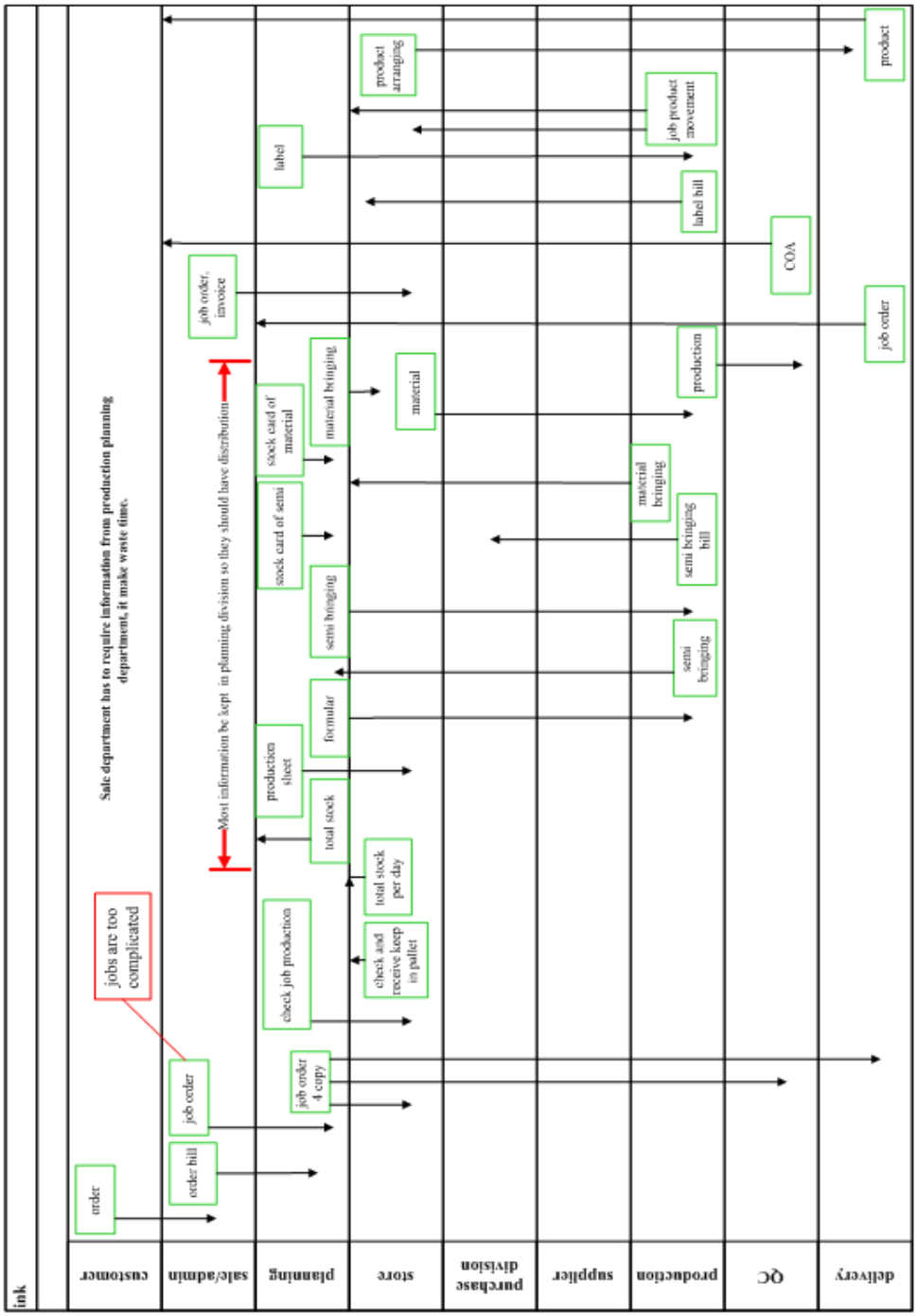


Figure 4-10 Swim lane diagram As-Is working process

4.4 Conclusive Problems

The study and analysis of the present working procedure of the case study-firm can be concluded as follows;

4.4.1 Most of the operation is under the responsibility of the planning department, therefore, any data have not been sent to other departments due to the disconnection of data of goods remains within the warehouse to the sales department and the production planning department. For the sales department must enquire information of goods remains within the warehouse from the planning department and then the planning department will check goods within the warehouse. By this reason, such procedure will waste the time and delay in fixing the day for transporting goods to customers.

4.4.2 The step of material requisition and payment must be passed by the planning department and the planning department will send the requisition order to the warehouse department. Thereafter, the warehouse department will send material to the production department to further production. As a result, such a step is rather complicated and delays the operation and waste the time in waiting for material.

4.4.3 The data gathering of goods remains within the warehouse is delayed and irregular because there is no personnel for data gathering.

4.4.4 No inform of production results back to the sales department. Thus, the sales department does not know that Order that has been ordered comes to whichever step.

4.4.5 As the purchasing department receiving order from customers and it will release 4 copy to the planning department and finally the planning department will distribute to other departments again. At this step, working process is more complicated and all procedure will be delayed because of waiting for working order data.

4.5 Trend of solving problems

4.5.1 There must be sharing goods data within the warehouse and also order data to all departments involved for checking immediately after the sales department and the marketing department having received order from customers so

that the procedure in finding goods and checking order status can be fast operated and that the procedure can respond the need of customers in time.

4.5.2 Making and arranging data-base system as the center in data gathering of order and goods within the warehouse.

4.5.3 Re-developing the system to be consistent with such operation

4.6 Design of the new system

Gathering data, studying problems and analyzing the present working process of the case study-company can develop as a new system and a new system itself can fix the scope of the system users with Login to the system. The system is divided as follows; the system superintendent, the sales department and marketing department, the production planning department, the warehouse department, the QC department, the production department and the transportation department. Of these, a new system can be operated as follows;

4.6.1 Order System

Order system is the system which can be particularly created by the sales and marketing department, that is to say, the sales and marketing department will receive purchase order from customers and records purchase order on working order, thereafter, it will send order data through Local Area Network System to all departments concerned, as the production planning department receiving order will fix Lot.No to goods and finds if goods are stored in the warehouse, if no, it will purchase material in order to produce such goods, and if goods are stored in the warehouse, the production planning department can immediately cut goods remained in the warehouse. Thus, order of other departments is not able to create order, but other departments can investigate order status that order is in the step of production planning, producing, quality assessing and goods transporting.

4.6.2 Warehouse Management System

Warehouse management system is the system of gathering all kinds of goods data within the warehouse whether they are material goods or produced goods. This system can check remained goods, find position in storing goods, transporting

goods, bringing and paying goods from the warehouse. Therefore, the warehouse department is the only one that can transport position in storing goods, but other departments can only check goods status and the planning department will be the one that can bring out goods from the warehouse.

4.6.3 Functioning of a New System

4.6.3.1 Warehouse

The warehouse includes 8 sub-menu; receiving goods, paying goods, transporting goods, finding goods, summarizing receipt / payment/ goods transportation, reporting the movement of goods, remained goods list and importing goods data. Of sub-menu, other departments can find and see particularly finding goods data and reporting the movement of goods.

4.6.3.2 Goods List

Goods list contains 2 sub-menu; adding goods list and correcting / deleting goods list. Of this menu, the warehouse department and the sales and marketing department can operate the system.

4.6.3.3 Order

Order includes 5 sub-menu; creating order, checking status, reporting purchase order, receiving goods from order, detailing order, QC department doing COA and QC report. Of order menu, the sales and marketing department is the only one that can create order, besides, other departments can only check status and order detail. For the warehouse, it can receive goods into the warehouse from order.

4.6.3.4 Customers' Data

Customers' data contain 2 sub- menu; adding customers' data and correcting/deleting customers' data. Of customers' data, the sales and marketing department is the only one that can add, correct and delete customers' data.

4.6.3.5 Purchasing Order History

Purchasing order history contains 2 sub-menu; adding purchasing order history and correcting/ deleting purchasing order history. Of this menu, the sales and marketing department is the only one that can add, correct and delete purchasing order history. And in this menu, it can be classified each kind of goods according to purchasing order history.

4.6.3.6 System User

The system user contains 2 sub-menu; changing password and creating system user. Of this menu, all departments can change password and create new system user, but they can create the system user particularly at Login to the system but they can not create the system user into other departments.

4.6.4 IDEFF0 and Swim Lane diagram of the new system

The present working process diagram of the new system can be shown with IDEF0, Swim Lane diagram. See figure 4-11 and 4-12

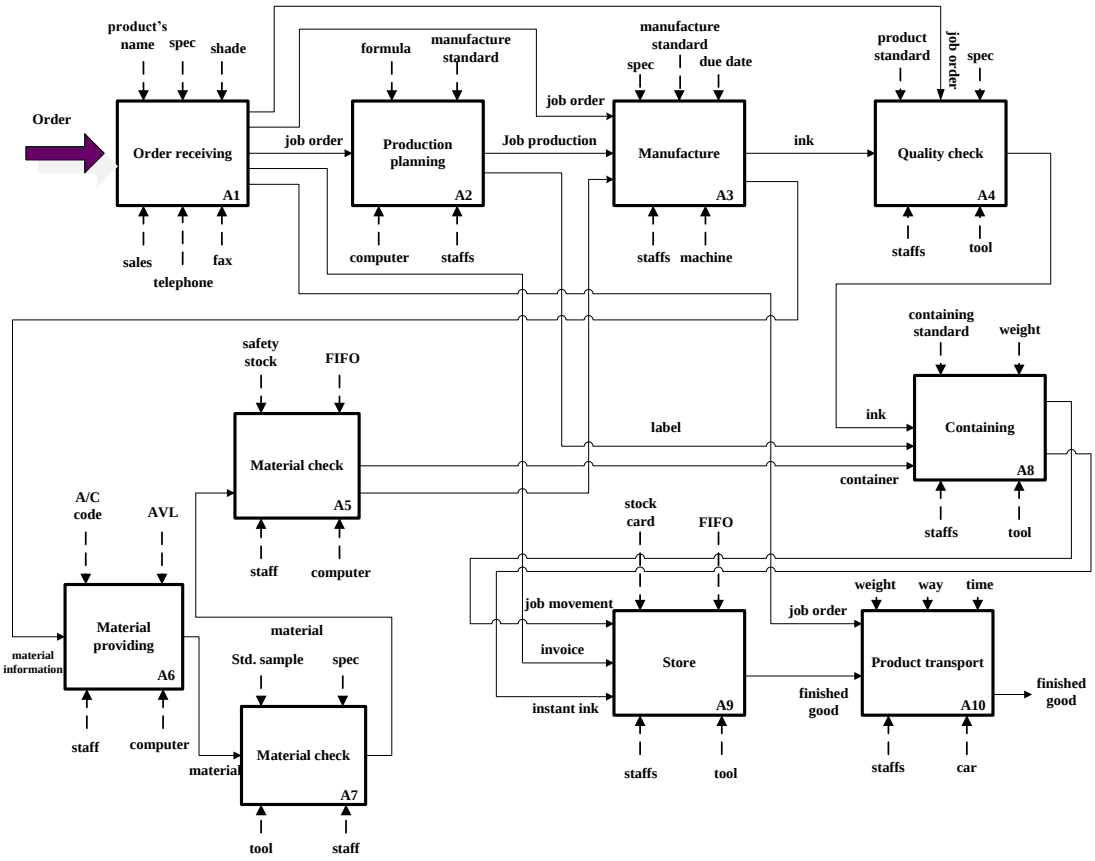


Figure 4-11 IDEF0 To-Be working process

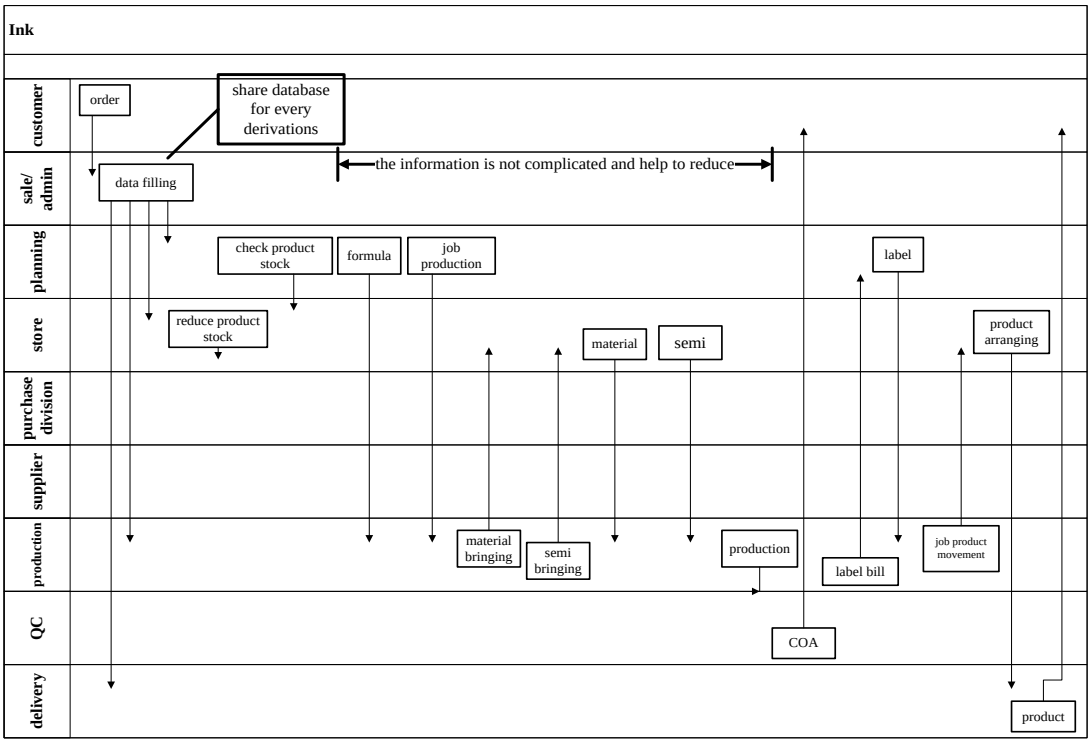


Figure 4-12 Swim lane diagram To-Be working process

From Swim Lane and IDEF0 diagram, as the sales and marketing department has already received purchase order from customers, it will fill in data in the developed program. From such data, the production planning department, production department, QC department and transportation department can immediately check status of order. As a result, each department can operate its function without informing the information from other departments, for example, when the production planning department receiving order will check goods within the warehouse immediately and can cut goods remains without informing the warehouse department, because the warehouse can check goods remains cut from the system, and for the transportation department itself, when it has checked order status and found that goods has already passed production process and been in the warehouse, so it can bring and transport to customers without informing from the planning department so as to be able to transport goods to customers quickly.

4.6.5 Data flow diagram of the new system

Data flow diagram of the new system developed derives from taking all knowledge obtaining from gathering the needs of the system user for analyzing in detail to show environment of the system to make clear that how can the system respond to the user. The detail can be demonstrated according to Context diagram as shown in figure 4-14 and the detail involved can also be demonstrated as shown in figure 4-13.

List of Process

1. Main information improvement
   - 1.1 list of goods improvement
   - 1.2 customer information improvement
   - 1.3 purchase history improvement
   - 1.4 order receipt improvement
2. Order receipt creation
   - 2.1 goods searching
   - 2.2 company searching
   - 2.3 information saving
   - 2.4 list deleting
   - 2.5 order receipt printing
3. Order receipt status checking
4. COA Making
5. Warehouse management
   - 5.1 goods receiving
   - 5.2 goods moving, transfer
   - 5.3 goods giving
   - 5.4 goods searching
6. Add/edit login password
7. Printing

List of Data

1. Customer
2. Product
3. Type of Product
4. History
5. Location
6. Lot No
7. Report
8. Task
9. Order
10. User

List of External Entities

1. Administrator
1. Marketing
2. Planning
3. Store
4. QC
5. Delivery

Figure 4-13 List of External Entities, List of Data and List of Processes

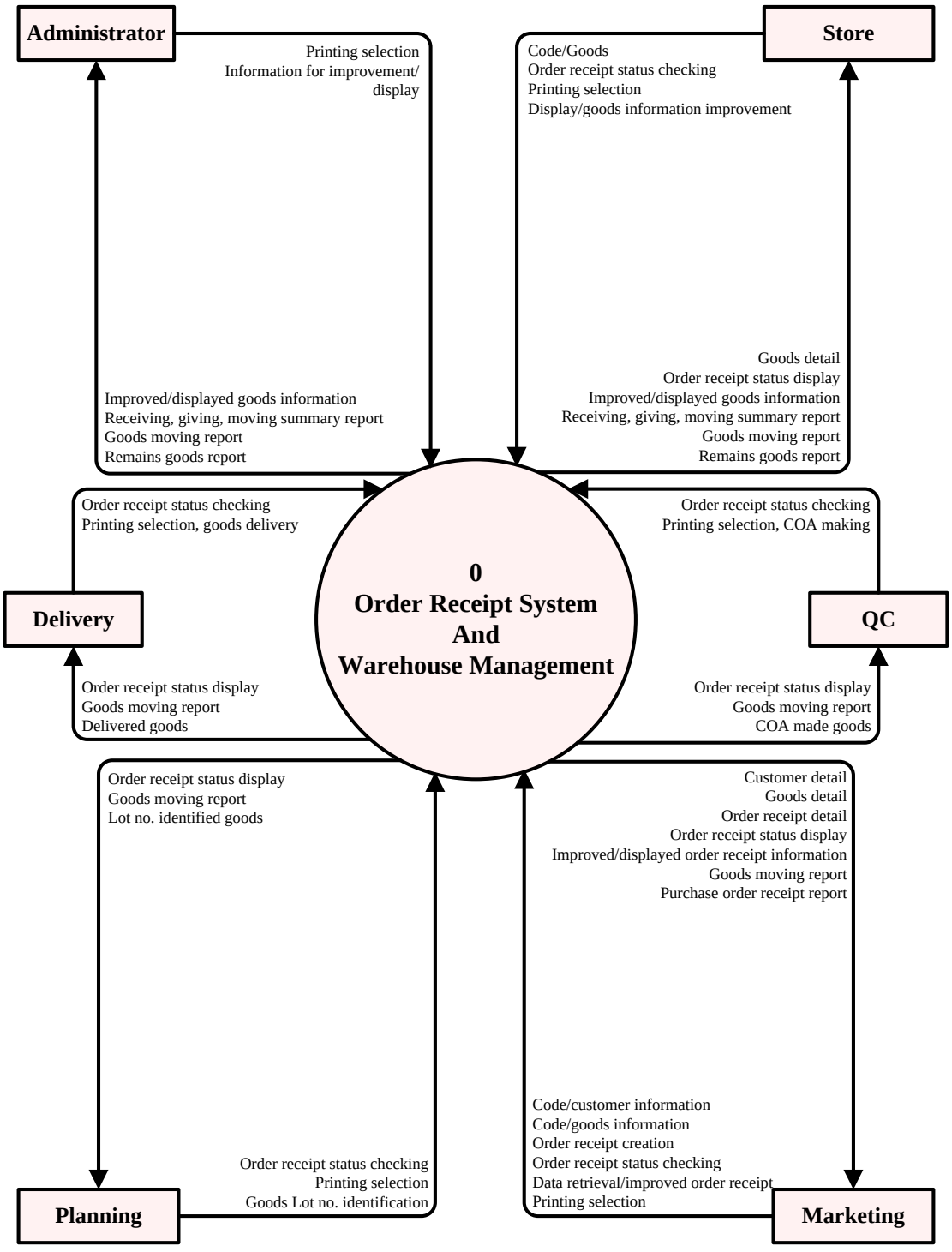


Figure 4-14 Context Diagram (DFD Level0)

From context diagram, showed the environment of order receipt system (Process) and warehouse that involve external entities, The external entities send input data to process and the process send output data to external entities too. The researches do the process decomposition diagram to show the processes in data flow sheet from the list of processes operation in figure 4-15.

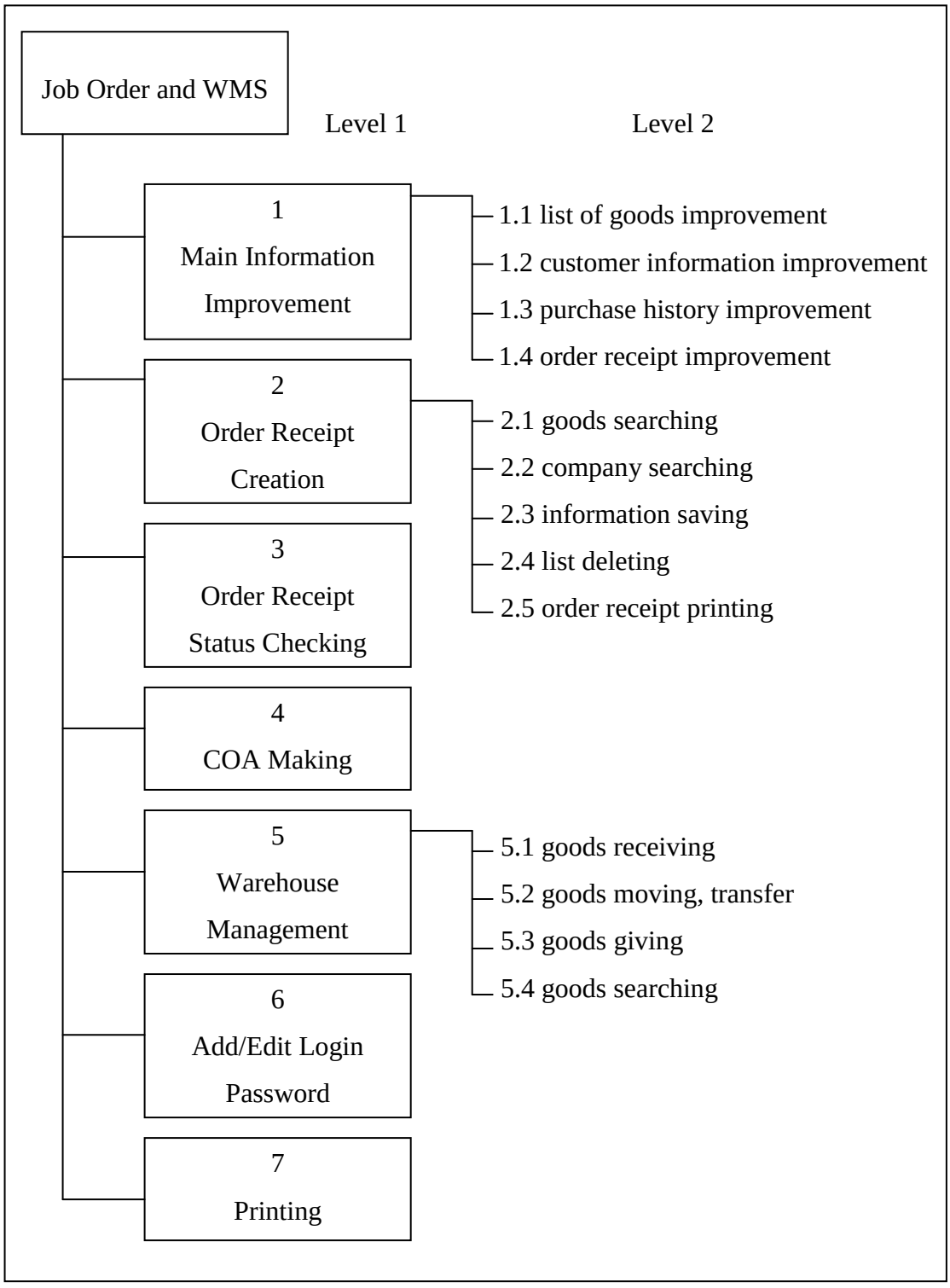


Figure 4-15 Process Decomposition Diagram: order receipt system and warehouse management

From figure 4-15 : process decomposition diagram, showed the group of process and DFD level1 showed the process and main data from separation in each processes are DFD fragments as show in figure 4-16 – 4-22 then the researcher compound the DFD fragments together to be DFD level1 as show in figure 4-23.

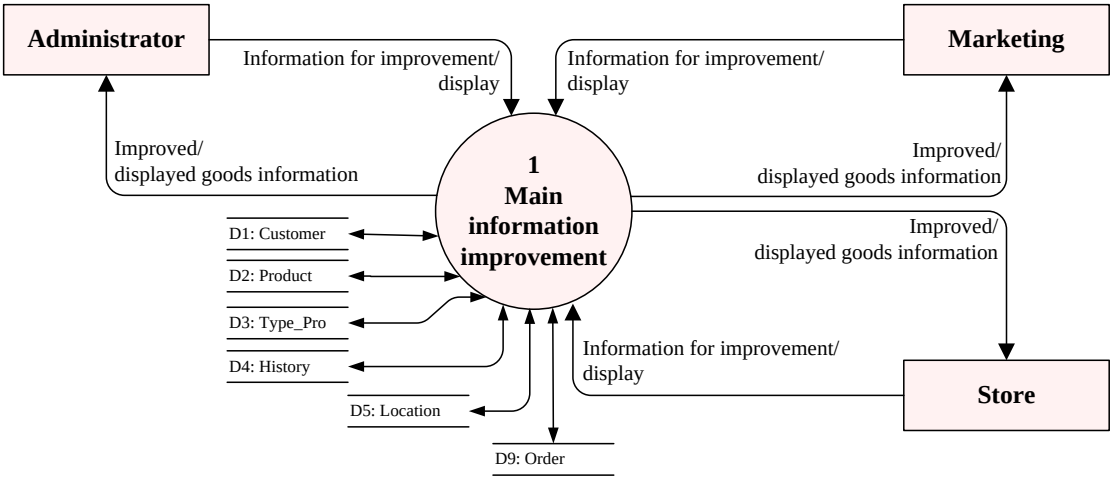


Figure 4-16 DFD Fragment 1: Main Information Improvement

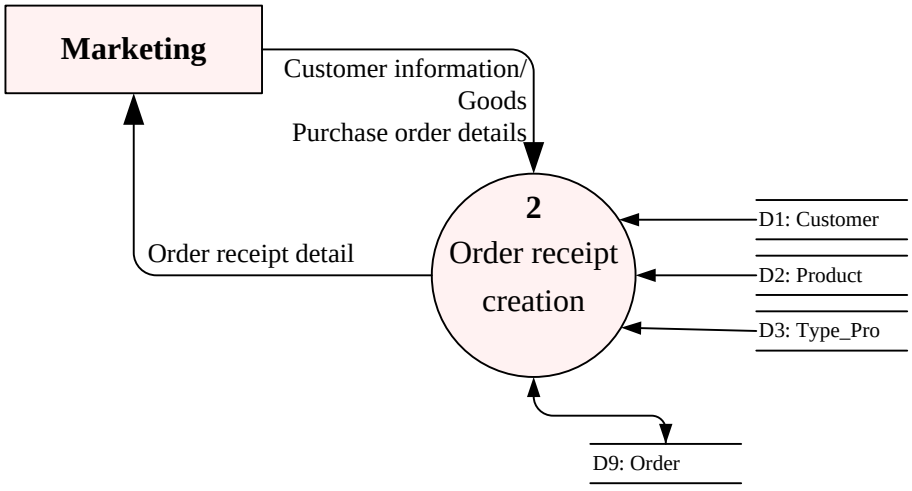


Figure 4-17 DFD Fragment 2: Order receipt creation

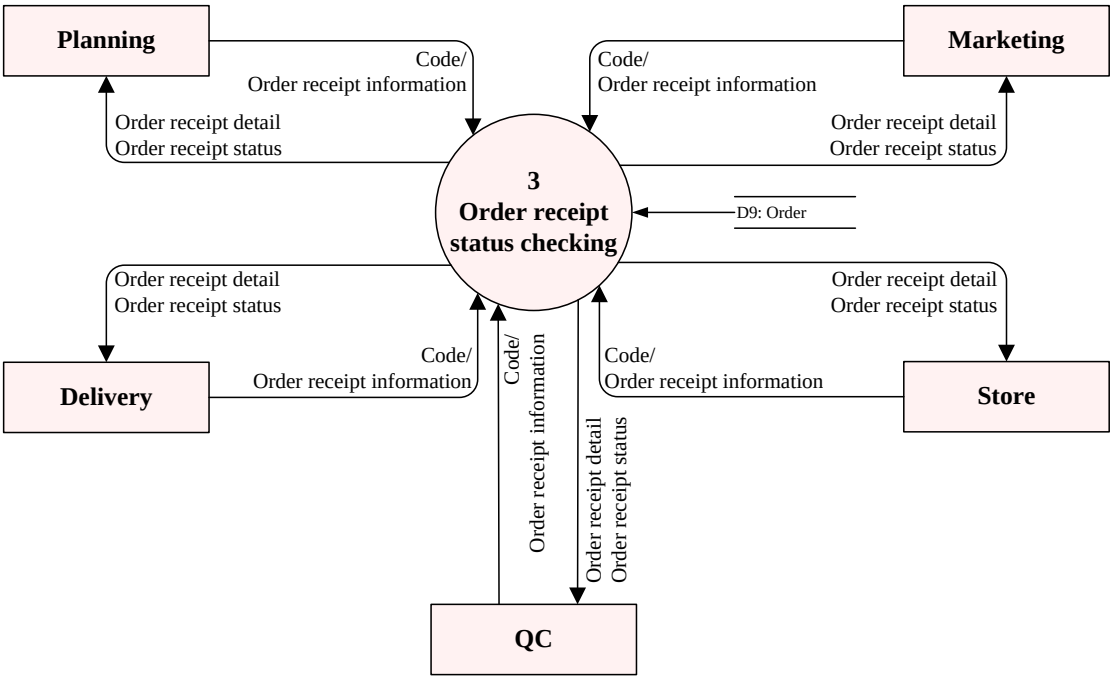


Figure 4-18 DFD Fragment 3: Order receipt status checking

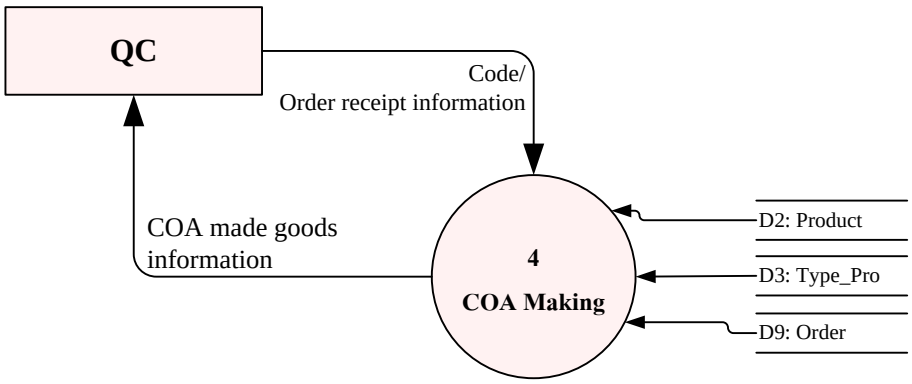


Figure 4-19 DFD Fragment 4: COA Making

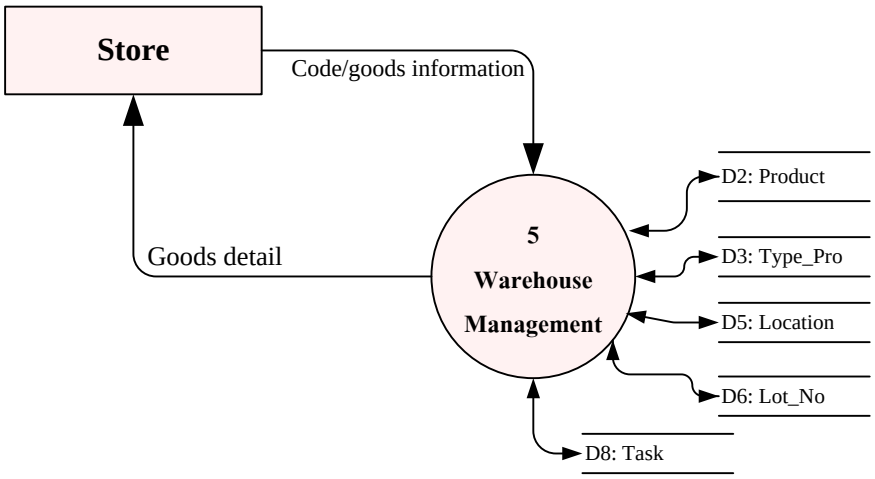


Figure 4-20 DFD Fragment 5: Warehouse Management

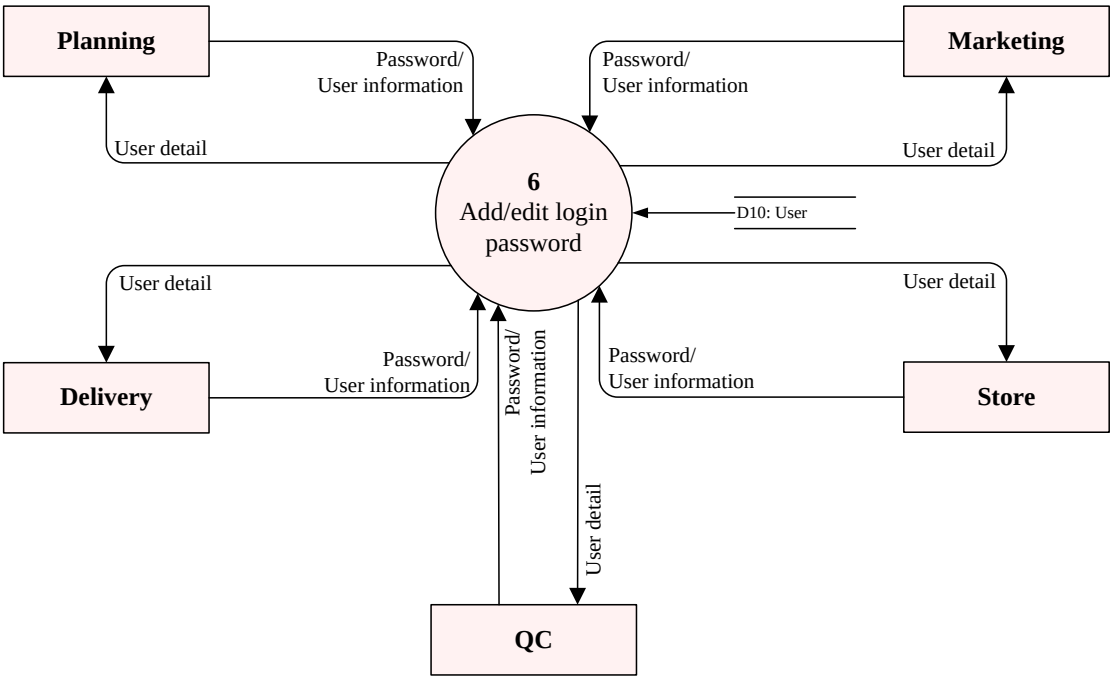


Figure 4-21 DFD Fragment 6: Add/edit login password

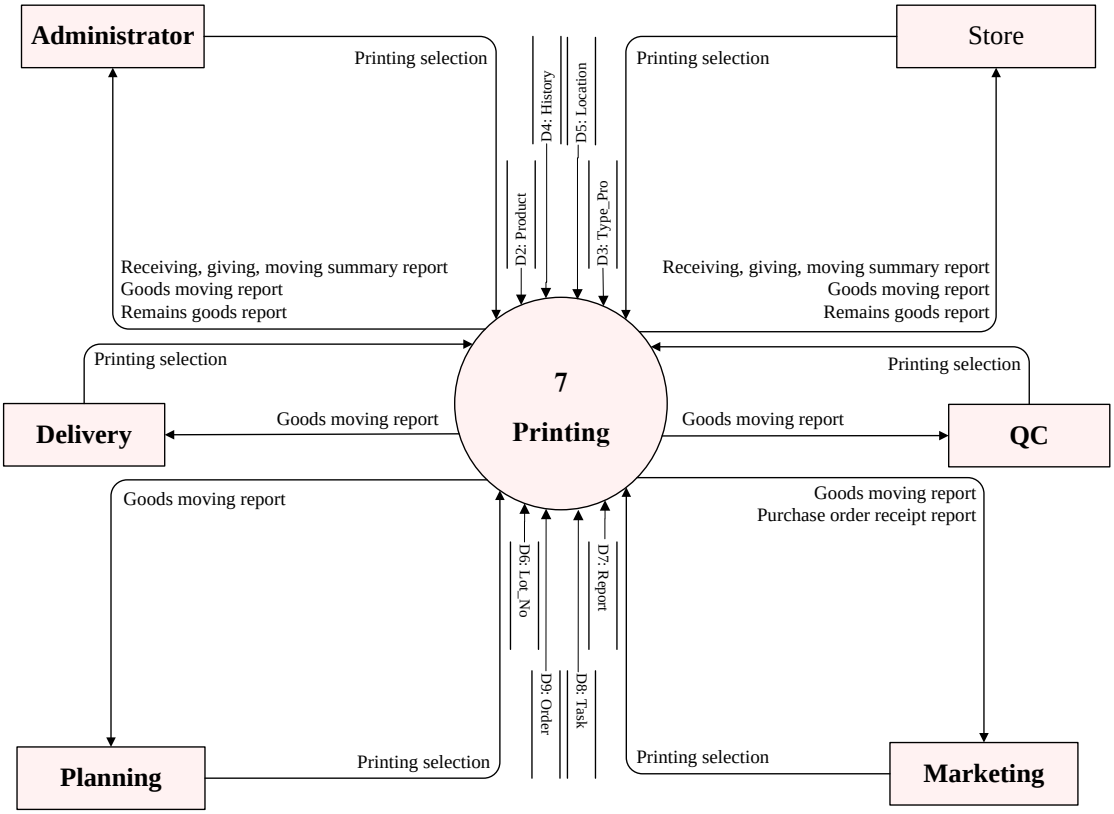


Figure 4-22 DFD Fragment 7: Printing

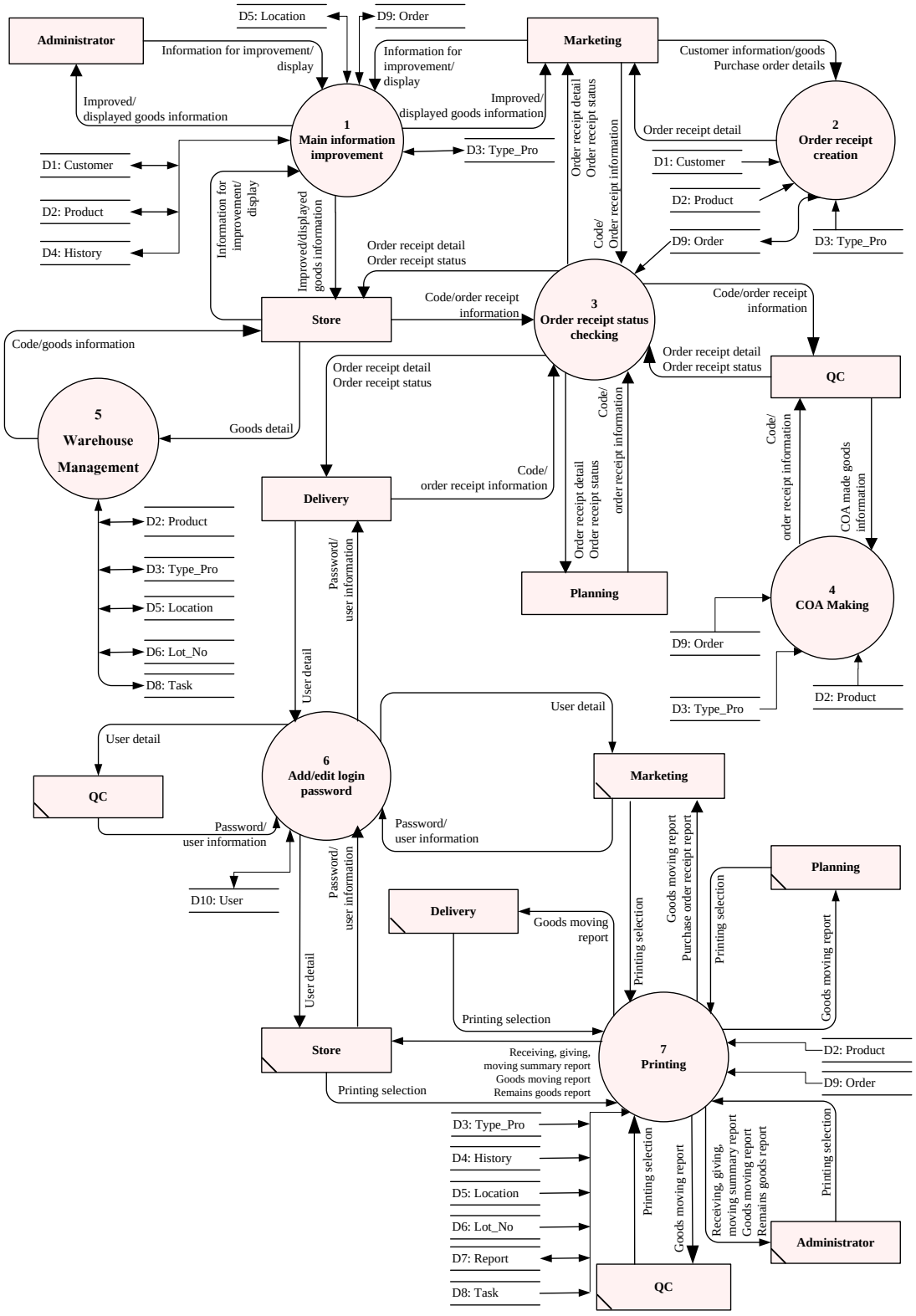


Figure 4-23 DFD Level1

This research showed the working of sub process of DFD level1 in DFD level2 for showing the working process system. The separation of function in DFD level1 that called functional decomposition as show in figure 4-24 – 4-26

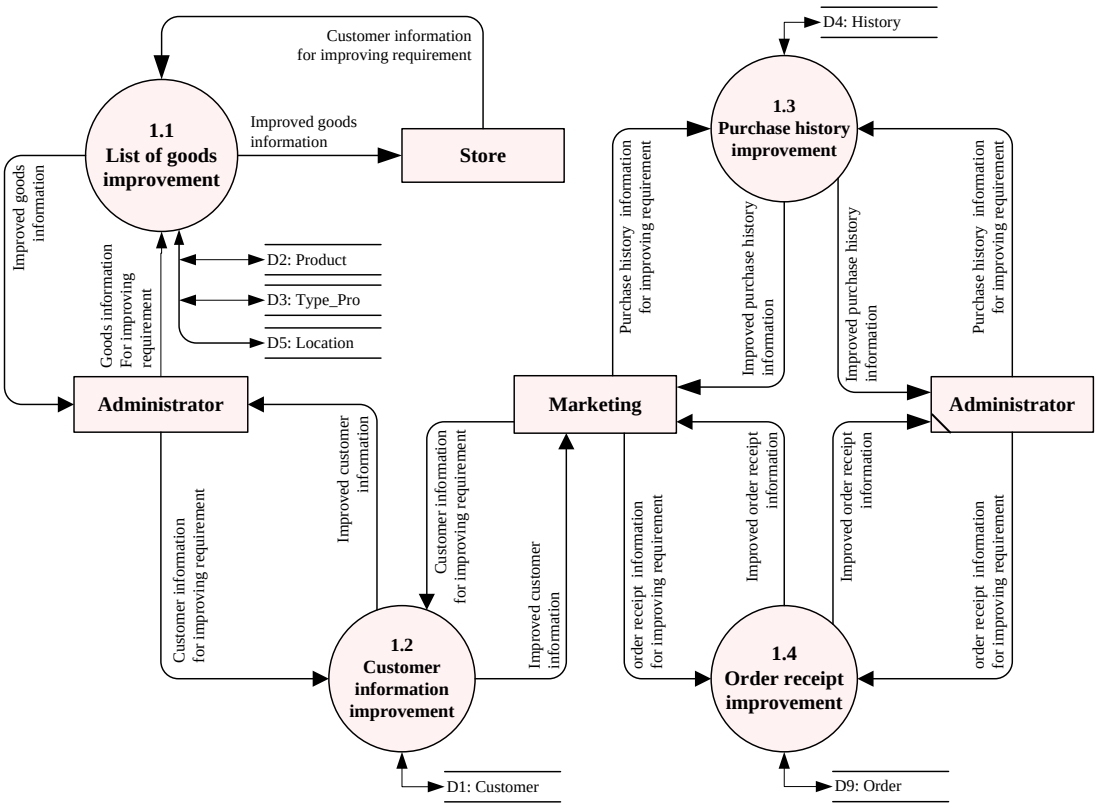


Figure 4-24 DFD Level2: Main Information Improvement

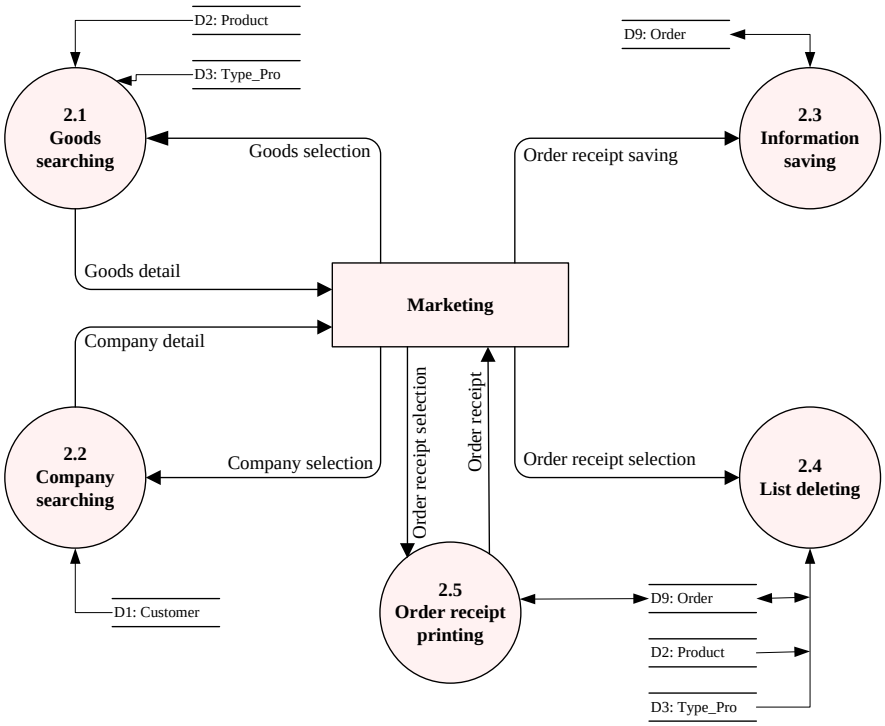


Figure 4-25 DFD Level2: Order receipt creation

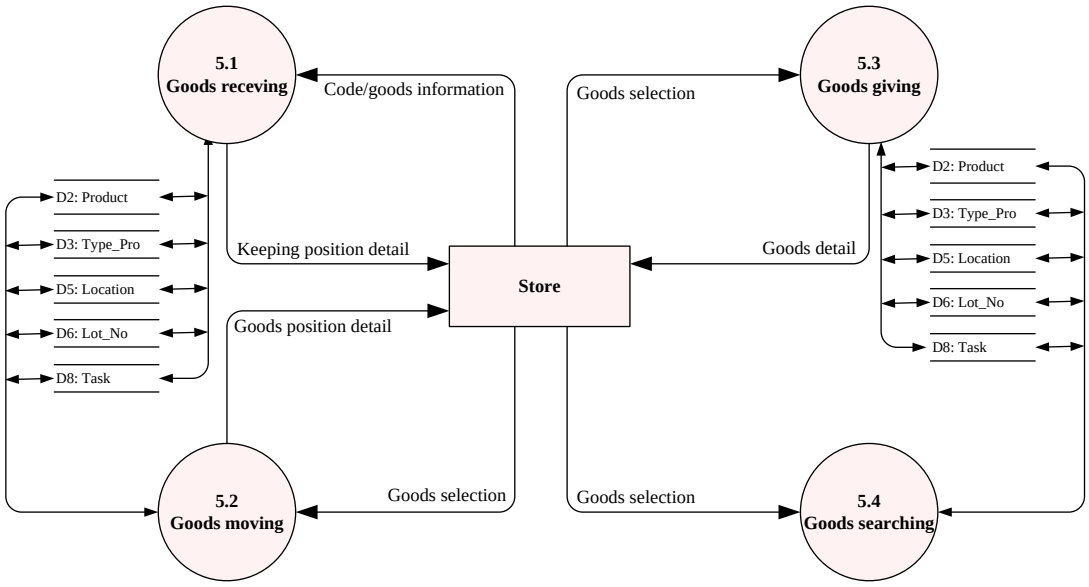


Figure 4-26 DFD Level2: Warehouse Management

4.6.6 Entity Relationship diagram of the new system

ER-Diagram (Entity Relationship diagram) is the data model that use if for explanation about the information for business process supporting in case study. This information derive from data flow diagram as shown in figure 4-27.

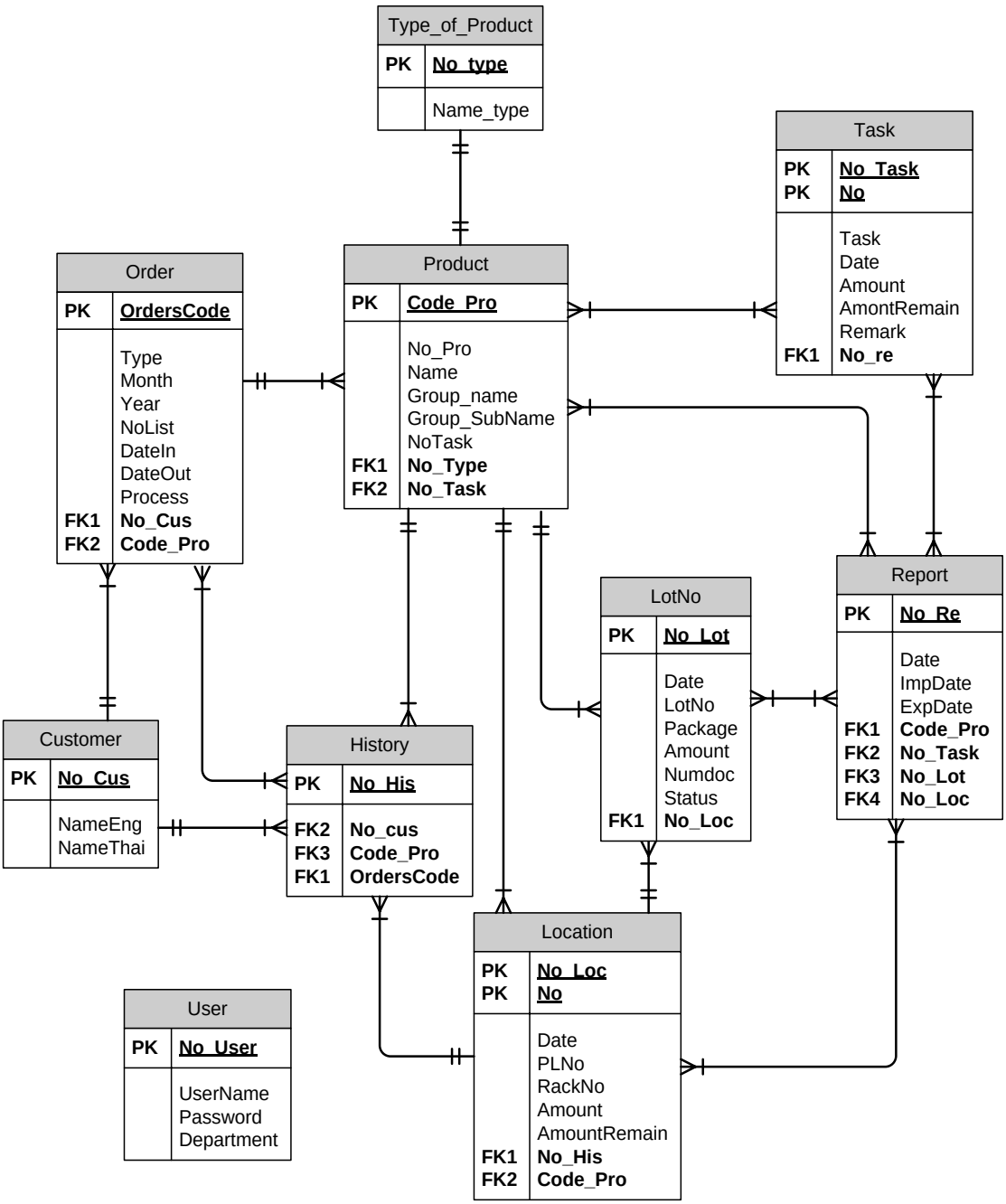


Figure 4-27 E-R Diagram

4.6.7 User Interface design of the new system

The researcher use graphics user interface that interact the user with key board or mouse in new system. Main program form are composed of:

4.6.7.1 Main program form for user name and password filling before access in program as shown in figure 4-28. When accessed the program, main form will show that composed 6 sub menus: 1) warehouse 2) product list 3) job order 4) customer information 5) purchase history 6) user information as shown in figure 4-29

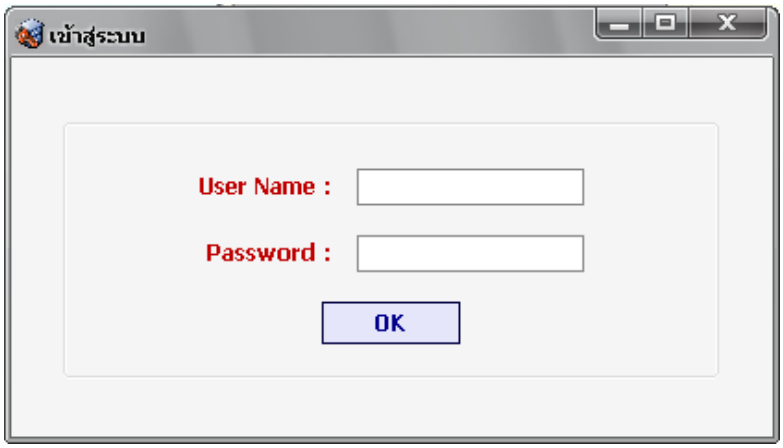


Figure 4-28 Log in form

Figure 4-29 Main Program Form

4.6.7.2 Warehouse form is the menu that involve product bringing to warehouse as shown in figure 4-30

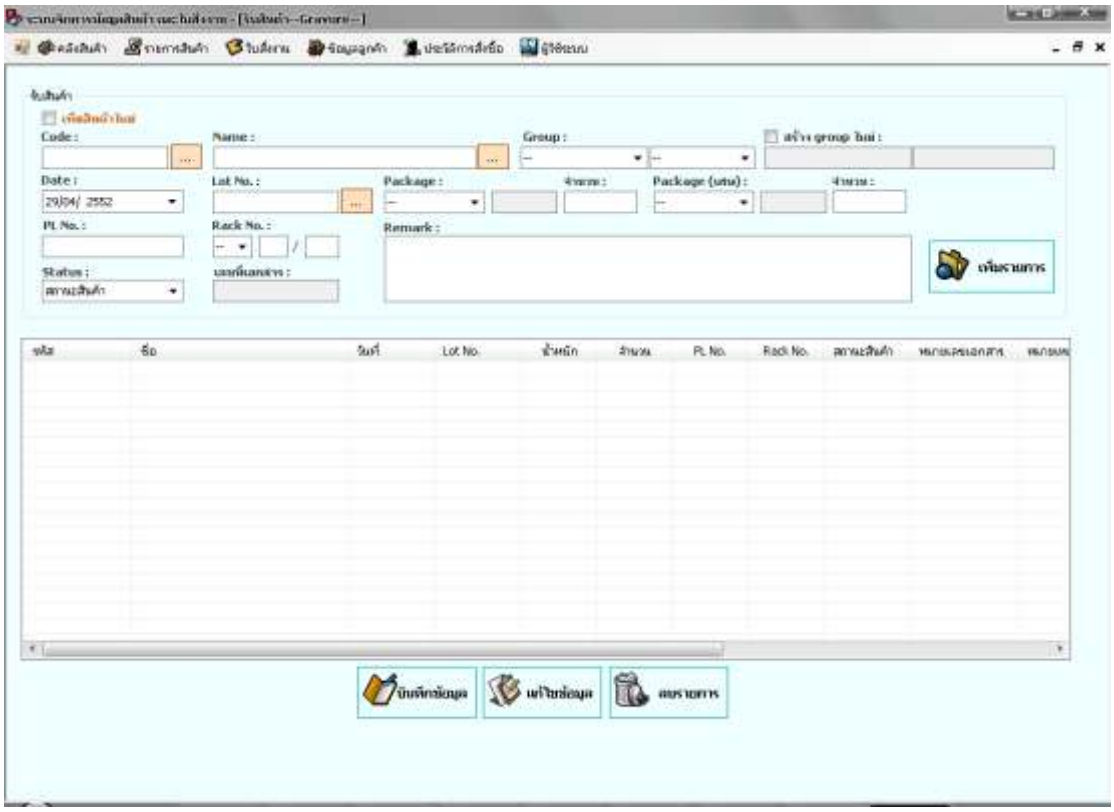


Figure 4-30 Warehouse form

4.6.7.3 Product list form is the menu that collect total product information in the company as show in figure 4-31.

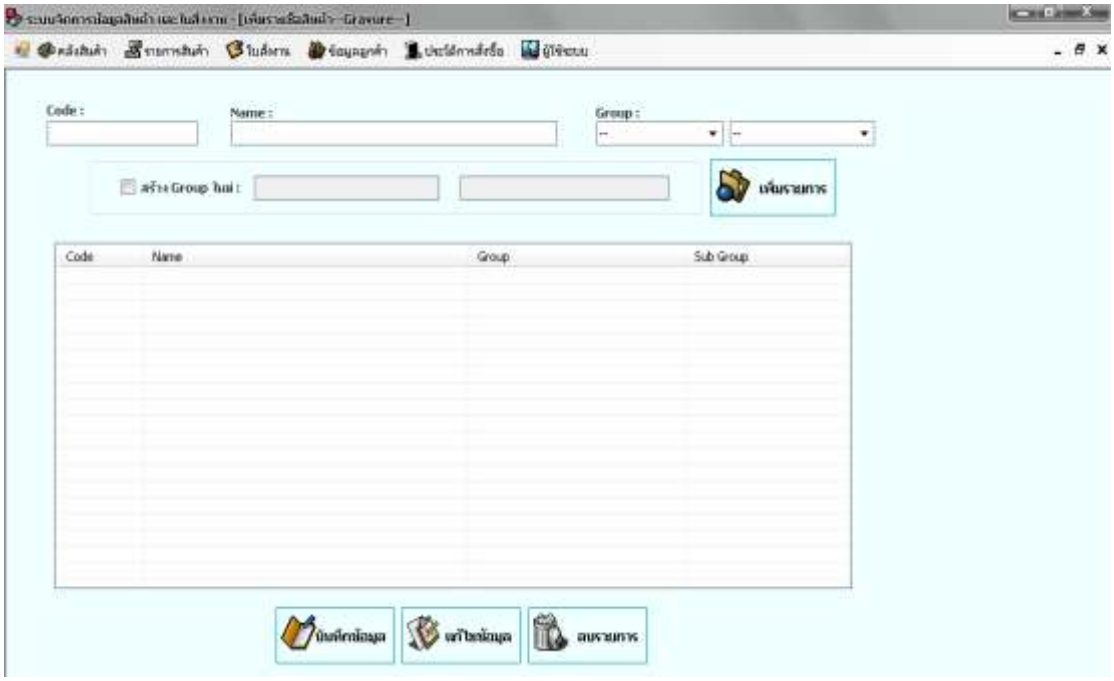


Figure 4-31 Product list form

4.6.7.4 Job order form is the menu that involve purchase order receiving from the customer for purchase order printing to other divisions by LAN as show in figure 4-32.

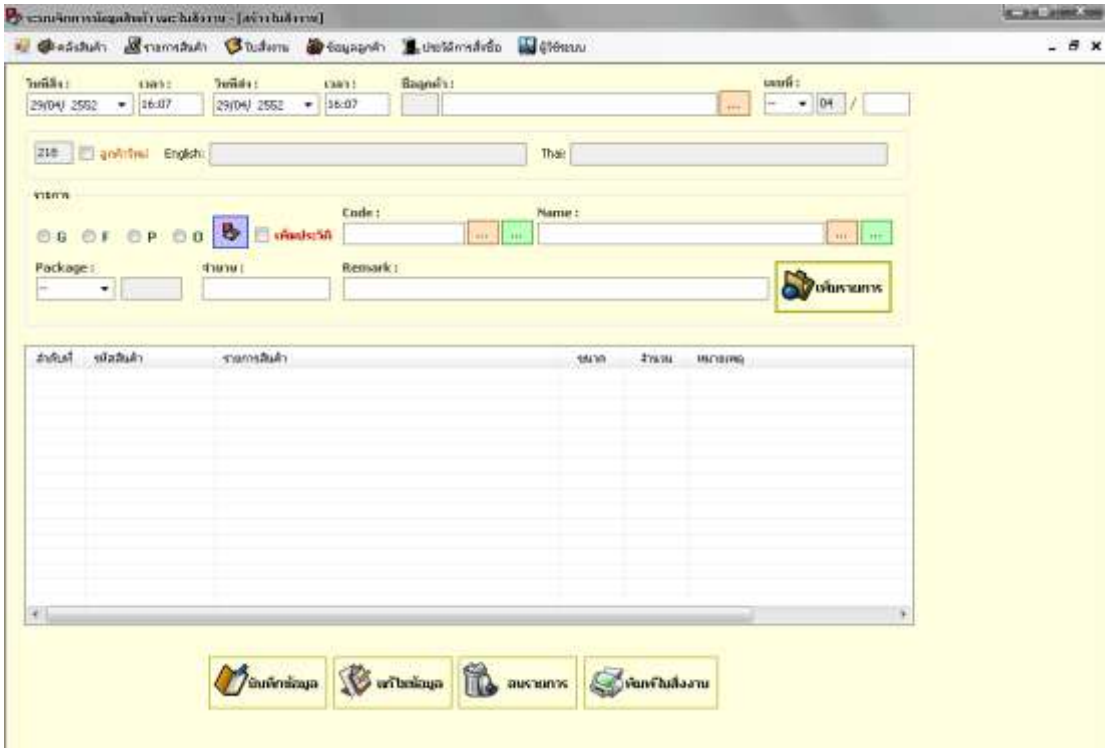


Figure 4-32 Job order form

4.6.7.5 Customer information form is the menu that collect customer history as shown in figure 4-33.

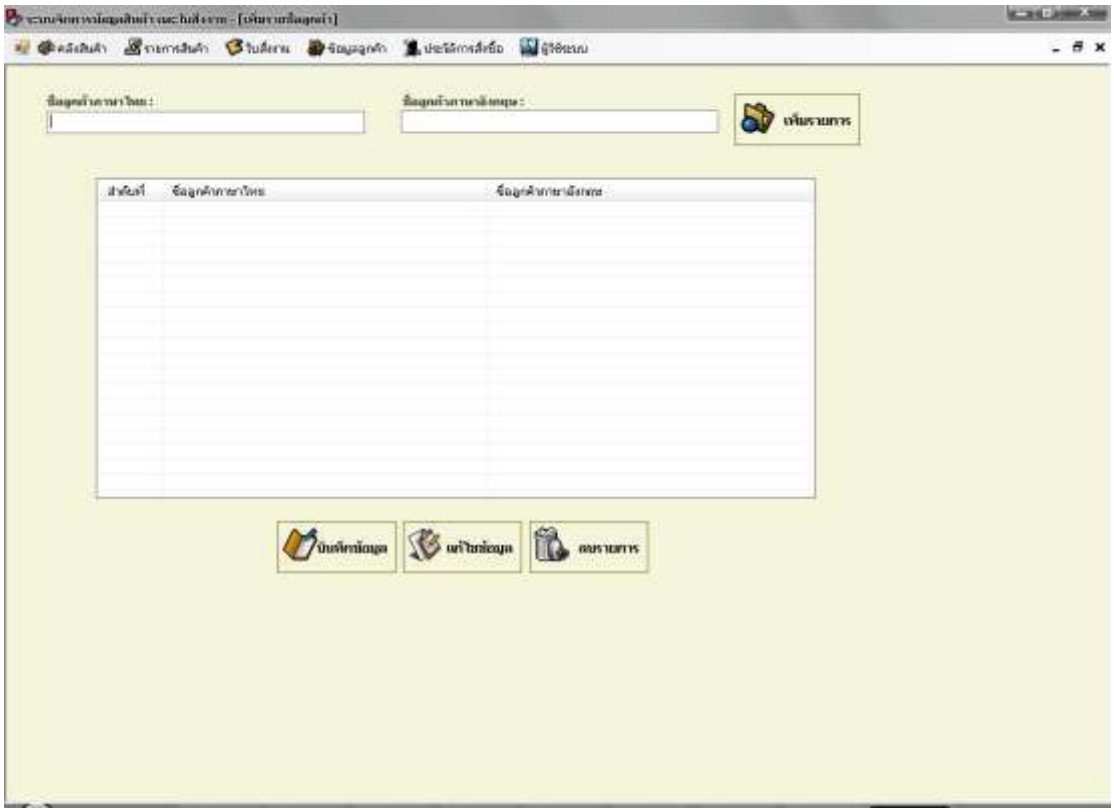


Figure 4-33 Customer information form

4.6.7.6 Purchase history form is the menu to collect purchase history form as shown in figure 4-34.

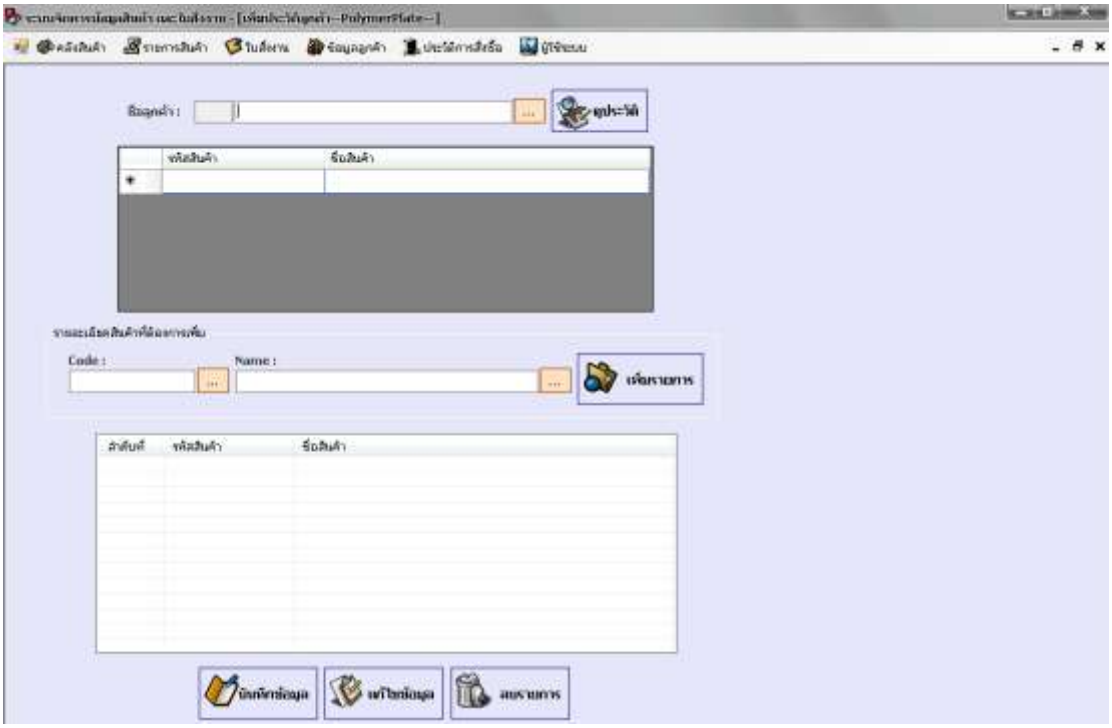


Figure 4-34 Purchase history form

4.6.7.7 User form is the menu that control password editing and new user creating as show in figure 4-35.

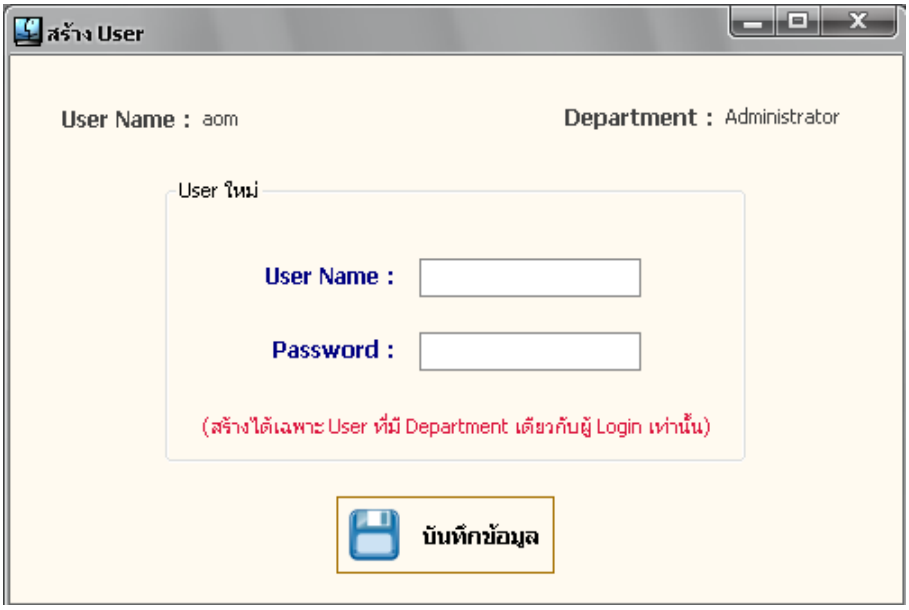


Figure 4-35 User form

4.6.8 Architecture of the new system

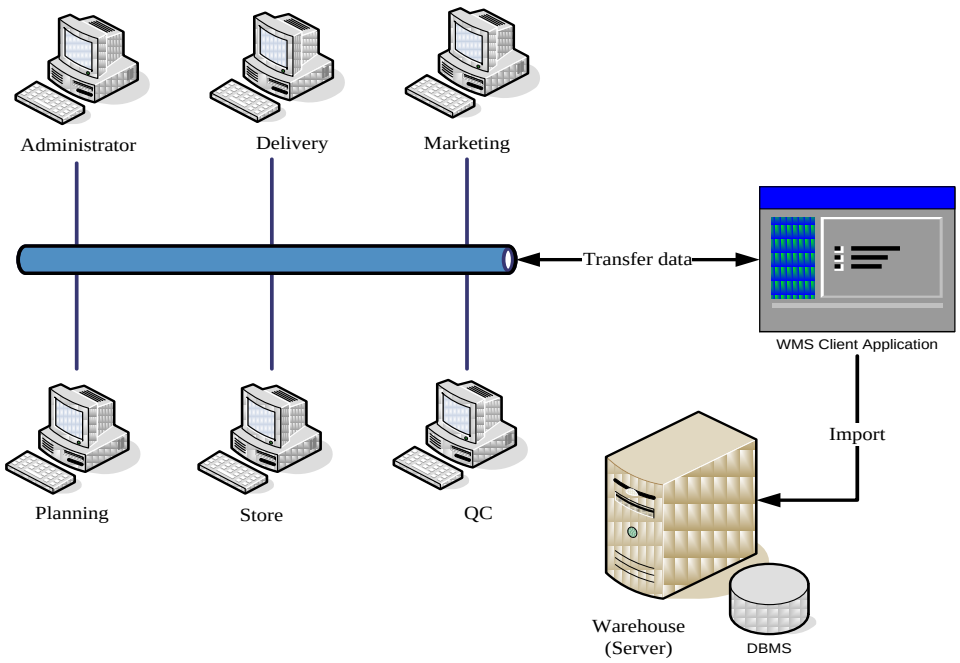


Figure 4-36 Architecture of the new system

Core components of new user architecture that composed:

1) Server function as processing and database collecting of warehouse management system include job order and customer information.

2) Client: every clients are connected by LAN (Local Area Network) to server that fill input and show output information in system

3) Application function as clients and server connection

4) Network: used local area network that help to share the resources together and receiving the utilities.

CHAPTER V
RESULTS

The results of system implementation have been divided into 3 as follows:

5.1 Implementation Result

Mostly the system implementation is to cover the main functions which are shown on the top page of program and are relevant to the Marketing department, Production Planning department, Quality Assessment department, Warehouse department, and Delivery department. Firstly, the system is supported the sales process. The sales representatives would directly be placed the order by phone call, facsimile or face-to-face dealing. And then the product code and details would be checked and filled in the production order generated by the implemented program. The production order will be automatically sent to the related departments by LAN system. Once the production order is checked, the process can be started without any unnecessary steps by Sales department.

5.2 Testing Result

This is to test the system validation and accuracy in accordance with the customer's requirement based on the authentic working environment and data. That is to say the complete IT implementation system is relied on the validity of input data and needed the careful validation. The testing is divided into 3 schemes:

5.2.1 Modules Testing: The separated functions are tested, starting from the data importing, reporting, adding, deleting, editing of data, including to checking the calculation results.

5.2.2 Overall Testing: This process has been done upon the complete system in order to check the full functions of data importing and presenting in written form.

5.2.3 Security Testing: The system security has been implemented to allow the valid users only and set the users' authorization to view the report.

5.3 Result of System Evaluation

This is to analyze and consider the process of the system, called Value Stream Mapping, which is categorized into 3 transactions namely Non Valuable-Added: NVA, Necessary but Non Value Added: NNVA, and Value Added: VA. All transactions are reported and represented the circle of Job Assignment Form and Warehouse Management.

5.1 Implementation Result

On the Log In page of Warehouse Management, the user name and password are required as shown in the figure 5-1. Upon finish log in, the program interface exists and there are 7 sub-modules as shown in the figure 5-2 as below:

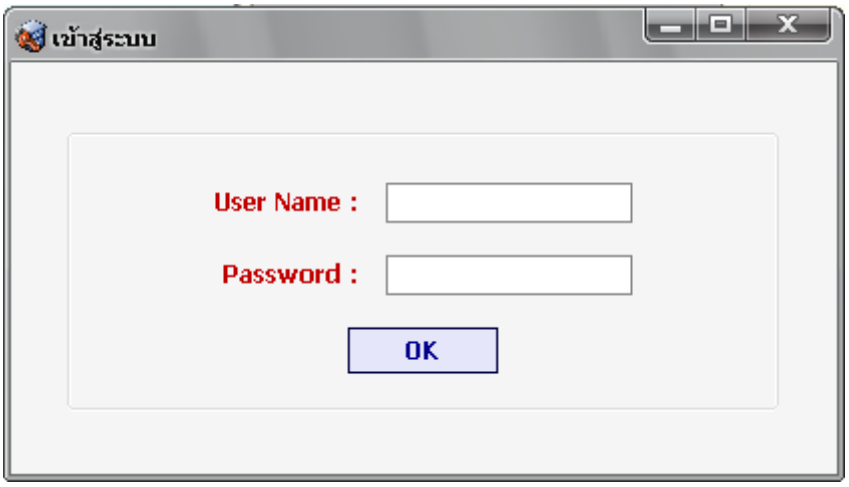


Figure 5-1 Fill in user name and password form

Figure 5-2 Main Program Form

5.1.1 Order Forms

The program is mainly supported and created the Order Form upon receiving the customers' Purchase Order as demonstrated in the figure 5-3.

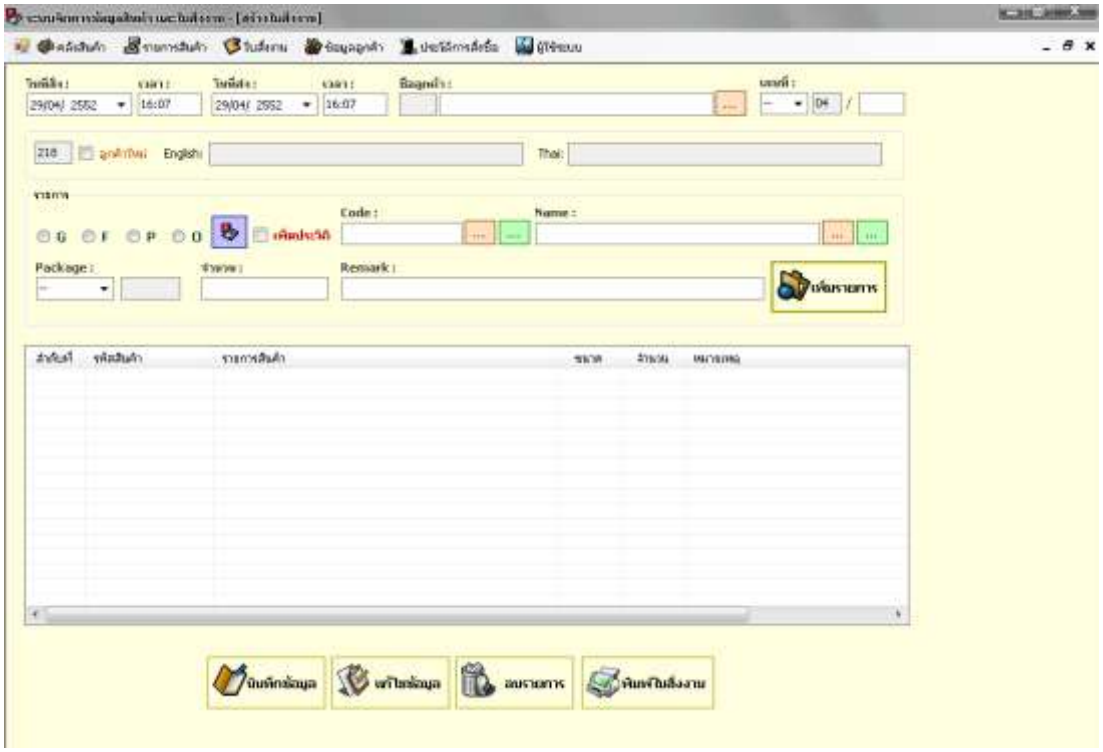


Figure 5-3 Order receipt creation form

For the system of Order Form, the users in each department can directly track on the status of order. As noticed, the status of transaction is categorized by colors for easier checking because the color shades means the level of success. Moreover, the detail of order can be shown as in the figure 5-4.

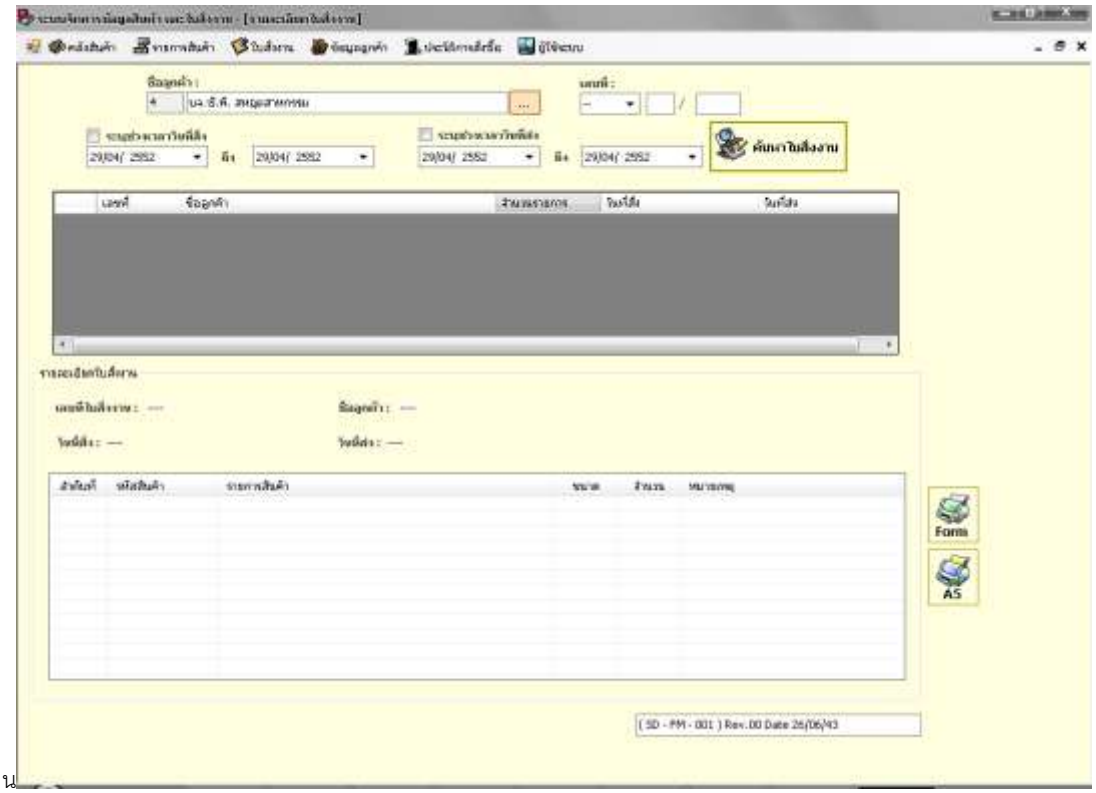


Figure 5-4 Order details form

5.1.2 Product List

All the product lists of the company are gathered by searching the product code or name. The user can add, delete and edit the information of products as show in the figure 5-5 and 5-6.

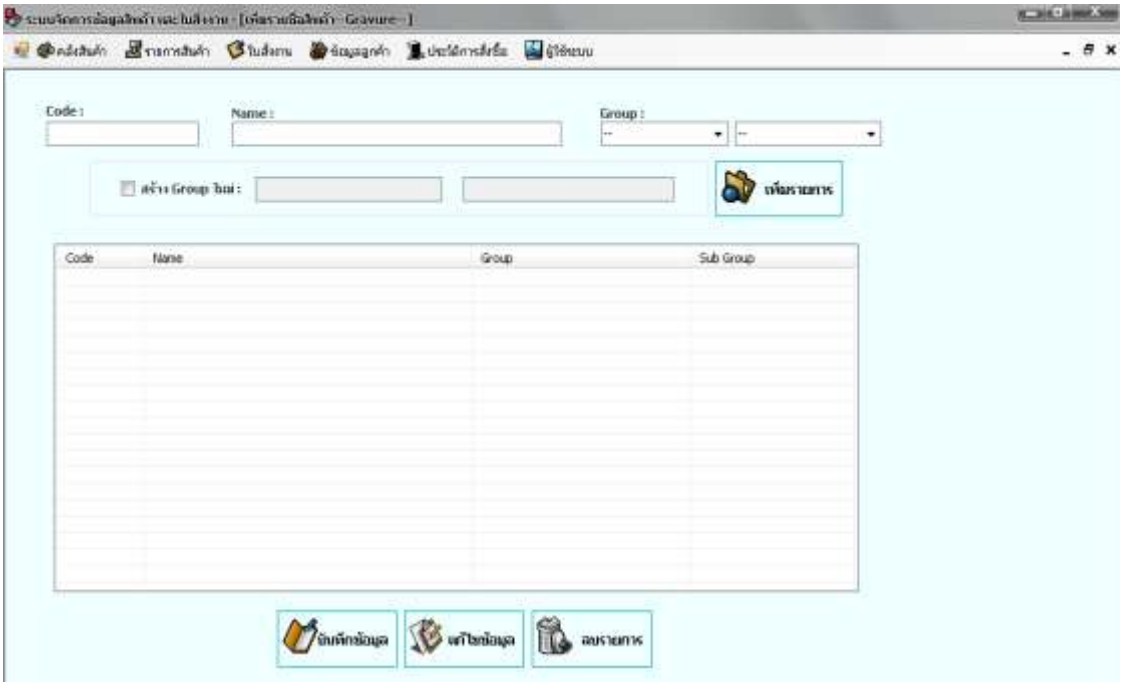


Figure 5-5 Adding product list form

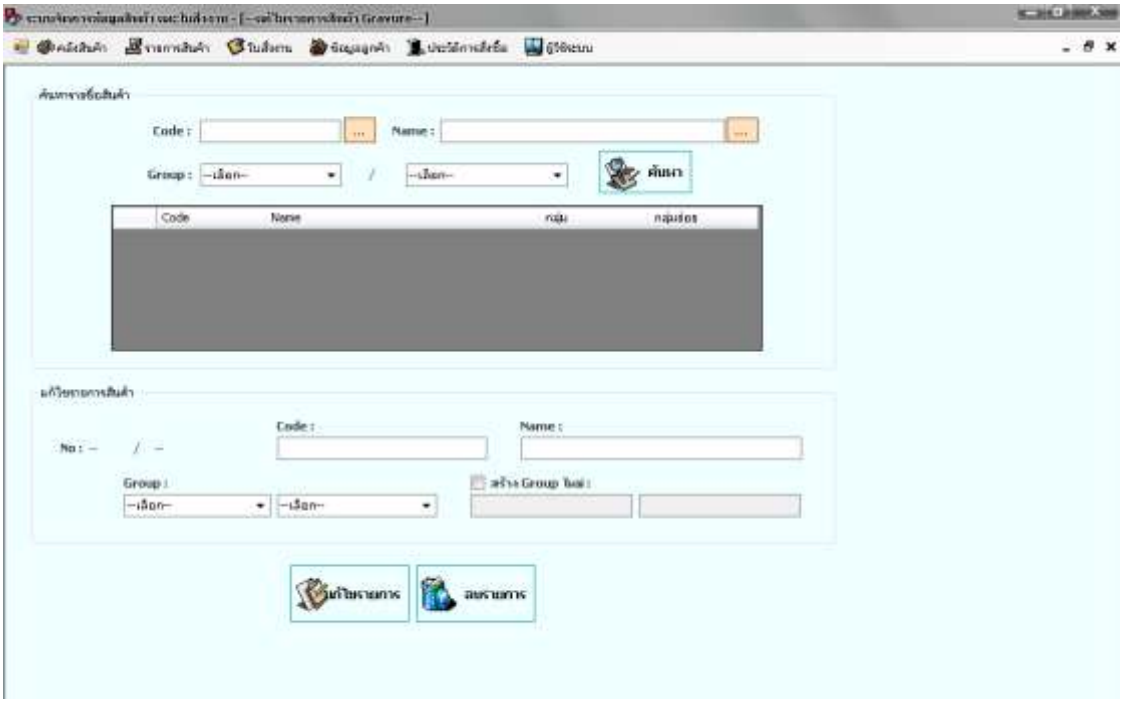


Figure 5-6 Editing product details form

5.1.3 Warehouse

This is to cover the range of product storing, the delivery, the balance checking, the stock-cutting, as well as the product report as shown in the figure 5-7 to 5-11.

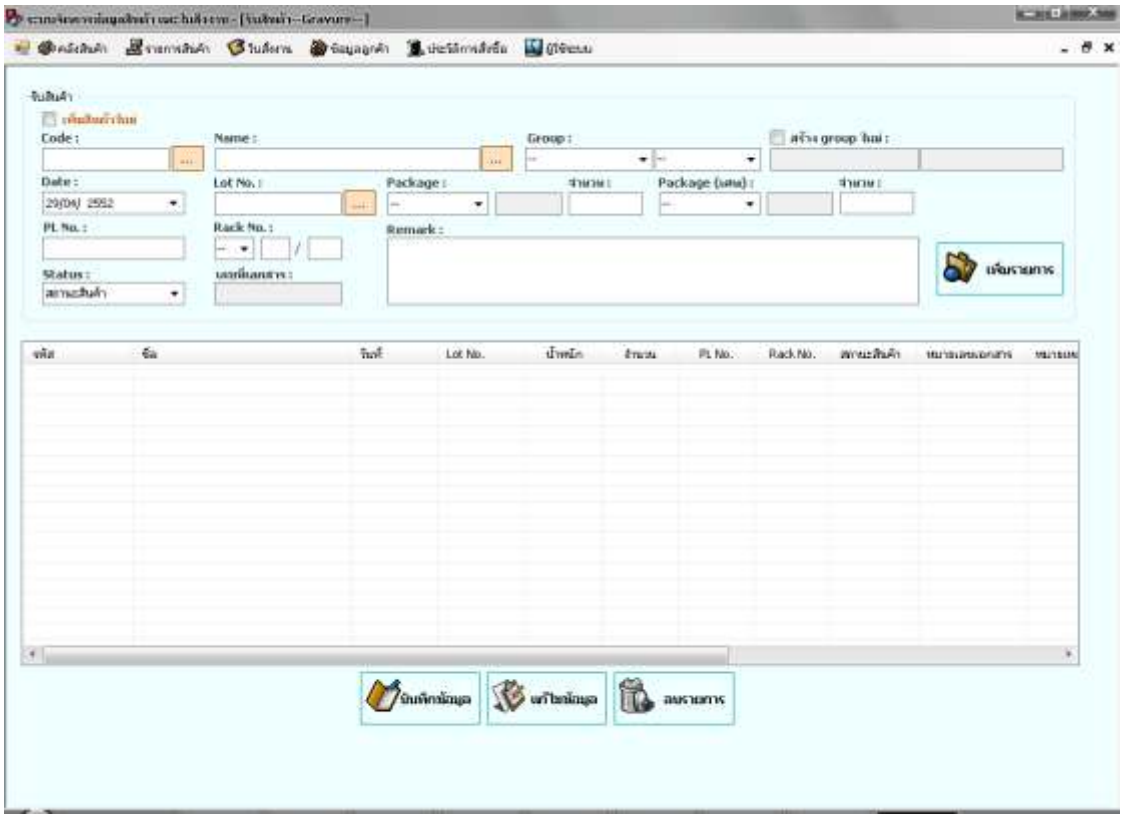


Figure 5-7 Products storing to warehouse form

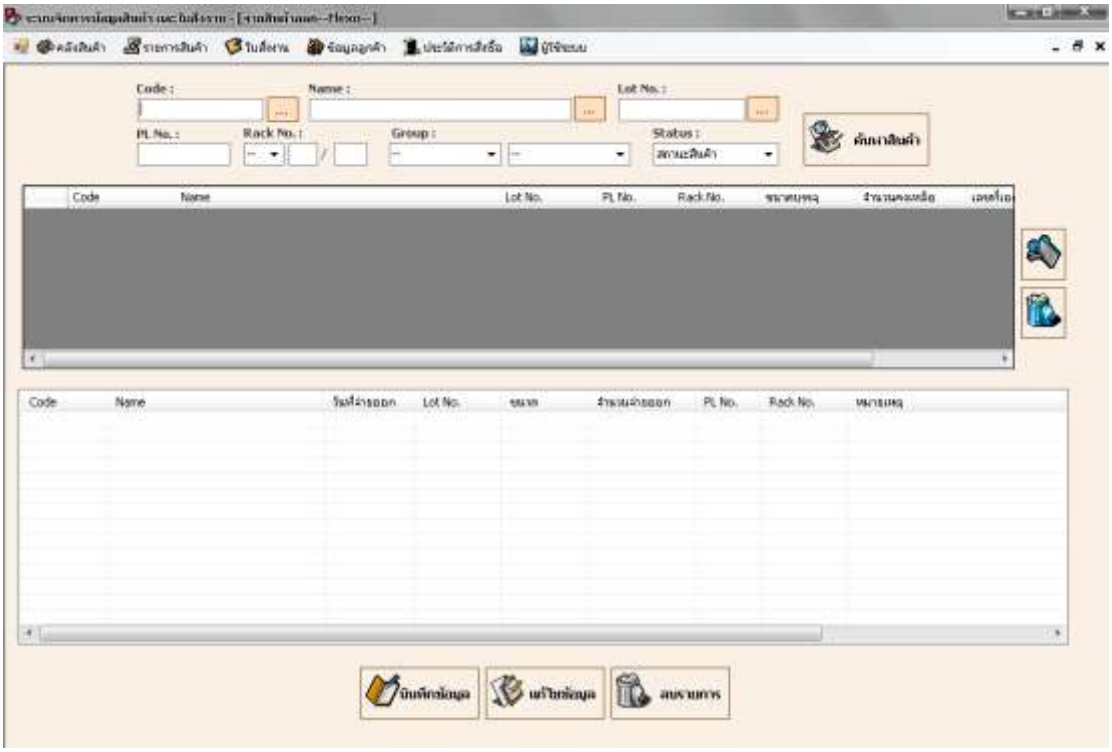


Figure 5-8 Products delivering from warehouse form

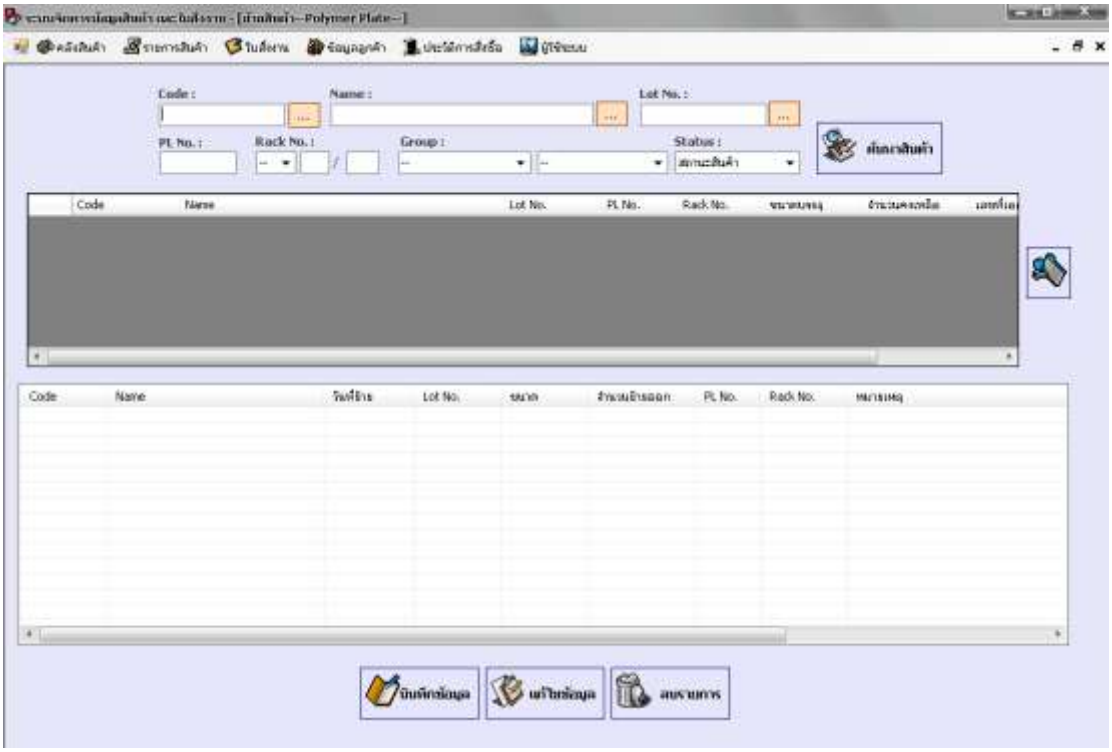


Figure 5-9 Products relocation within warehouse form

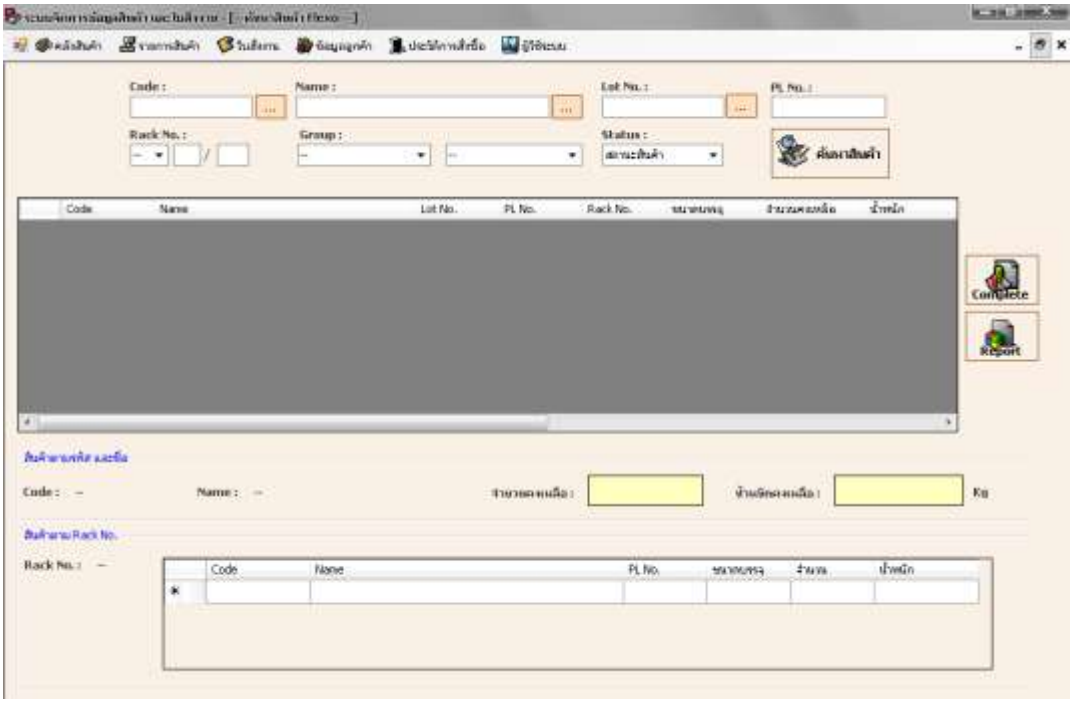


Figure 5-10 Search for products in the warehouse form

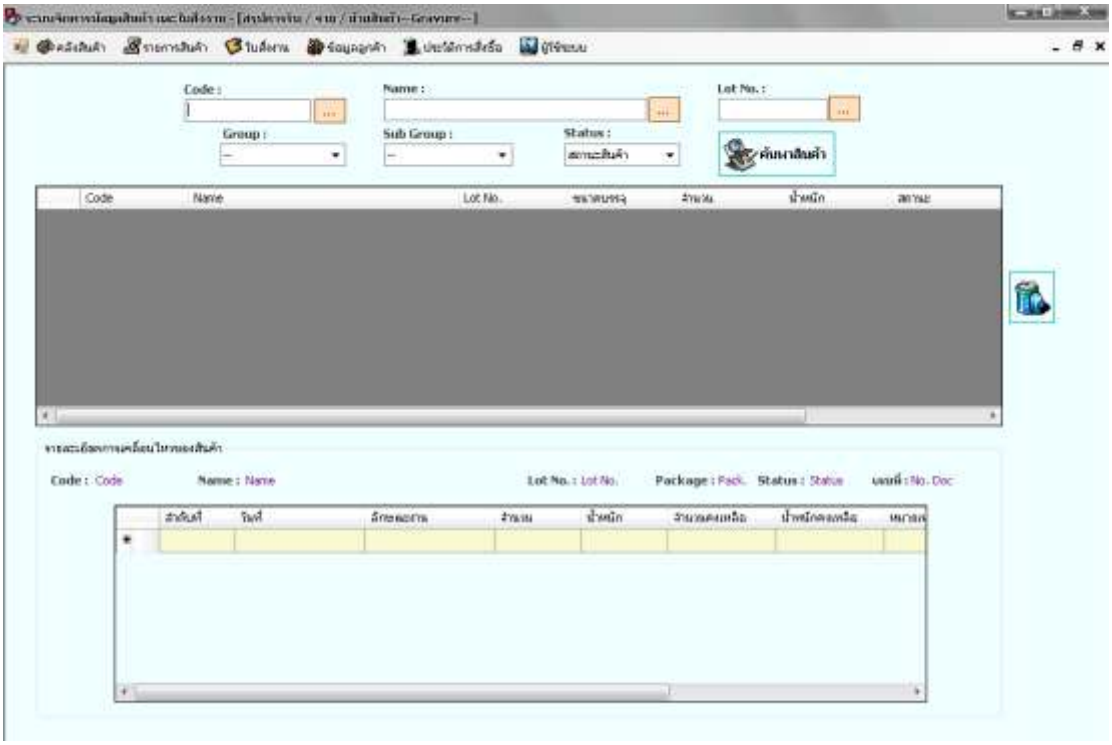


Figure 5-11 Summary of incoming, outgoing and remaining products in the warehouse form

5.1.4 Customer Record

This function is to record the customer's information which can be added, deleted and edit as stated in the figure 5-12 to 5-13.

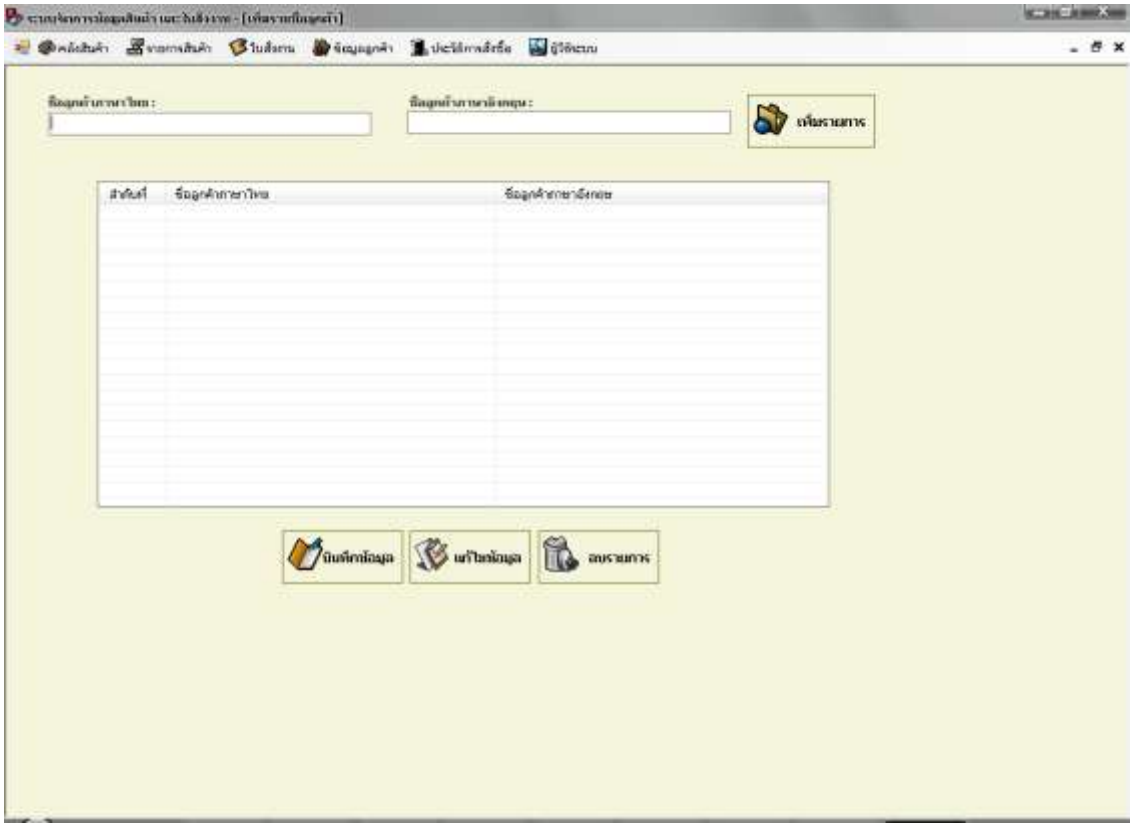


Figure 5-12 Adding customer's information form

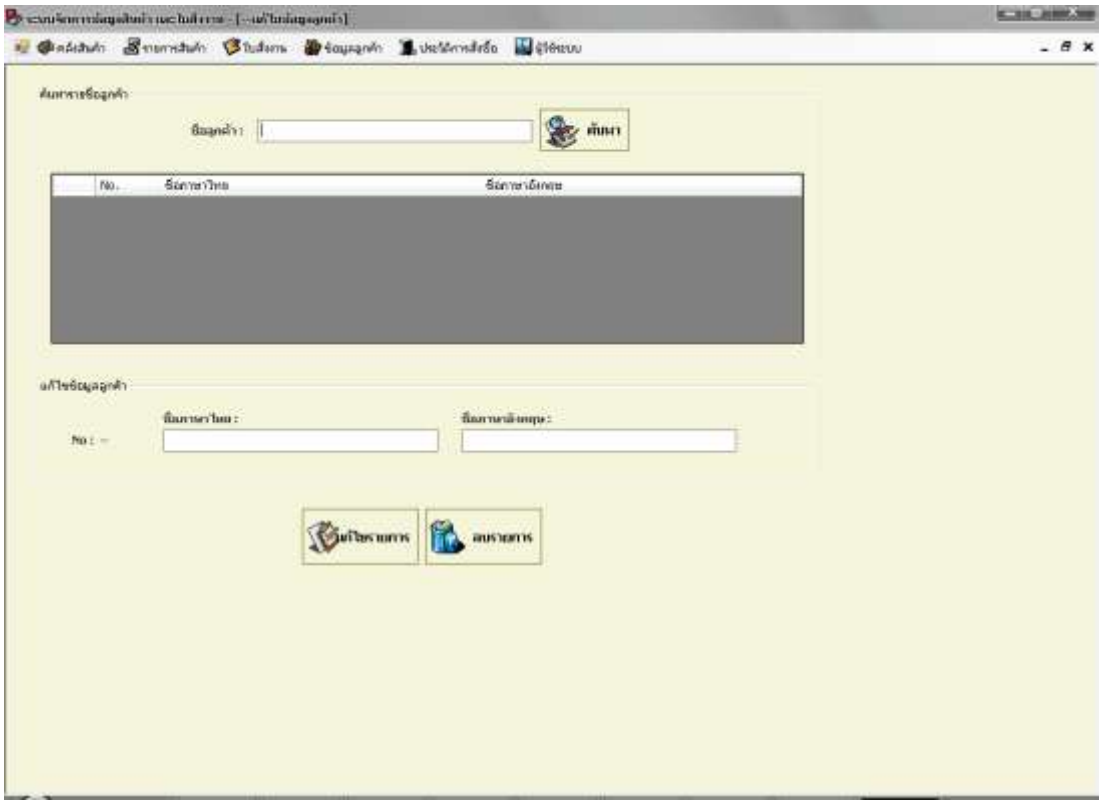


Figure 5-13 Editing customer's information form

5.1.5 Purchasing Record

This function is to record the Purchasing history of the customers' order and transaction which the user can add, delete, edit the order description as shown in the figure of 5-14 to 5-15.

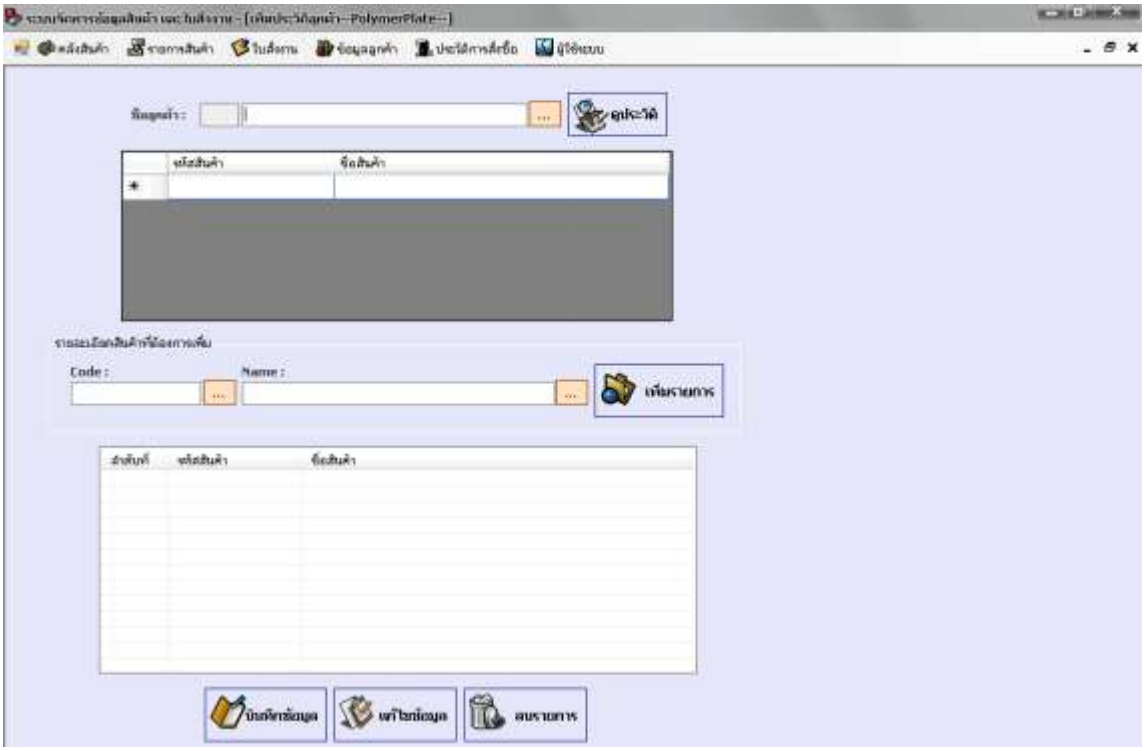


Figure 5-14 Adding the purchasing history of customer form

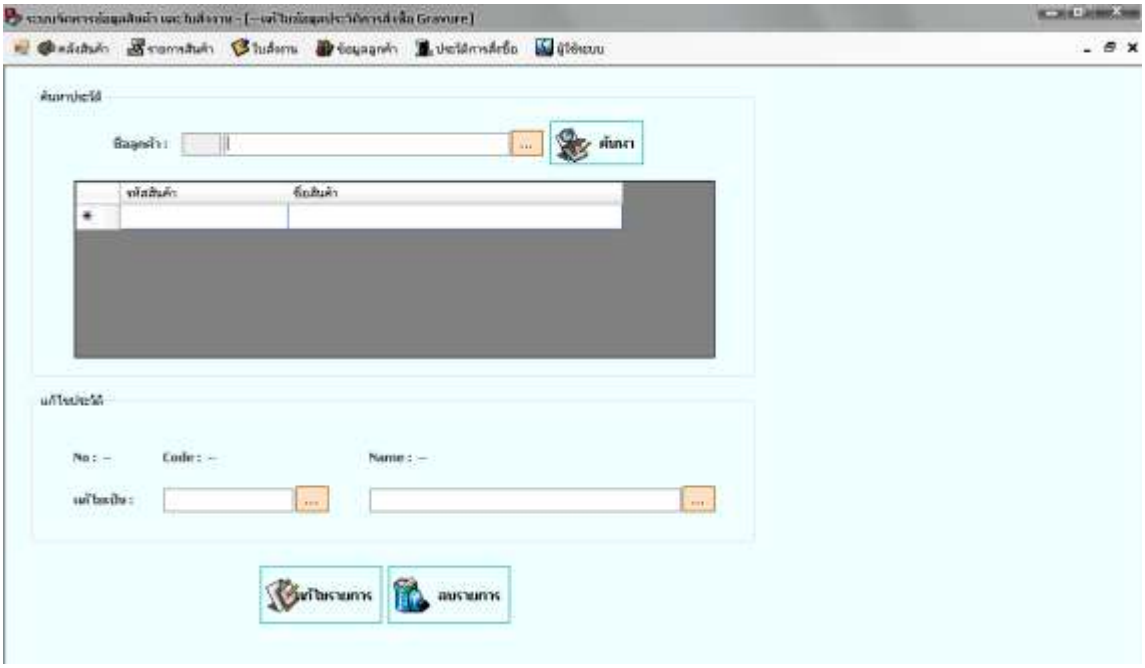


Figure 5-15 Editing the purchasing history of customer form

5.1.6 Report Printing

The user can select to print the report relevant to the sole department. For example, the Warehouse Department can neither print the report of order nor the Production Planning Department can do the product status report. The authority to access and print the report is depended on the business responsibilities as stated below;

5.1.6.1 Marketing Department

Report of Order Acceptance is allowed to print as shown in the figure of 5-16. The user can print by setting the date, document no., product code and product name.

Figure 5-16 Select to print the report of order acceptance form

Upon the printing report of order acceptance, the Marketing Department can also print the product status report as in the figure 5-17 to 5-18.

Figure 5-17 Selecting to print the product status report form

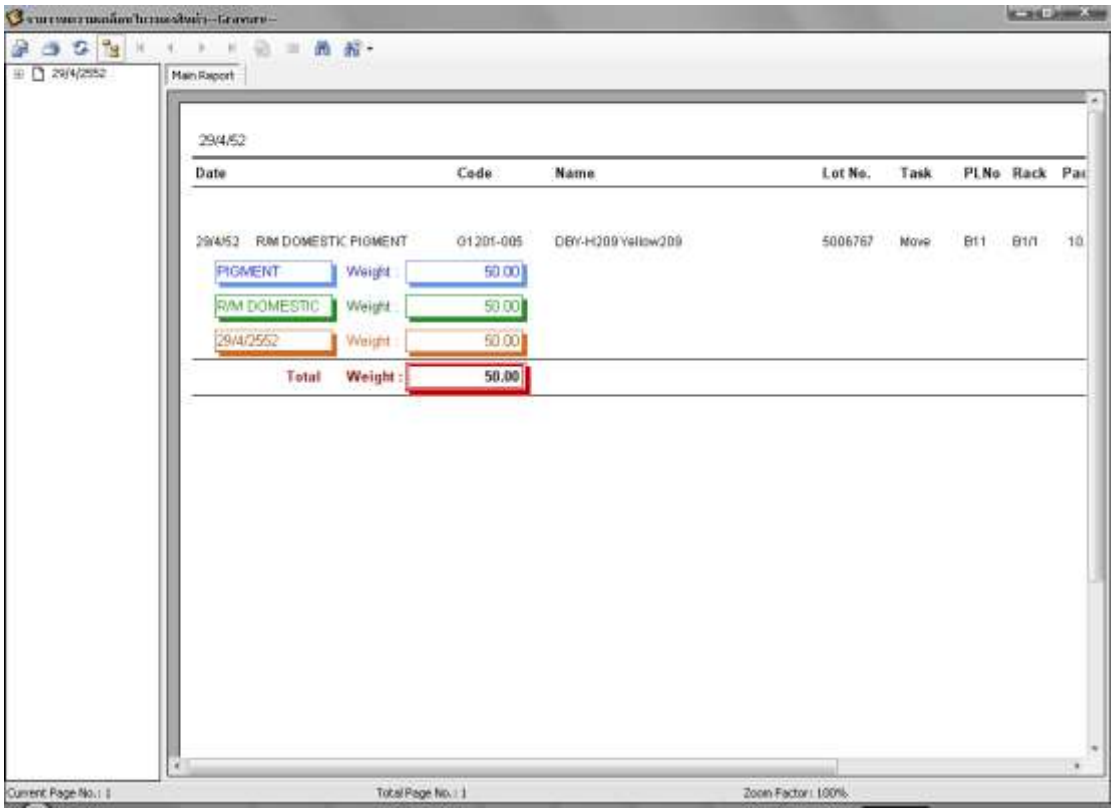


Figure 5-18 Printing the report of product status form

5.1.6.2 Warehouse Department

The department can print the report of product status as same as Marketing Department and report of remaining product by searching with product code, production name, aisles and date as shown in the figure 5-19 and 5-20.

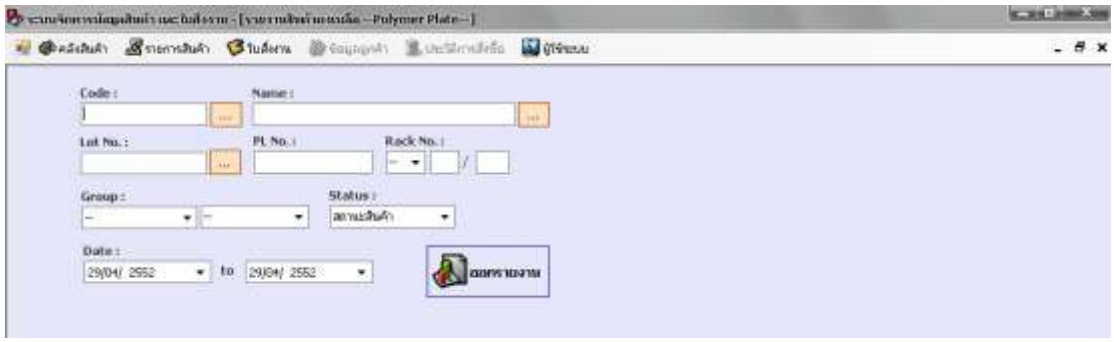


Figure 5-19 Select and print the report of remaining product form

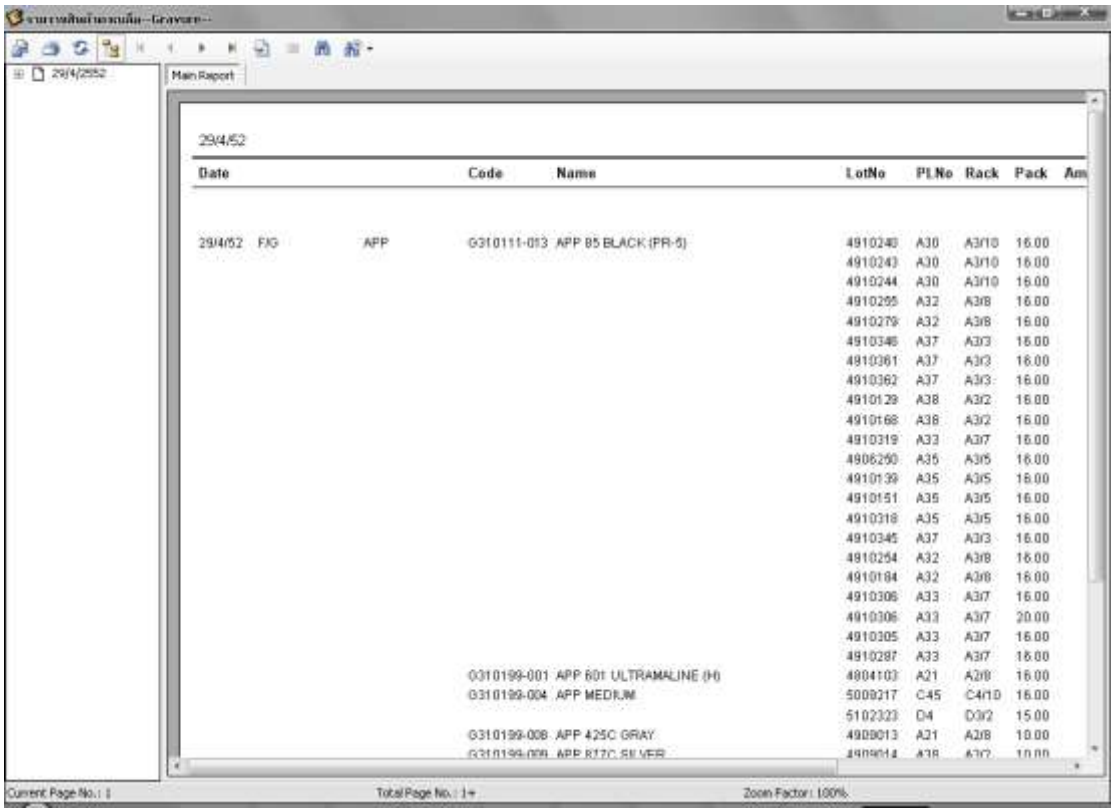


Figure 5-20 Print the report of remaining product form

5.1.6.3 Production Planning Department

The department can print the report of product status as same as Marketing and Warehouse department.

5.1.6.4 Quality Assessment Department

Besides of printing the report of product status as Marketing and Warehouse department, this can also pint the list of products which quality assessment is already done as shown in the figure 5-21.

Figure 5-21 Select and print the report of products passed quality assessment form

5.1.7 User Management

The User Management of the program is very effective since the user in each department is set the operations' authorization and scope of report accessing and printing will be exclusive done by the user of the department. Moreover, user account creating of crossing department is locked. There is also the update report of new user and the password changing shown in the figure 5-22 and 5-23 respectively.

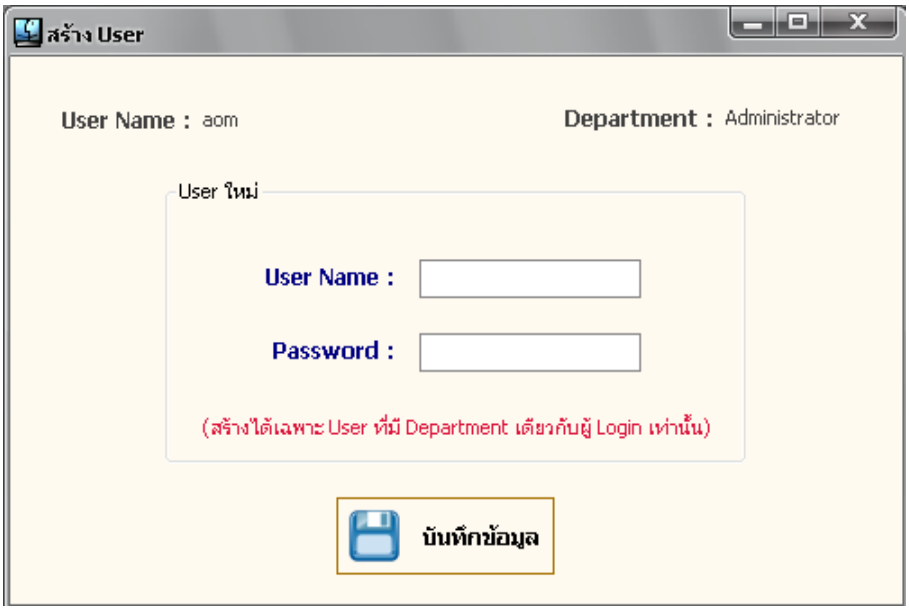


Figure 5-22 Create new user account form

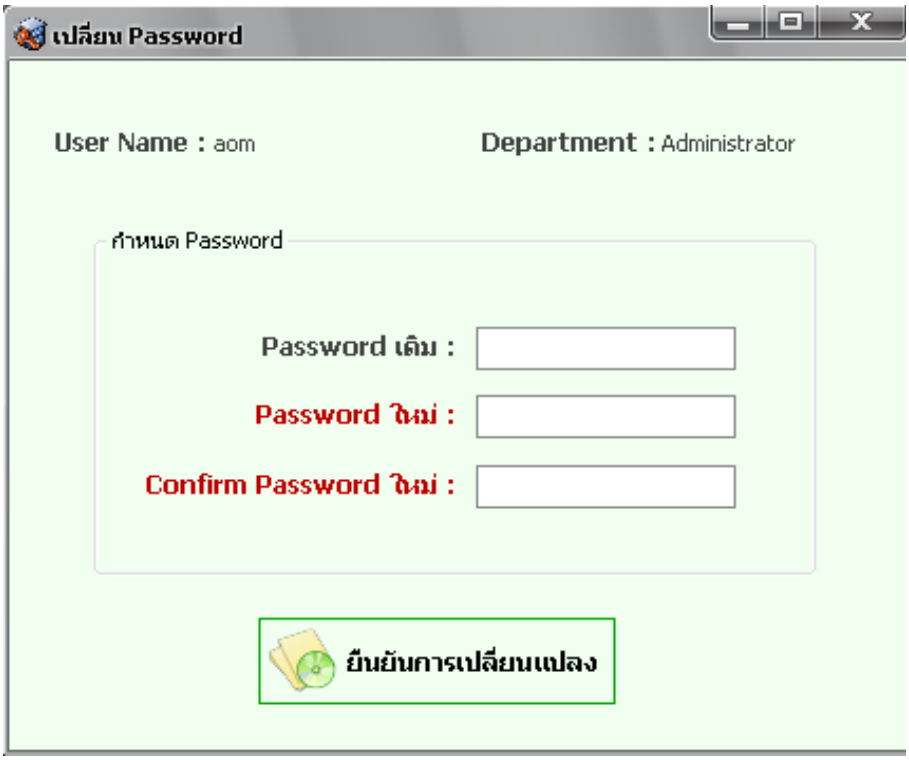


Figure 5-23 Change password form

5.2 Results of System Testing

The authentic data for testing is done by the operator in order to verify the complete of system. This is to certify that the system is able to function the business process accurately and perfectly. The techniques of Beta Testing and Blackbox Testing are done to find the error that maybe happened. The results of system testing are stated as follows;

5.2.1 Log in Testing

This is to test log in process to access the system by filling the User Name and Password. In case of incompletely filling or incorrect information, there is a pop-up message of the failed log in and this will allow only the authorized user as shown in the figure 5-24.

Figure 5-24 Pop-up message shown upon the incorrect User Name and Password

5.2.2 Testing of accessing the warehouse information

In case of incomplete filling the product description or missing the product status, the warning pop-up will be shown as figure 5-25.

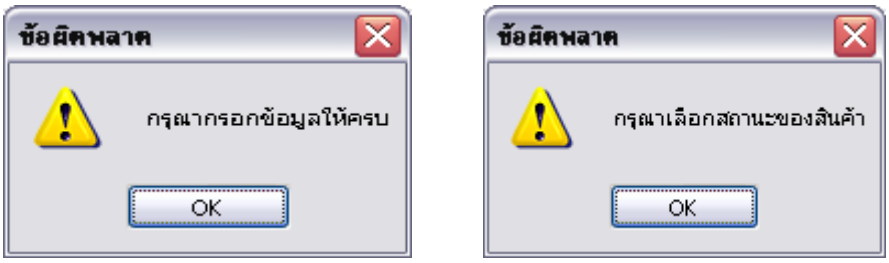


Figure 5-25 Pop-up message shown upon the incomplete information

5.2.3 Testing of editing information

The program can edit the information. Upon finishing the new entry, there is pop-up message said ‘completely save’ as shown in the figure 5-26.

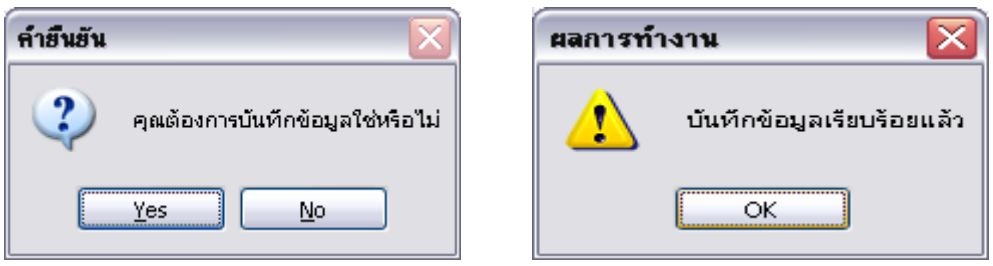


Figure 5-26 Pop-up message shown upon completely editing and saving

5.2.4 Testing of product searching

To search the product information, there maybe search by Lot. No, PL No., Rack No. and the pop-up message show upon the product is not found in the warehouse as stated in the figure 5-27.

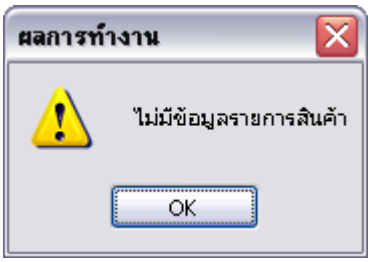


Figure 5-27 Pop-up message shown upon the product not found in the warehouse

5.2.5 Testing the product distributing process

If the product is not specified and the overloaded quantity is required, there is a pop-up message as shown in the figure 5-28. The distribution with unlimited quantity is done if the product lists are the same when storing. Moreover, the program automatically control the distributed quantity if the products' weight or capacity are set.

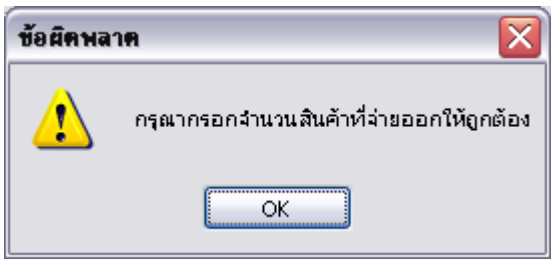


Figure 5-28 Pop-up message shown upon the quantify requirement incorrect

5.2.6 Testing of product relocation

If the relocated product is not stated or the overloaded one is specified, there will be a pop-up message as shown in the figure 5-29. The relocation with unlimited quantity is done if the product lists are the same when storing.

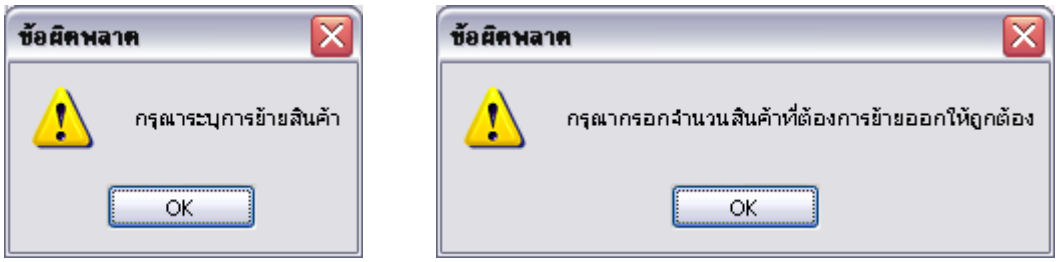


Figure 5-29 Pop-up message shown to specify the relocation and quantities

5.2.7 Testing of product deleting

If the user require to delete the product in the search criteria, click the icon on the right. (The deleting process can be done upon the product quantity zero and none product date is shown in the warehouse database. If the products have been already stocked in the warehouse, the process will be failed as shown in the figure 5-30.

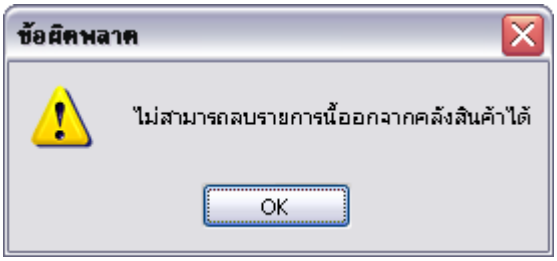


Figure 5-30 Pop-up message shown upon the invalid deleting process

5.2.8 Testing of order searching

If the order cannot be found, the pop-up message would be shown as in the figure 5-31.

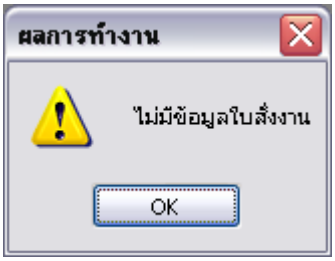


Figure 5-31 Pop-up message shown upon none order found

5.2.9 Testing the order status by Quality Assessment department

The user of Quality Assessment department can search the status of order. If the order status is 'Marketing', to change the status to 'QC' can not be done and there is a pop-up message as 5,35. In order hand, if the status shown "Planning' or 'Store', to change to be 'QC' is be able by clicking to authorize to issue 'CQA' and the pop-up message will be show as 5-32.

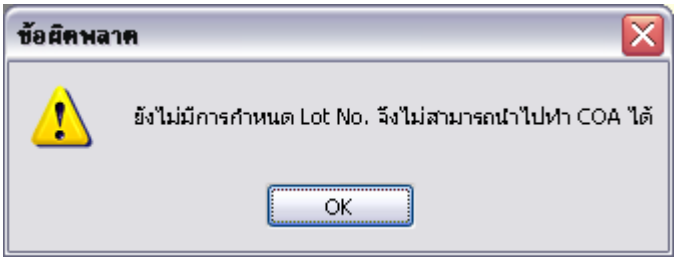


Figure 5-32 Pop-up message shown upon the invalid Lot No. setting

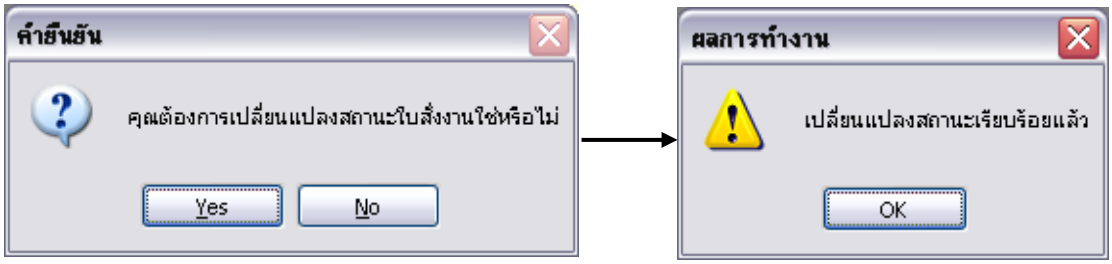


Figure 5-33 Pop-up message shown upon the completely order status changing

5.2.10 Testing of delivery product

Once every department check the status of order and delivery step is already done. The Marketing department will issue the success of product delivery and be shown in the figure 5-34.

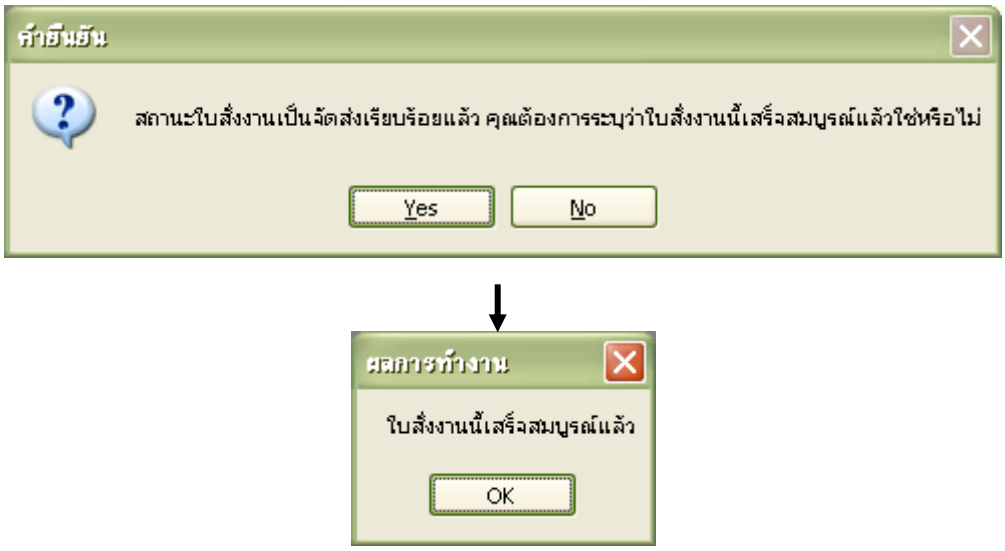


Figure 5-34 Pop-up message to inform the complete of product delivery

5.2.11 Testing the purchasing history searching

In case of searching by not completely filling the customer name, there is not customer information shown and the pop-up message will as below:

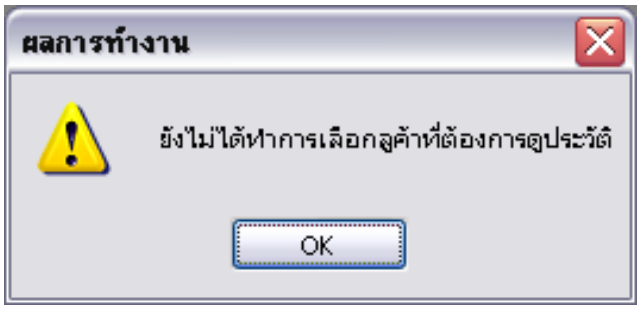


Figure 5-35 Pop-up message shown upon none customer name selected

5.3 Evaluation Results of System Operation

The research is to study and analyze the business procedure in order to implement the IT system for the full-functioned effectiveness of warehouse management. Herewith, the business procedure is analyzed and applied by the Value Stream Mapping concept to consider the fruitful activities which are categorized into 3; namely, activity with Non Value Added: NVA, activity with Necessary but Non Value Added: NNVA, and activity with Value Added: VA. The tangible analysis

tables based on Value Stream Mapping for Ordering Management, Warehouse Management, the Consuming Time of Ordering and Warehouse Management as stated in details in the tables 5-1, 5-2, 5-3 and 5-4 respectively as follows:

Table 5-1 Value Stream Mapping of Ordering Management

Activity	Consuming Time (Minute)	Analytical Activity Value	Remark
1. Marketing Department receives the customers' order.	15	VA	Receipt of customer orders to directly build values for the organization because they resulted in the production volume increase as per the customers' demands.
2. Marketing Department issues the order documentation.	15	VA	Being the activities necessary for the working quality because correct order data entry was required.
3. All relevant departments wait the order documentation issued by Marketing.	60	NVA	Waiting was just time wasting and hence was a useless activity for the organization.
4. Marketing Department submits the order documentation to Planning Department.	10	NNVA	Being the unnecessary but value-increasing activities because the work orders could be sent via the LAN system instead of walking to do so.
5. Planning Department revises the Lot Number.	10	VA	Being the activities that increase values because correct purchase order data had to be designated.
6. Upon revising Lot Number, Planning Department sends the documentation to Store Department.	30	NNVA	Being the unnecessary but value adding activities because the Store Department did not have to wait for the work orders from the Production Planning Department.
7. Upon receiving the order documentation, Store Department runs the cutting stock.	40	VA	Being the unnecessary but value adding activities because correct data had to be filed in for stock dispensing from the warehouse.

Table 5-1 Value Stream Mapping of Ordering Management (cont.)

Activity	Consuming Time (Minute)	Analytical Activity Value	Remark
8. Upon running the cutting stock, Store Department sends the report to Planning Department.	15	NNVA	Being the unnecessary but value increasing activities because the Production Planning Department did not have to wait for the Store Department's stock dispensing data but had to know such operations.
9. Planning Department forwards the lot of products to Quality Assessment Control checking.	15	VA	Being the value increase activities. Once production completion, quality check was needed to add more values for the products and the organization.
10. Quality Assessment Control Department dispatches the products to Distribution Department.	15	NNVA	Being the unnecessary but value adding activities because the Auditing Department had to send the product data by walking to the Delivery Department.
11. Distribution Department informs the product list to Marketing Department.	15	NNVA	Being the unnecessary but value adding activities because the Delivery Department had to submit the product release data to the Marketing Department.
12. Marketing Depart waits the notices of Distribution Department.	30	NVA	Being the unnecessary and non value adding activities because the Marketing Department had to wait till the Delivery Department notified the product delivery status.

Table 5-2 Value Stream Mapping of Warehouse Management

Activity	Consuming Time (Minute)	Analytical Activity Value	Remark
1. Wait the order from Planning Department	30	NVA	Being the unnecessary but non value adding activities because it resulted in waiting for the work orders from the Planning Department.
2. Do the stock cutting	40	VA	Being the necessary but value adding activities because of the product dispensing as per the customers' orders.
3. Inform the stock cutting to Planning Department	15	NNVA	Being the unnecessary but value adding activities because the Production Planning Department did not have to wait for the Store Department's stock dispensing data but had to learn about such movements.
4. Add the product list to Stock	20	VA	Being the necessary and value adding activities because the product entries had to be added and stored in the warehouse.
5. Delete the product list from Stock	20	VA	Being the necessary and value adding activities because some unnecessary product entries had to be deleted from the stock to reduce the data storage space.
6. Set the product's aisles in Warehouse	30	VA	Being the necessary and value adding activities because the product location in the warehouse had to be designated for searching and pickup easiness.

Table 5-2 Value Stream Mapping of Warehouse Management (cont.)

Activity	Consuming Time (Minute)	Analytical Activity Value	Remark
7. Search the product from Warehouse.	60	VA	Being the necessary and value adding activities because product entries had to be searched once the work orders were received from the Production Planning Department so as to prepare the products for the Delivery Department.
8. Wait the process of product dispatch from Warehouse.	20	NVA	Being the unnecessary but non value adding activities because waiting emerged to waste time uselessly.
9. Report the product dispatch from Warehouse.	15	NNVA	Being the unnecessary but value adding activities because all Departments knew the data about the products released off the warehouse via the Warehouse's walking to notify.

Table 5-3 Currently Consuming Time of Order Process

Activity	**Consuming Time (Minute)**	**Percent (%)**
Activity with Non Value Added (NVA)	90	30.00
Activity with Necessary but Non Value Added (NNVA)	85	28.33
Activity with Value Added (VA)	125	41.67
Total	300	100

Table 5-4 Currently Consuming Time of Warehouse Management

Activity	**Consuming Time (Minute)**	**Percent (%)**
Activity with Non Value Added (NVA)	50	20.00
Activity with Necessary but Non Value Added (NNVA)	30	12.00
Activity with Value Added (VA)	170	68.00
Total	250	100

According to the table 5-3, the total consuming time of current order process and warehouse management are 300 and 250 minutes respectively. When implementing the IT management to the business run of warehouse management with the analytical application of Value Stream Mapping, the consuming time outcomes as mentioned process are stated in the tables of 5-5 and 5-6 as below;

Table 5-5 Report of Value Stream Mapping after Implementation of Order Process

Activity	Time Consuming (Minute)	Analysis of Activity Value	Remark
1. Marketing Department receives the customers' order.	15	VA	Receipt of the customers' purchase orders builds direct values for the organization because it causes production value increase as per the customers' demands.
2. Marketing Department issues the order documentation.	15	VA	Being the activities necessary to working quality because the correct purchase order data have to be filled in.
3. All relevant departments wait the order documentation issued by Marketing.	5	NVA	Waiting just wastes time and hence is a useless activity for the organization.
4. Marketing Department posts the status of order receiving online and the relevant departments will be informed.	1	NNVA	Being the unnecessary but value adding activities because the Marketing Department does not have to display the order receipt status to all Departments but all Departments should know it from the system.
5. Planning Department posts the revision of Lot Number and online.	10	VA	Being the necessary and value adding activities because correct purchase order correction is needed.
6. When the Store receives the order and runs the stock cutting, the other departments can directly check without waiting the written report.	20	VA	Being the necessary and value adding activities because the system must dispense the products from the stock immediately after work order status checking.

Table 5-5 Report of Value Stream Mapping after Implementation of Order Process (cont.)

Activity	Time Consuming (Minute)	Analysis of Activity Value	Remark
7. When the products completely packed, Quality Assessment Control Department can continue the process.	15	VA	Being the necessary and value adding activities because product quality check is needed after the production finish.
8. Upon checking, Quality Assessment Control Department will forward the products to Distribution Department.	5	NNVA	Being the unnecessary but value adding activities because the Auditing Department has to walk to the Delivery Department so as to send the product data.
9. Distribution Department reports to product delivery to Marketing Department.	5	NNVA	Being the unnecessary but value adding activities because the Delivery Department has to walk to the Marketing Department to notify the product release data.

Table 5-6 Report of Value Stream Mapping after Implementation of Warehouse Management

Activity	Consuming Time (Minute)	Analytical Activity Value	Remark
1. Wait the order from Planning Department	5	NVA	Being the unnecessary but non value adding activities because it resulted in waiting for the work orders from the Planning Department.
2. Do the stock cutting	20	VA	Being the necessary but value adding activities because of the product dispensing as per the customers' orders.
3. Inform the stock cutting to Planning Department	5	NNVA	Being the unnecessary but value adding activities because the Production Planning Department did not have to wait for the Store Department's stock dispensing data but had to learn about such movements.
4. Add the product list to Stock	5	VA	Being the necessary and value adding activities because the product entries had to be added and stored in the warehouse.
5. Delete the product list from Stock	2	VA	Being the necessary and value adding activities because some unnecessary product entries had to be deleted from the stock to reduce the data storage space.
6. Set the product's aisles in Warehouse	2	VA	Being the necessary and value adding activities because the product location in the warehouse had to be designated for searching and pickup easiness.

Table 5-6 Report of Value Stream Mapping after Implementation of Warehouse Management (cont.)

Activity	Consuming Time (Minute)	Analytical Activity Value	Remark
7. Search the product from Warehouse.	1	VA	Being the necessary and value adding activities because product entries had to be searched once the work orders were received from the Production Planning Department so as to prepare the products for the Delivery Department.
8. Wait the process of product dispatch from Warehouse.	20	NVA	Being the unnecessary but non value adding activities because waiting emerged to waste time uselessly.
9. Report the product dispatch from Warehouse.	5	NNVA	Being the unnecessary but value adding activities because all Departments knew the data about the products released off the warehouse via the Warehouse's walking to notify.

Using an analytical value stream mapping process to compare the time spent before and after the implementation of the order process and warehouse management, it was found that before implementation of the new system, it took 5 hours to process a purchase order through the order system and merely 1.31 hours, after implementation which was a reduction in time of 69.70%. For the physical movement of product in the warehouse, it took 4.10 hours before implementation of the new system and 1.05 hours after implementation, which was a reduction in time of 74.00%. All of these results of comparable consuming time are shown in the table 5-7 and 5-8.

Table 5-7 Comparable Time Consuming before and after Implementation of Order Process

Activity	Consuming Time before Implemented (Minute)	Consuming Time after Implemented (Minute)	Difference of Consuming Time before and after Implemented (Minute)
Activity with Non Value Added (NVA)	90 (30.00%)	5 (5.50%)	Reducing 85
Activity with Necessary but Non Value Added (NNVA)	85 (28.33%)	11 (12.09%)	Reducing 74
Activity with Value Added (VA)	125 (41.67%)	75 (82.41%)	Reducing 50
Total	300 (100%)	91 (100%)	Reducing 209 (69.70%)

Table 5-8 Comparable Time Consuming before and after Implementation of Warehouse Management

Activity	Consuming Time before Implemented (Minute)	Consuming Time after Implemented (Minute)	Different Consuming Time of before and after Implemented (Minute)
Activity with Non Value Added (NVA)	50 (20.00%)	25 (38.45%)	Reducing 25
Activity with Necessary but Non Value Added (NNVA)	30 (12.00%)	10 (15.40%)	Reducing 20
Activity with Value Added (VA)	170 (68.00%)	30 (46.15%)	Reducing 140
Total	250 (100%)	65 (100%)	Reducing 185 (74.00%)

CHAPTER VI
DISCUSSION

Subject to the analysis of business procedure by implementing the information technology system for warehouse management, the important results would be discussed as follows;

6.1 System Analysis and Design

6.2 Information Technology System Customization for Warehouse Management

6.1 System Analysis and Design

Warehouse Management System is implemented to function a range of business transactions in the case study company. The research has studied the existing problems and proposed the fine-tune solution with the implemented IT system. Firstly, the company faced the miscommunication or inconsistent data transferring between the departments which was caused to the business lost and delay. Therefore, the implementation of data networking through LAN has been performed. That is to say the developed system is not simply to control the warehouse but to cover and monitor the business stages starting from the purchase order receiving and task allocating to the other relevant departments.

However, the Warehouse Management System is still restricted as it cannot limit the volume of the products to be stored on racks and cannot control the accounting system. Those limitations are in line with the agreement made between the system users and the system developer. The case study firm hence should utilize the system/software that can cover all activities arising therein such as having the systems that control the accounting, the production scheduling, the production planning, etc. so that all operating processes can reach maximum efficiency, cut down documentary volume and build conveniences and fastness. The ERP (Enterprise Resource Planning) is another option that can ease and increase the efficacy of the operating procedures of

the case study firm. The ERP system is an IT system that helps facilitate every business process for all offices of the organization. That is, it can integrate the data of every process and office into the central single database, which accordingly cuts down the working time and the working redundancy, the errors and disputes that may arise owing to the communication inside the organization or with external ones. The ERP system directly uses the limited resources in every business process for maximum benefits.

6.2 Information Technology System Customization for Warehouse Management

It is found that there is rarely full-functional advantage of IT system for Warehouse Management in the case study company because the personnel lack of IT comprehension. For example, the staff will directly take the products from the aisles without any systematically informed or reported note, the other departments would absolutely miss the up-to-date product availability. This is disagreeable to Ernst F. Bolten's Managing Time and Space in The Modern Warehouse. If the store staff have the insufficient knowledge and concept of warehouse management, it is impossibly applied the IT system to support the warehouse operation. The company, therefore, is to acknowledge and train the staff on the warehouse management and practices, including to the related business matter like logistics system, principle of customer service, etc. This maybe say that the company need to organize the best-practice training system, starting from the company policy or business plan, survey of interesting training topics, training plan, training organization, and training evaluation, which are related to Wechayan Kitakomol's Training System. Furthermore, the company is necessary to carry out the evaluation of working performance as an individual personnel and teamwork. To focus on financial incentive is not related to Kaplan and Norton's Research of Balance Score Card (BSC), or a stereotype of the organizational-success measurement.

Besides of the warehouse staffs, the company may lack of the Warehouse Management System Implementer who be a mastery and suggests the beneficial knowledge of IT system. Therefore, the company should recruit the effective personnel mastered on IT knowledge of warehouse management. According to Titipat

Pitchayatadang's Research on Personnel Recruitment with Competency Based Interview, it is said that to assign and authorize the versatile IT and warehouse management knowledge implementer is maximally effective operation to the organization.

According to Thomas P. Dullinane, Jame A. Tompkins and Jerry D. Smith's How to Plan and Manage Warehouse Operation, the warehouse operations manual is required for the effective warehouse management. Nevertheless, the case study company neither lacks of warehouse manual nor manages the product storing. That is to say when there is no warehouse management expert; unsurprisingly, the product storing, aisle setting and labeling, maybe incomplete and inconvenient to the routine working. Therefore, the product classification is firstly done for the warehouse management.

CHAPTER VII
CONCLUSION AND RECOMMENDATION

The purposes of the research are to design and develop information technology system for warehouse management, including to increase the optimization practice of business process with the network operation and user friendly system. The program is implemented in Thai menu for comprehensive usage, effective system security, as well as the authorization to access the data. In this chapter, the conclusion and suggestion are herewith proposed as follows;

7.1 Conclusion

7.1.1 Conclusion of System Implementation

To accomplishment the analysis of business procedure by implementing the information technology system for warehouse management, the researcher has developed the program to operate the order and warehouse management. For the case study of an authentic business-run company with non IT practice, there are disadvantages and problems such as the overused paper-based documentation, the data or report missing, inconsistent-crossing and delayed operation between departments, etc., which cause and block the organization's working efficiency. Therefore, the implemented system is fundamentally applied IT practice to control the work line and collect the data. The system outcome does not merely accelerate the working effectiveness and standard, but also support the more advanced system in the future. The system potentialities and functions are described as follows:-

7.1.1.1 Create, check and edit the work order;

7.1.1.2 Record, monitor the product status, add, delete and edit the product information, store, relocate and distribute the product from warehouse;

7.1.1.3 Add, delete, and edit the customer's purchasing record;

7.1.1.4 Add, delete, and edit the customer's information;

7.1.1.5 Print the reports of products, customer, and order;

7.1.1.6 Monitor and check the products in the warehouse;

7.1.1.7 Authorize user's responsibility for printing report and checking order status;

7.1.2 Conclusion of System Testing

The testing is based on the real data and the system is tested by the environmental user in order to confirm the complete of system functions. The techniques of Beta testing and Blackbox are used to find the system error which is probably happened. The testing is found that there would be the pop-up message every time upon the misleading step by user, incorrect information, and transaction results of unavailable data in the system.

7.1.3 Conclusion of System Evaluation

As applied the IT system for warehouse management in the case study company, it is found that the overall transaction time is reduced because the Marketing Department can directly key in the customer's order into the program and confirm the appointed delivery supported by up-to-date production monitoring in the warehouse and production timeline. Moreover, the other departments can view the customer's order details. Importantly, the Marketing Department can monitor product status all the time and manage the production plan upon ordered effectively. Using an analytical value stream mapping process to compare the time spent before and after the implementation of the order process and warehouse management, it was found that before implementation of the new system, it took 5 hours to process a purchase order through the order system and merely 1.31 hours, after implementation which was a reduction in time of 69.70%. For the physical movement of product in the warehouse, it took 4.10 hours before implementation of the new system and 1.05 hours after implementation, which was a reduction in time of 74.00%.

7.2 Recommendation

7.2.1 As the report of product list and its location upon the new storing or borrowing, the program should calculate and show the order of shortest distance to the product aisles in the further research;

7.2.2 The program should provide the delivery order by rating the shortest route and mostly save time;

7.2.3 Based on the provided report, the user and executive board of company may have further requirement. The advanced implementation should fulfill the tailor-made requirement e.g. data processing and report printing;

7.2.4 The program should be implemented to support the increasing data in the future.

7.2.5 The case study firm can use the ERP system for its integrative operations that start from purchasing, employment and contracting, sale, accounting and finance and human resource management. The work of each part is connected by the material and informational flows, has the data management system that gives out the best results of the integrative activity management and immediately learns of the working situation and problems. Such capabilities help build fast decision making towards solutions to corporate problems.

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APPENDIX

DATA DICTIONARY

Table Structure of Customer

Attribute	Description	Type	Key	Reference
No_cus	ID customer	int(4)	PK	
NameEng	Customer name Eng	nvarchar(50)		
NameThai	Customer name Thai	nvarchar(50)		

Table Structure of Product

Attribute	Description	Type	Key	Reference
No_Pro	Sequence of product	int(4)		
Code_Pro	Code of products	numeric(10)	PK	
Name	Product name	nvarchar(40)		
Group_name	Name of product group	nvarchar(40)		
Group_subname	Name of product subgroup	nvarchar(40)		
No_Type	Code type	numeric(10)	FK	Type_of_Product
No_Task	Job code	numeric(10)	FK	Task
No_Lot	Code of productions Lot	numeric(20)	FK	LotNo

Table Structure of Type_of_Product

Attribute	Description	Type	Key	Reference
No_Type	Code type	numeric(10)	PK	
Name_type	Name of product type	nvarchar(40)		

Table Structure of Task

Attribute	Description	Attribute Domain	Type	Key	Reference
No_Task	Sequence of work		numeric(5)	PK	
No	Job code	1 = receive 2 = distribute 3 = move	numeric(1)	PK	
Task	Job description		nvarchar(100)		
Date	Date of work		datetime(5)		
Amount	Quantity of work		numeric(5)		
AmountRemain	Of the rest		numeric(5)		
Remark	Remark		nvarchar(40)		
No_Re	Report code		numeric(10)	FK	Report

Table Structure of Order

Attribute	Description	Type	Key	Reference
OrdersCode	Order code	numeric(10)	PK	
Type	Type of report	nvarchar(10)		
Month	Month of order	numeric(2)		
Year	Year of order	numeric(2)		
NoList	Sequence of order	numeric(3)		
DateIn	Date of order	datetime(5)		
DateOut	Date of delivery	datetime(5)		
Process	Work order status	nvarchar(30)		
No_Cus	Customer ID	numeric(10)	FK	Customer
Code_Pro	Code of products	numeric(10)	FK	Product

Table Structure of History

Attribute	Description	Type	Key	Reference
No_His	Sequence of order history	numeric(10)	PK	
No_Cus	Customer ID	numeric(10)	FK	Customer
Code_Pro	Code of products	numeric(10)	FK	Product
OrdersCode	Order code	numeric(10)	FK	Order

Table Structure of User

Attribute	Description	Type	Key	Reference
No_User	No. users	numeric(10)	PK	
UserName	User name	nvarchar(10)		
Password	Password	nvarchar(10)		
Department	Department	varchar(30)		

Table Structure of LotNo

Attribute	Description	Type	Key	Reference
No_Lot	Sequence of production	numeric(10)	PK	
Date	Date of receive product	datetime(5)		
LotNo	Code of productions Lot	numeric(20)		
Package	Package	numeric(3)		
Amount	Production amount	numeric(3)		
Numdoc	ID document	numeric(10)		
Status	Product status	numeric(10)		
No_Loc	Code of location	numeric(10)	FK	Location

Table Structure of Location

Attribute	Description	Type	Key	Reference
No	Sequence of receive product	numeric(10)	PK	
No_Loc	Code of location	numeric(10)	PK	
Date	Date of receive	datetime(5)		
PLNo	Pallet number	numeric(5)		
RackNo	Rack number	numeric(5)		
Amout	Quantity of work	numeric(5)		
AmountRemain	Of the rest	numeric(5)		
No_His	Sequence of order history	numeric(10)	FK	History
Code_Pro	Code of products	numeric(10)	FK	Product

Table Structure of Report

Attribute	Description	Type	Key	Reference
No_Re	Report code	numeric(10)	PK	
Date	Date of report	datetime(5)		
ImpDate	Date of work	datetime(5)		
ExpDate	Date of print	datetime(5)		
Code_Pro	Code of products	numeric(10)	FK	Product
No_Task	Sequence of work	numeric(10)	FK	Task
No_Lot	Sequence of production	numeric(10)	FK	LotNo
No_Loc	Code of location	numeric(10)	FK	Location

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