Warehouse Management Software Development

by

Mr. Ha Manh Quan

A Final Report of the Three-Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
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Academic Year	March 2005

The Graduate School of Assumption University has approved this final report of the three-credit course, CE 6998 PROJECT, submitted in partial fulfillment of the requirement for the degree of Master of Science in Computer and Engineering Management

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ABSTRACT

The objective of this project is to create and develop a warehouse management system in order to improve the efficiency of the existing system and provide an effective computerized system for warehouse staff and warehouse manager.

The existing system operation is based on both the manual and some computerized systems. Some data are stored on hardcopy, while some are kept in file (like excel). It takes time in order to inquire information. Human errors caused a great deal of incorrect data problems.

The proposed system will be developed to place the existing system. All data are kept in Paradox database and supported by barcode technology combined with pictures to eliminate all kinds of error in identification and recognition. The user interface is designed for the users to do their works easily and conveniently.

Cost justification of the proposed system was seriously considered in all kinds of warehouse activities such as receiving, put-away process, picking/packing, checking, replenishment and so on… to save the cost by at least 30 %.

Implementation required a cooperation of all involved parties to make software work smoothly and effectively in warehouse system. Testing is done by programmer and involved persons to make sure that all functions of the system work properly. Training and documentation are necessary and important for user to avoid unexpected situations. The result showed that all the performances of warehouse management activities are improved such as stock checking, receiving/put-away process and so on…

Finally, there are several ideas and technologies that WMS has to consider to improve in flexibility and effectiveness such as Web-base technology, product reservation ability …

ACKNOWLEDGEMENTS

Several people have made contributions to this project. The writer would like to acknowledge their efforts and thank them for their contributions.

He would like to thank Dr.Chamnong Jungthirapanich, his project advisor, for his valuable suggestions and advice given for the preparation of this project.

He extends his sincere thanks to Mr. Peter Johansson – Director's Tellus Company Limited– for his timely assistance and information provided to the writer while carrying out the data collection required for his project.

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I. INTRODUCTION

1.1 Background of the Project:

Nowadays many small to medium companies either still do not know how to effectively manage their stock, or how to organize warehouse activities for better standardization and productivity. So that I chose "developing the warehouse management software (WMS)" as my project topic.

WMS is the software which manages and controls warehouse operations such as goods entry, quality control, goods storage and delivery, with inventory tracking at stock item level by location, in a transparent and standardized way by means of barcodes, detailed reports and pictures of the goods. It also facilitates details of goods, information on origin of goods (e.g. supplier), stock balancing, history of action list, low inventory report, order tracking, and many more features.

WMS is hardware independent, meaning that it utilizes all existing hardware customer has which allows flexibility to use extra ones. It functions just well even if it was installed on just a normal computer with Microsoft Windows operating system (Windows 95 and later). For example, product identification can be either manual or by means of barcodes printed by any existing printer on both regular A-4 paper or recommended standard A-4 sticker papers. Another example would be capturing pictures of the goods, which can be done through any existing picture scanner or by importing from disk and digital camera.

In implementing WMS, no extra driver, database software is needed, usually seen in Access-based or Oracle-based software. It can, however, also export its entire database to any other database system in standard data formats. Another benefit WMS provides is that all reports and printouts, including barcodes, can be stored and reprinted

at any time thus eliminates need to regenerate them as well as allows easy documentation.

WMS will be designed based on the concept of adaptability, standardization, simplicity, flexibility, security and controllability. It also has to be light and affordable.

(a) Adaptability

The software package can adapt itself to the environment, under which it runs, and use any necessary standard-conformed device (Printer, picture scanner, barcode scanner, and so on) to achieve its full functionality. It will also adapt itself to customer's actual physical storage systems, such as shelving, racking, as to name some, whether they already exist or are about to be built, so they can be anything that facilitates storage for goods.

(b) Standardization

The software package provides transparent processes and procedures to follow in order to achieve warehouse management tasks. All screens and reports are as informative and standardized as possible, thus minimum training for users of the software required. As a result, WMS can be bought off-the-shelf as a software package, meaning it conforms to many standards the customers may have known in working with computers and warehouses. Therefore the customers may not need extra training in order to get the software started.

(c) Simplicity

In working with the software, no actions other than necessary will be required. That means it will be as autonomous as possible in performing tasks. The software package itself is an all-in system with everything needed for operations provided, therefore installing and putting it to run is really simple too. There are

no special requirements for hardware or software, since, for example, the use of barcodes and pictures depends upon customer's decision.

(d) Flexibility

The software provides a very flexible way to define customer's storage: it can have more than 1 store (Warehouse); storage aisles can be different in length, height; customer can use 1 or both sides to store goods; and locations can be categorized (Light/heavy goods, bulky goods, etc.). The user interface of this software package facilitates multi-lingual, which can be changed anytime without having to stop and re-run the software. The customer can even modify display strings of its user interface to his familiar ones. Moreover, even reports are multi-lingual too.

At work, the software provides many options to perform tasks to maximize possibilities and to achieve better efficiency as well as productivity. For example, many printing options can be used when printing barcode (Type, size), reports (Filtering, groups); quick actions allowed immediate confirmation of input orders without having to wait for actual goods movement to be done; storage locations can be locked; reports can be saved and re-read easily; output goods selection can be on FIFO, LIFO, Manual basis; and many more.

(e) Security

All functions are classified based on security levels so the system access is limited to registered users only. System database is also password-protected, and customer can back it up to save space or restore it. Every action that involves security or changes the way the software behaves will be recorded for later examination. The software package is designed to be as fail-safe as possible so

most accidental cases such as electricity failure, computer hangout, will not affect its database.

(f) Controllability

Although the software is designed to be as autonomous as possible, it will never limit customer control by providing action history list, manual change to database, access and password control, and so on. All input and output orders data and status, activities done, goods tracking and inventory control to location level, are also under complete customer control.

1.2 Objectives:

(a) To study the existing system and identify the problems occur in the system

(b) To develop more practical computerized systems that can solve the problem

(c) To achieve efficiency in information analysis and report generation

(d) To facilitate the procedures of warehouse management activities

1.3 Scope:

(a) Analyze, design and develop a computerized system for the general warehouse system

(b) Analyze the hardware and software for warehouse management system

(c) Analyze and design database for warehouse management system

(d) Design screen layout for user

(e) Design a decision support system for the warehouse manager

II. THE EXISTING SYSTEM

The problems in warehouse management are divided into four categories: Receiving/Put away, Order Picking / Packing / Checking / Shipping, Replenishment / Letdown, Inventory control and Cycle counting.

(1) Receiving / Put away:

A study of current receiving operations is best done by reviewing common problems experienced at the dock. Interviews should be conducted with a receiving supervisor and an experienced receiving operator. They will be able to identify all receiving exceptions which cause dock congestion and time loss. There are many factors which cause receiving exceptions and WMS will not eliminate all of them. However, WMS will alleviate all of the strains related to manual paper based systems which slow down the receiving and put away processes. On-line real-time receiving combined with bar code labeling of inbound product will reduce dock congestion and substantially improve inventory accuracy. Furthermore, system-directed put away will greatly improve the time required to clear off the dock. In turn, a reduction in dock congestion improves overall flow of goods and ability to receive and ship more volume through the facility.

Receiving and Put away can be inefficient due to the following reasons:

(a) When inbound loads arrive, and there is no information available to identify the inbound order(s) and order details. It is not easy for the warehouse manager to find the buyer as he works in shift.

(b) Inbound order line item discrepancies in the form of overages, underages and damages. These exceptions need to be entered into a front

office computer and resolved with approvals from buyers and/or inventory managers.

(c) Product-specific information including expiry date, lot numbers and serial numbers must be captured at the time of receiving. This data in turn needs to be keypunched into a computer.

(d) Delays in entering receipts into the host computer system cause inventory to sit at the receiving dock congesting the operation and resulting in productivity loss. Lost sales opportunities occur because the inventory is not considered available until it is stored.

(e) Keypunching of receiver documents and information yields erroneous data and subsequent research processes to correct the data entry mistakes.

(f) Mistakes in return processing cause inaccurate credit memos to be issued, resulting in overpayment of credit and intensive clerical labor requirements in Accounts Receivable.

(g) Not providing pallet-stacking instructions to the receiving operator causes slow and inconsistent unit load creation.

(h) Put away operators cannot commence put away activity until the entire receipt is closed out by the receiver causing congestion on the dock.

(i) Put away operators search the aisles within the warehouse to find storage locations for the product.

(j) Put away locations are written down on a paper document or cards and subsequently keypunched into the computer.

(k) Put away inventory to the wrong location causes inventory clerks to search and retrieve work to resolve the missing inventory.

(l) Operators could perform multiple put away tasks of many items in a single trip, but this cannot currently be done due to confusion and errors.

(2) Order Picking / Packing / Checking / Shipping

Inefficiencies in these areas are probably the most important to identify because these activities typically represent 60 - 70% of overall warehouse labor hours.

Inefficiency in order picking / packing / checking / shipping are typical for the following reasons:

(a) Paper pick lists need to be manually sorted out prior to their release due to lack of systematic order planning system.

(b) Paper pick lists are not sorted out in a logical bin sequence causing pickers to have to figure out the best route.

(c) Order pickers are forced to read too much information on their pick list.

(d) Pick locations are identified by complex addressing systems which are difficult to understand and cause new employees to make errors.

(e) No ability to take multiple small orders with a single pass through (e.g., batch picking or cluster picking).

(f) No ability to ensure that order lines are optimally picked by breaking the demand quantity across multiple stock-keeping units of measure (e.g., full case pick instead of picking caches).

(g) Multiple units of measure for the same item are picked from the same bin location.

(h) Multiple SKUs are picked from the same location.

(i) Operators pick products that have been received, but not have been yet entered into the inventory system causing confusion later.

(j) Poor organization of the pick line results in high activity products being picked in the furthest locations away from the shipping dock

(k) Vertical upward travel is required to pick products that have sufficient movement velocity to warrant being picked from ground locations.

(l) High volume products inappropriately slotted in locations which are too small (e.g., an item moves a pallet per week and is picked from a shelf bin).

(m) Packing and checking are managed as distinctly separate activities when they could potentially be combined with picking.

(n) Inaccurate replenishments of pick locations generate many pick errors.

(o) Pick locations are empty, causing the picker to search for a replenishment operator or "scratch" the order line.

(p) Pickers use inappropriate mobile equipment, causing unnecessary time loss getting on and off a vehicle, or having to manually pull non-motorized heavy equipment such as tuggers.

(q) Aisles are congested or temporarily filled with staged inbound products awaiting put away, making it difficult for pickers to access their products.

(r) Dead-end aisles or aisles that are too narrow for passing comfortably.

(s) Pickers must manually record information on pick lists or inventory cards.

(t) Packers or checkers validate all picking results to confirm shipping accuracy.

(u) Lot / serial number data entry is a required data keypunching step as part of the shipping cycle.

(v) Information is unnecessarily keypunched at the time of shipping to satisfy a trading partner's EDT ASN (86) requirements.

(w) Containers holding multiple order lines are manually labeled and recorded at shipping to satisfy outbound EDT / ASN compliance.

(x) Product is re-handled or restacked in the process of load preparation.

(y) Completed orders are unnecessarily transferred across the shipping dock due to weak outbound shipping planning.

(z) Shipments are loaded onto the wrong trailer.

(aa) Orders are delayed or shipped incomplete because segments of the orders were not completed and were hung up.

Many of the above examples will not be applicable to your particular operation. The challenge is to ask the right questions that answer new ways of doing things because work is eliminated.

(3) Replenishment / Letdown

Inefficiency in replenishment is only applicable in the operating environment where products are assigned to fixed pick locations. In the random picking environment, replenishment is eliminated. Random pick slots do not necessarily provide a more productive operating environment because of the fact that the replenishment function is eliminated. There are definite tradeoffs to be considered when implementing the random locator system, and this strategy definitely does not lend itself well to many distribution environments.

For those companies performing the replenishment activity in the warehouse, the following inefficiencies are common:

(a) The replenishment operator must travel long distances throughout the facility to retrieve reserve inventory.

(b) Reserve inventory is not where it was supposed to be causing the search and retrieval of product.

(c) There is no ability to track reserve inventory, causing poor inventory rotation control and unnecessary search and retrieval time for product.

(d) Too many replenishments are performed because there is no system to dynamically trigger replenishments with optimal product quantities.

(e) Pick slots are inappropriately undersized for the faster velocity items, causing too many replenishments to be done.

(f) Pallet letdowns are performed too early, causing excessive re-handling of residual product in the pick slot.

(g) Manual operator directed replenishment procedures which result in operators roaming the aisles looking for depleted pick slots.

(h) Commingling of multiple SKUs or pallet loads in the same location, causing multiple product handling tasks to retrieve a unit load of reserve inventory.

(i) Poor control of expiry date and poor inventory rotation causes reserve inventory to expire slowing down the replenishment activity.

(j) Poor control over the timing of replenishments causing pick slots to be depleted during order picking such that the picker searches for the replenishment operator to perform "hot" letdowns.

(k) "Pick scratches" cause replenishment operators to perform product retrievals to be brought forward to the shipping dock.

(4) Inventory Control and Cycle Counting

Most distribution companies perform physical inventory counts at least once a year to ensure inventory accuracy. The implementation of WMS in conjunction with bar coding and radio frequency technologies provides such accurate inventory levels that most major accounting firms now accept inventory asset information without the need to perform a physical count.

For many companies currently performing cycle counts as a means to ensure inventory accuracy, it is typical that system support in this area is weak. Many systems do not offer the flexibility needed by the distribution company to truly manage the cycle counting function.

Inefficiency in inventory control is typical for any of the following reasons:

(a) "Pick scratches" cause replenishment operators to perform product retrievals to be brought forward to the shipping dock.

(b) The physical inventory count causes the operation to shut down once a year or per fiscal quarter resulting in expensive time loss.

(c) The physical count results in costly overtime expense.

(d) It is uncertain if the physical count actually improves the quality of inventory information, or if inventory inaccuracy is negatively affected by the count.

(e) Cycle counting operations are manually controlled and it is difficult to ensure that all cycle counts are actually performed by the operators.

(f) System support for cycle counting is limited to logic based on ranges of products rather than ranges of locations resulting in difficulty recovering "out f book entries" (i.e., lost product residing in locations are considered empty).

(g) Cycle counting is not performed, causing inaccurate inventory which have negative impacts on all aspects of labor performance as well as customer service levels.

(h) Poor inventory control results in product expiration.

(i) Poor inventory control results in demand for storage capacity. The fuller the warehouse, the slower the operation becomes.

III. THE PROPOSED SYSTEM

3.1 Proposed solution

(1) All data are kept in Paradox database that can facilitate fast and secure data access.

(2) Supported by barcode technology combined with picture verification to eliminate errors rate in data input.

(3) Simple and convenient graphical user interface

Using warehouse management system technology will benefit in:

(a) Quantitative:

(1) Labor cost savings:

Warehouse labor cost reduction is typically the major contributor to the cost justification of a WMS investment. In many instances, a WMS enables sales growth without the equivalent increase in warehouse staff and equipment. In other cases, WMS reduces the need to add temporary labor during peak shipping periods. Most commonly, WMS enables a reduction or elimination in the need for overtime labor because a day's work can be done during that day's normal working hours.

(2) Inventory savings:

It is well documented that WMS technology is a key enabler to achieving near perfect inventory accuracy in the warehouse. The benefit of inventory accuracy is most often associated with improvements in customer service levels and order fill rates. However, inventory accuracy can also contribute a significant reduction in

inventory levels within the distribution center. After all, one of the components of safety stock is the unstated covering off for inventory inaccuracy. In short, consistent inventory accuracy directly translates into lower safety stock levels.

(3) Outbound Transportation Savings:

Improved order planning and scheduling enable orders to be released in waves such that outbound transportation shipments can be optimized in advance of order picking. Depending on the distribution environment, outbound transportation savings may range from a negligible to a significant amount of money. For many distribution companies, the use of a third party software system dedicated to transportation optimization can further help to improve the shipping and dispatch functions.

(4) Paperwork Reduction

WMS technology introduces the potential for paperless warehousing. All transactions are recorded in detailed electronic audit trails with the operator and date/ time stamped on every single activity. Quick online access to this information eliminates huge stacks of paperwork.

(5) Picking / Shipping Accuracy:

The ability to ship customer orders with 100% accuracy is one of the main qualitative benefits of WMS technology. It is difficult to express this as a quantitative dollar savings because the true value of order accuracy is that you stay in business. Sometimes people express order accuracy and order fulfillment improvements as a quantitative

amount by estimating lost or gained sales revenue. It is the author's opinion that it is best to express this as a qualitative benefit rather than attempting a guess at this type of information.

There are real cost savings related to improve shipping accuracy which may be included in your analysis. For example, if order lines are returned to the distribution center because of picking or shipping errors, then this is a real cost. If these mistakes result in credit memos being issued and transportation costs being absorbed to return products, then these are real costs to be saved.

(6) Warehouse and Fixed / Mobile Equipment Savings

Improved labor productivity often translates into savings in mobile equipment. If fewer people are involved in the operation then one may conclude that less mobile equipment is required as well. This may be expressed as a one-time avoidance cost savings and also as an ongoing maintenance savings. For example, by eliminating the need for a forklift operator, can you avoid the acquisition of a new forklift during the time horizon considered (e.g., the next five years)? One-time capital expenditures are important to identify because they represent real savings if they can be eliminated or delayed. For example, if the expansion of your distribution center is delayed for three years as a result of the WMS project, then the required capital is available for reinvestment at the current rate of interest. This is a tangible savings. If labor productivity gains cause the oldest piece of mobile equipment to be retired, then maintenance costs are saved, and so on.

Outside storage costs should also be considered if inventory reductions enable less rental of outside storage space. Warehouse shuffle costs should also be saved in this scenario.

(b) Qualitative:

The key qualitative benefits to WMS technology are related to inventory accuracy and the elimination of manual systems and their related problems. Since these benefits are difficult to quantity, they should be expressed as commentary.

Potential qualitative benefits relating to the elimination of inaccurate inventory include:

(1) Reduced sales loss due to missing products.

(2) Reduced back orders.

(3) Improved customer order accuracy.

(4) Improved order fulfillment rates.

(5) Faster order turnaround time.

(6) Improved delivery scheduling and planning.

(7) Less inventory obsolescence.

(8) Trading partner label compliance and fine avoidance.

(9) Increased cross dock activity.

(10) Elimination of labor-intensive data and file maintenance.

(11) Elimination of risk related to memory-based warehousing practices and reliance on key individuals.

(12) Customer order lead time reductions.

(13) Improved reporting and monitoring tools.

(14) Improved management control.

(15) Improved return on assets.

3.2 System Design

System will be designed based on the modular concept which consists of:

(a) Goods receiving module:

In order to do goods receiving, the following steps have to be done:

(1) Goods registration: All information such as part number, requested location type, weight, minimum/maximum/threshold quantity to keep, and so on, will be recorded. These sorts of information are necessary to identify incoming goods and a suitable storage location is to be selected for it.

(2) Entry order creation: Incoming goods have to have entry orders to group them together and to allow order tracking later. Upon creation of orders, each goods unit will be assigned a unique unit number to facilitate inventory tracking.

(3) Barcode printing: This step is optional. It allows printing of barcodes containing unit number, part number, and entry date and lot number. Such information is useful for visual check and barcode pattern is especially helpful when doing the actual input.

(4) Actual input: unique unit numbers of entry orders will be typed in / scanned in or selected from entry order list. The software then will automatically select suitable storage locations for them (Judging from requested location type of goods). After visual check incoming goods again pictures (If any), customer can either confirm that these incoming goods are already in place or marked them as on the move for later confirmation when they are all really stored.

(b) Goods delivery module:

In order to do goods delivery, the following steps have to be done:

(1) Delivery order creation: Outgoing goods have to have delivery orders to group them together and to allow order tracking later.

(2) Actual output: Delivery orders will be selected from delivery order list. The software then will automatically select storage locations with right goods unit for them (Based on part number and selection bases, which are FIFO/LIFO/Random and Manual) or let customer choose desired locations him-/herself. Customer can either confirm that these outgoing goods are ready to be docked or marked them for later confirmation when they are all actually delivered.

(c) Report, barcode and location label printing

Reports can be done at any time and printouts can be saved for later browsing by means of a report reader. Location labels can also be printed out to assist visual check for warehouse staffs by means of a location labeler. These following reports provide:

(1) Registered user list: A user can print out the list of his/her subordinates only but no passwords will be shown

(2) Historical action list: All actions involve security or change the way the system behaves can be printed. This list can be filtered for a specific date, action class or user name.

(3) Recorded order list: Entry and delivery orders, whether they are waiting / on the move or done, can be printed out in full or after filtering out a specific order / lot number, order date or completion date.

(4) Registered part list: All information of registered goods will be printed here and similar to above reports, the printout can be filtered for a specific part number, unit measurement (Box, bag, pallet, etc.), weight and requested location type.

(5) Storage location list: Information on every storage location such as status, type, name, goods stored, etc. can be printed out here with option to filter out a specific part number, store / aisle number, status and type.

(d) Inventory and order tracking

The system allows tracking of storage item to location level, orders and goods quantity in stock.

(1) Low inventory list: All goods in stock can be checked again minimum / maximum / threshold quantities, as described in registered part list, to find out which need to be replenished. After that the user can determine whether to print them out.

(2) The software provides tracking of a stored unit based on unit number, location number and order number. In case of order tracking, it allows search on order number, unit number and order date / time

(e) System settings

The customer can use this module to change interface language, output selection basis such as FIFO / LIFO / Random or Manual, and time duration in which all activity records will be kept.

(f) Security

This module allows adding, removing, and changing registered user data. It also helps to enhance the system database for faster database

operation, to backup and restore system database, and to export database into standard data-exchange formats.

(g) Manual database change

When having proper authorization, a user can manually change the orders and storage location database if that is really necessary.

(h) Administrator and analyst assistance

The assistance provided here requires special authorization because it highly affects the system database. When necessary, an administrator can create / change the location database such as number of aisles / bays / stores, etc. and an analyst can do the same plus some special possibilities.

3.3 Data Flow Diagram of the Proposed System

(Please see in appendix A)

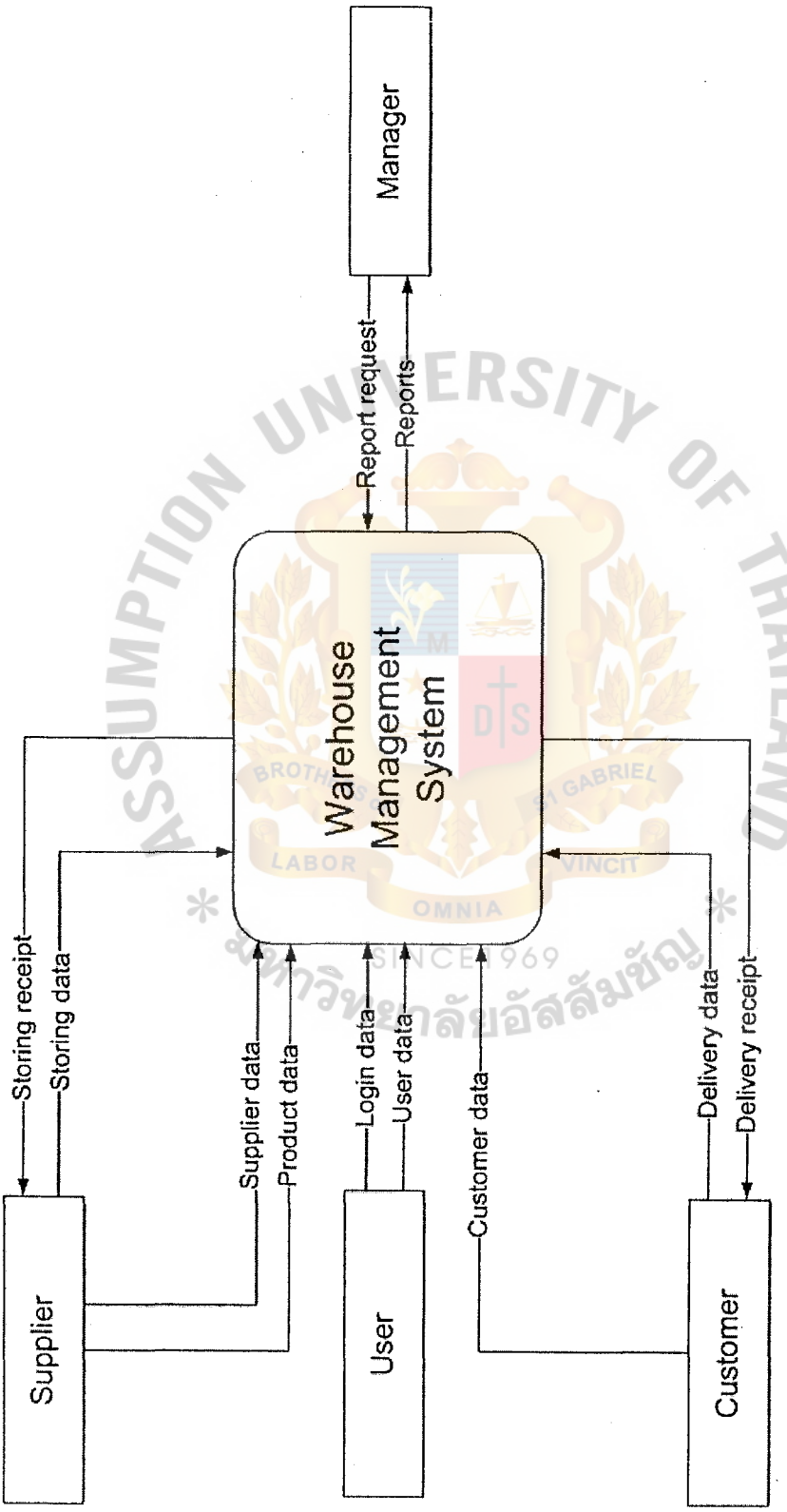


Figure 3.1. Context Diagram of the Proposed System.

3.4 Data Structure Chart of the Proposed System:

(Please see in appendix B)

3.5 Entity Relationship Diagram of the Proposed System

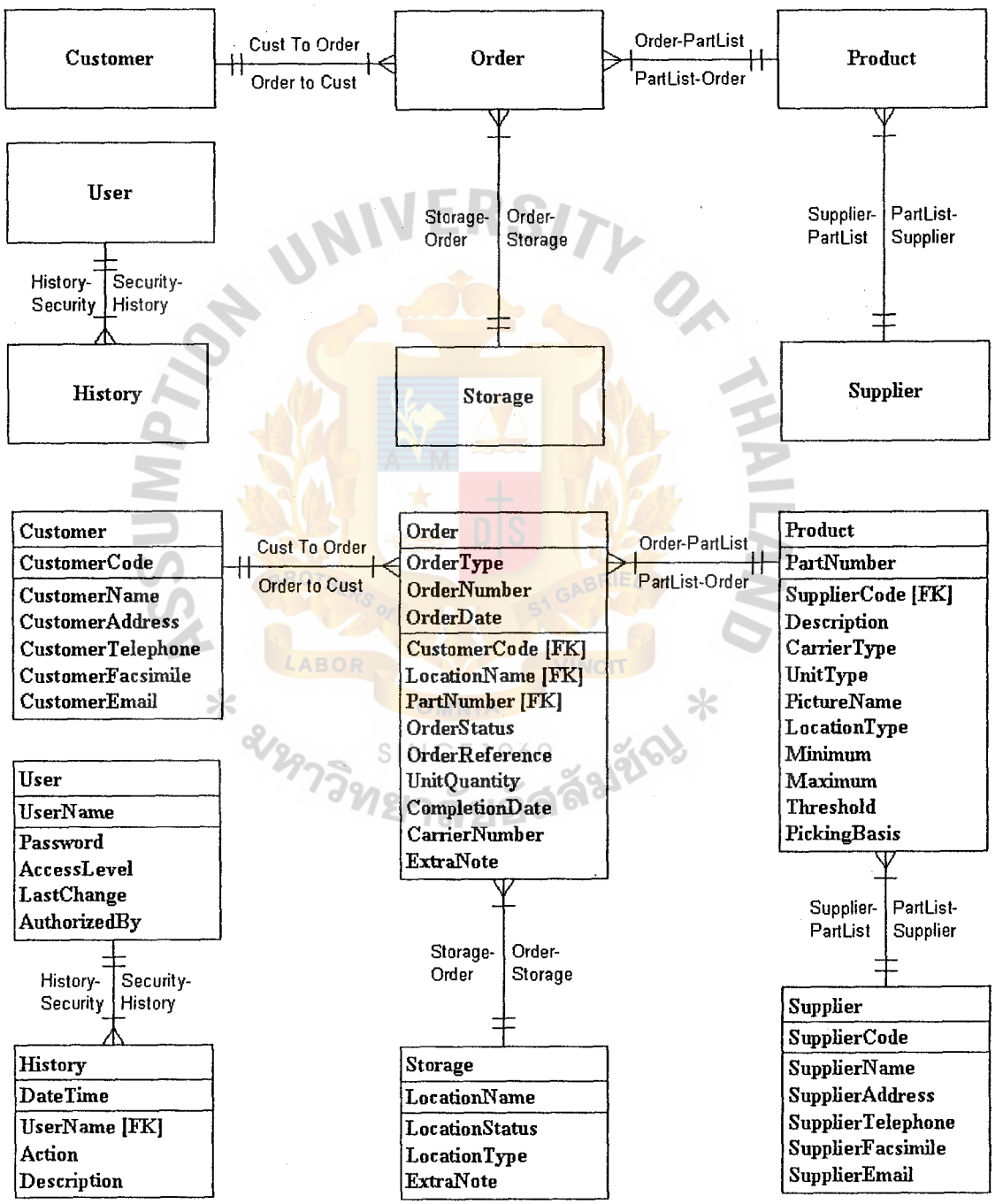


Figure 3.2. Entity Relationship Diagram of the Proposed System.

3.6 Database Structure

Structure of User table

Name	Type	Length	Null
UserName	Char	10	No
Password	Char	16	No
AccessLevel	Char	1	No
LastChange	Date	10	No
AuthorizedBy	Char	10	No

Figure 3.3. Structure of User Table.

User table is designed to store a user information which includes:

(1) UserName field: store the name of user to login to WMS

(2) Password field: store the password of user to login to WMS

(3) AccessLevel field: store the authority level of user in WMS

(4) AuthorizedBy field: store the name of the authorized person

(5) LastChange field: store the date of issuing

Structure of Customer table

Name	Type	Length	Null
CustomerCode	Decimal	13	No
CustomerName	Char	30	No
CustomerAddress	Char	80	No
CustomerTelephone	Char	20	Yes
CustomerFacsimile	Char	20	Yes
CustomerEmail	Char	30	Yes

Figure 3.4. Structure of Customer Table.

Customer table is designed to store a supplier information which includes:

(1) Customer Code field: store the code is used to identify the Customer

(2) Customer Name field: store the name of Customer

(3) Customer Address field: store the address of Customer

(4) Customer Telephone field: store the telephone number of Customer

(5) Customer Facsimile field: store the facsimile number of Customer

(6) Customer Email field: store the email address of Customer

Structure of Supplier table

Name	Type	Length	Null
SupplierCode	Char	13	No
SupplierName	Char	30	No
SupplierAddress	Char	80	No
SupplierTelephone	Char	30	No
SupplierFacsimile	Char	30	Yes
SupplierEmail	Char	30	Yes

Figure 3.5. Structure of Supplier Table.

Supplier table is designed to store a supplier information which includes:

(1) SupplierCode field: store the code is used to identify the supplier

(2) SupplierName field: store the name of supplier

(3) SupplierAddress field: store the address of supplier

(4) SupplierTelephone field: store the telephone number of supplier

(5) SupplierFacsimile field: store the facsimile number of supplier

(6) SupplierEmail field: store the email address of supplier

Structure of Product table

Name	Type	Length	Null
SupplierCode	Char	13	No
PartNumber	Char	13	No
Description	Char	80	Yes
CarrierType	Char	10	No
UnitType	Char	10	No
PictureName	Char	13	Yes
LocationType	Char	13	No
Minimum	Long VarBinary		Yes
Maximum	Long VarBinary		Yes
Threshold	Long VarBinary		Yes
PickingBasis	Char	1	No

Figure 3.6. Structure of Product Table.

Supplier table is designed to store a supplier information which includes:

(1) SupplierCode field: store the suppliercode of supplier to provide the product

(2) PartNumber field: store the code of product is used to identify a product

(3) Description field: store the products description

(4) CarrierType field: store the type of carrier that product is carried by

(5) UnitType field: store the type of product

(6) PictureName field: store the name of picture file to identify the product

(7) LocationType field: store the location type to store a product

(8) Minimum field: store the minimum number of product unit

(9) Maximum field: store the maximum number of product unit

(10) Threshold field: store the number of product unit that is larger than minimum number and smaller than maximum number.

(11) PickingBasic field: store the way of delivery that the product will be handled

Structure of Order table

Name	Type	Length	Null
CustomerCode	Decimal	13	No
LocationName	Char	10	No
PartNumber	Char	13	No
OrderType	Char	1	No
OrderNumber	Char	13	No
OrderDate	DateTime		No
OrderStatus	Char	1	No
OrderReference	Char	13	No
UnitQuantity	Integer 4		No
CompletionDate	DateTime		Yes
CarrierNumber	Decimal	13	No
ExtraNote	Char	80	Yes

Figure 3.7. Structure of Order Table

Order table is designed to store the order information which includes:

(1) LocationName field: store the name of location in storage

(2) CustomerCode field: store the code of Customer

(3) PartNumber field: store the code of product

(4) OrderType field: store the type of order

(5) OrderNumber field: store the code which is used to identify an order

(6) OrderDate field: store the issued date of order

(7) OrderStatus field: store the status of order

(8) OrderReference field: store the code of involved document (optional)

(9) UnitQuantity field: store the quantity of product

(10) CompletionDate field: store the completion date of order

(11) CarrierNumber field: store the unique number to track the order

(12) ExtraNote field: store the note of order

Structure of Storage table

Name	Type	Length	Null
LocationName	Char	10	No
LocationStatus	Char	1	No
LocationType	Char	13	No
ExtraNote	Char	80	Yes

Figure 3.8. Structure of Storage Table.

Storage table is designed to store a storage information which includes:

(1) LocationName field: store the code of location to identify a location

(2) LocationStatus field: store the status of location

(3) LocationType field: store the type of location

(4) ExtraNote field: store the note about location

Structure of History table

Name	Type	Length	Null
UserName	Char	10	No
DateTime	DateTime		No
Action	Char	8	No
Description	Char	80	Yes

Figure 3.9. Structure of History Table.

History table is designed to store the history of WMS action information which includes:

(1) UserName field: store the name of user that the action is issued by

(2) DateTime field: store the action issued date

(3) Action field: store the name of action

(4) Description field: store the description of action

3.7 User Interface Design of the Proposed System

3.7.1 Main Screen

(a) Main menu:

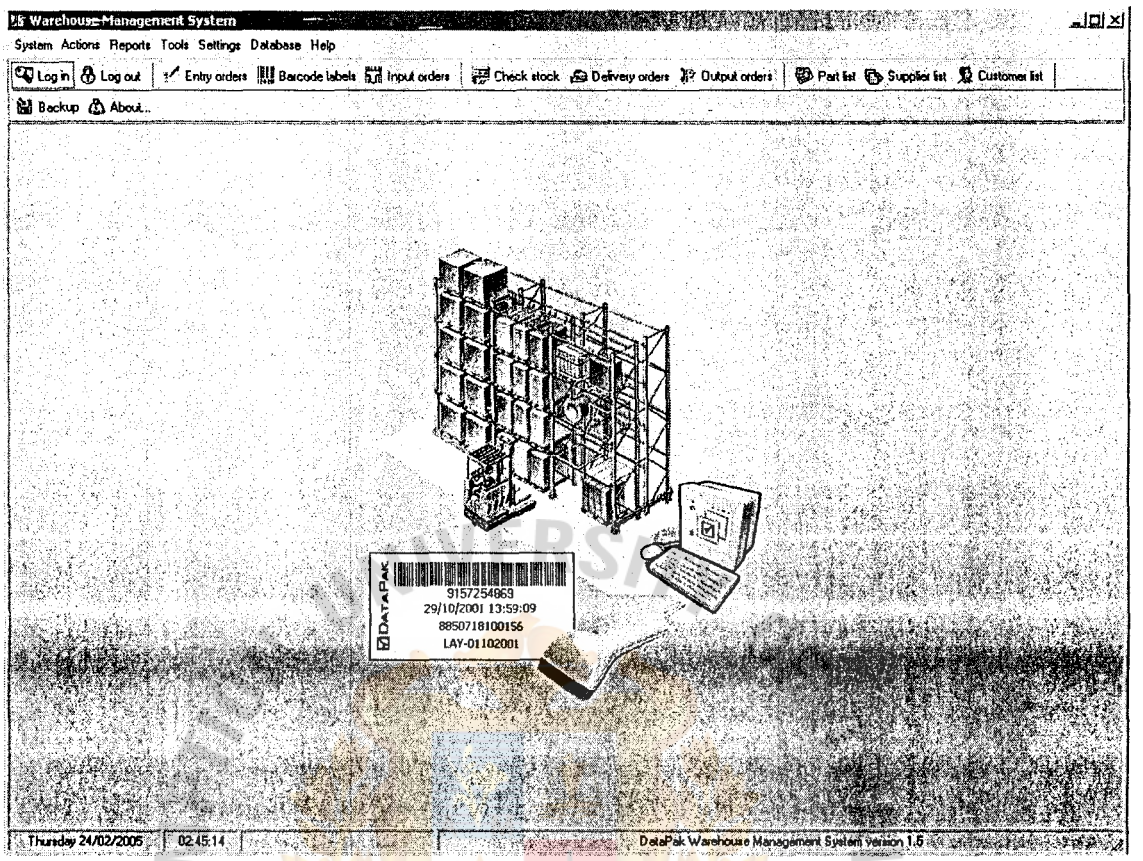


Figure 3.10. Main Screen Interface.

After you have logged into the system, the main menu with associated menu items will be shown allowing you to access all system functions. Please note that depending on your security level, which defines the maximum right you have in using software features, some menu items might be removed from the main menu. The above figure shows the working environment. WMS has several levels of user and, it depends on its users who have to be authorized and registered to the system.

The levels are as follows:

(1) Unauthorized.

(2) Operator.

(3) Supervisor.

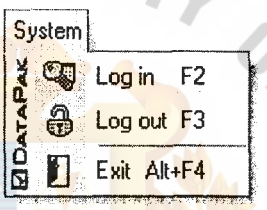
(4) Manager.

(5) Analyst.

Content of the main menu:

System

The system menu contains functions that allow users to access or exit the system.



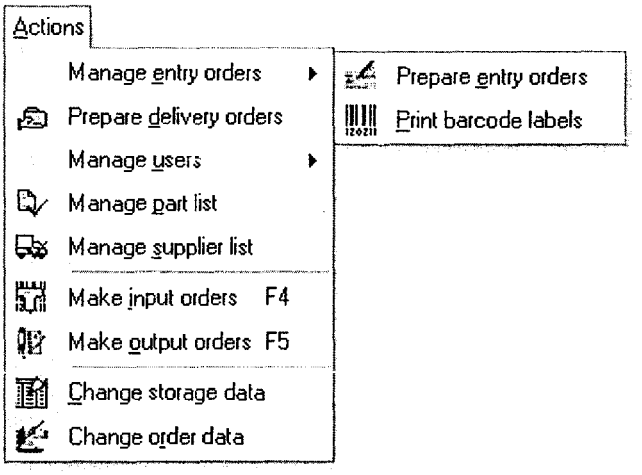
Log in or F2: To start working with the system functions in accordance to authorization code (User name and Password checking). See Starting to work with the system for more details.

Log out or F3: To exit the working environment only, the WMS program still remains ready for new access. See Stop working with the system for more details.

Exit orAlt+F4: To quit WMS program, everything will be closed.

Action

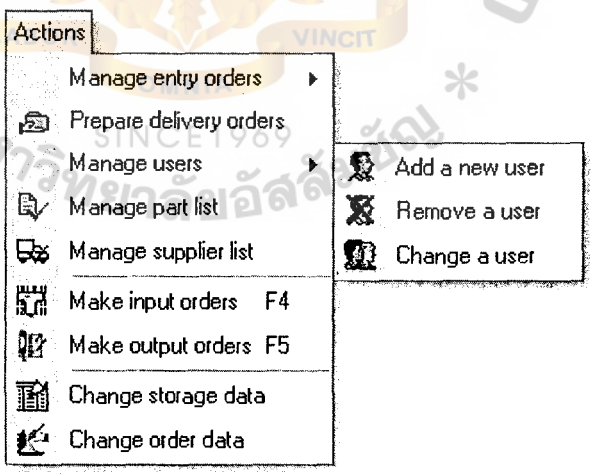
Action contains functions that help users / warehouse staff to do daily jobs.



Prepare entry orders: This function is used to prepare entry orders for incoming goods which will be ordered from suppliers.

Print barcode labels: Barcodes to identify incoming goods can be printed based on entry orders. These barcodes help the automation of the input process and eliminate human errors when checking goods.

Prepare delivery orders: This is the preparation step prior to delivery of goods out of warehouse according to orders received from customers.



Add a new user: When a new user is to be authorized to use the WMS software, this function is used to add user information to the system.

Remove a user: If a user is no longer to be authorized to enter the system, this function is employed to remove user security information.

Change a user: Authorized and empowered personnel can use this function to change security information for user subordinates.

Manage part list: Any goods that will be stored inside the warehouse must have their characteristic data registered in advance using this function.

Manage supplier list: This function helps register supplier information of goods in order to ensure back-tracking of goods origin.

Make input orders or F4: This is the final step in goods receiving procedure. This function executes the process that transfers goods into warehouse.

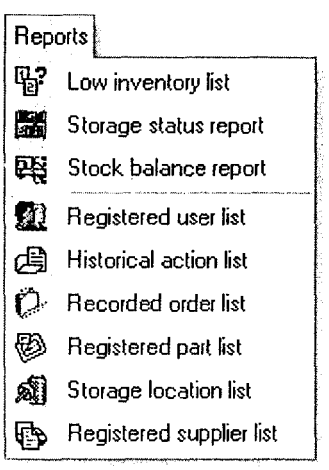
Make output orders or F5: This function executes the delivery orders that were prepared in advance.

Change storage data: This function helps to rectify any errors occured due to warehouse activities. It is useful for auditing purpose.

Change order data: Similar to Change storage data, this function helps to rectify errors in making/executing input and output orders.

Reports

Reports contain functions that help to print reports showing system data.



Low inventory list: Goods that are available in lower quantity than their predefined thresholds will be listed out. This function is useful for replenishment of goods to ensure fulfillment of delivery orders.

Storage status report: At anytime information on usage of warehouse space or percentage of warehouse used for any specific goods type can be checked by using this function.

Stock balance report: For any specified period of time, this function helps to list out all inputs/outputs done and inventory status during the period.

Registered user list: For management purpose this function is used to print list of authorized users and their security levels.

Historical action list: All transactions done that were automatically recorded inside the system during a predefined customizable period of time can be printed out for management purpose with this function.

Recorded order list: Similar to Historical action list, this function will print the reports of all entry/input/delivery/output orders during a predefined customizable period of time.

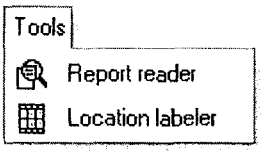
Registered part list: For documentation as well as purchasing/selling purpose, list of goods that can be stored inside the warehouse will be printed out with all details and characteristic data here.

Storage location list: Printed report on storage locations and their storage data plus status can be obtained here.

Registered supplier list: All necessary information about approved suppliers of goods stored inside the warehouse will be listed out using this function.

Tools

Tools contain miscellaneous functions that help users to increase productivity.

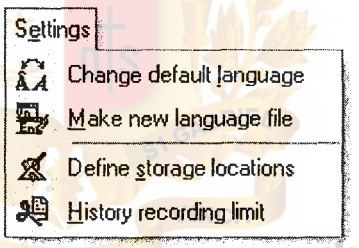


Report reader: This function invokes a report reading module that allows viewing and printing previously-saved reports.

Location labeler: This function invokes a label printing module that helps generate standardized storage location labels in barcode format.

Settings

Settings contains functions that allow users to change the system outlook and functionality.



Change default language: To change from a default language (Initially English) to another is available in the program. Any user that does not require a specific interface language will be using this default one.

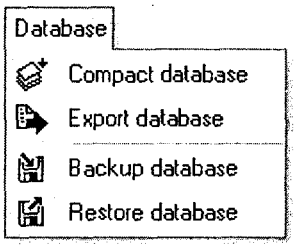
Make new language file: In case a new interface language is needed for some users, an authorized and empowered personnel can use this function to generate it.

Define storage locations: This one-time function is used to define storage configuration for the warehouse.

History recording limit: The time duration that DataPak WMS will keep records of transactions and orders can be changed by using this function.

Database

Database contains functions that help users to manage and maintain system database.



Compact database: Changes in the system database during a long period of time will affect the system performance due to fragmentation of data. This function is designed to make the database more compact thus enhances general system performance.

Export database: When it is necessary to share data with another management software or system, the system database can be exported out in standard data exchange formats by using this function.

Backup database: Current database can be stored into a safe location to ensure highest recovery possibility with most up-to-date warehouse information in case of failure by invoking this function.

Restore database: After a system failure the database can be restored from a previously backed- up copy that was stored by Backup database.

Help

Help Contains functions that show users software information and helpful instructions.

(b) Toolbar

The toolbar is designed for user convenience. It is complementary to the main menu bar and provides shortcuts to most frequently-used functions of the software.

(c) Status bar

The status bar stays at the bottom of the system main window and provides current date/time information, currently logged-in users security level and useful hint of a currently-active system function accessed through main menu or through toolbar.

3.7.2 Defining the storage configuration

Storage locations are usually designed with the same specification but in practice we often need to classify them differently for administration or safety purpose. Some will be used to store only light- weighted goods but other for heavy ones; some which stay close to output points will be used to store last-moving (most often-moved) goods while other for medium- or slow-moving ones. Locations, therefore, will be differentiated by their types, weight or size or category, and so on, of accepted goods.

WMS supports hundreds of location types, given that they are described in one of the ASCII-letters such as 'A'..'Z', '0.9' and so on. The meaning of these types will be defined by the user and not known by the software.

To define the configuration, the user chooses Define storage locations from the Settings menu. The dialog for data input is as follows:

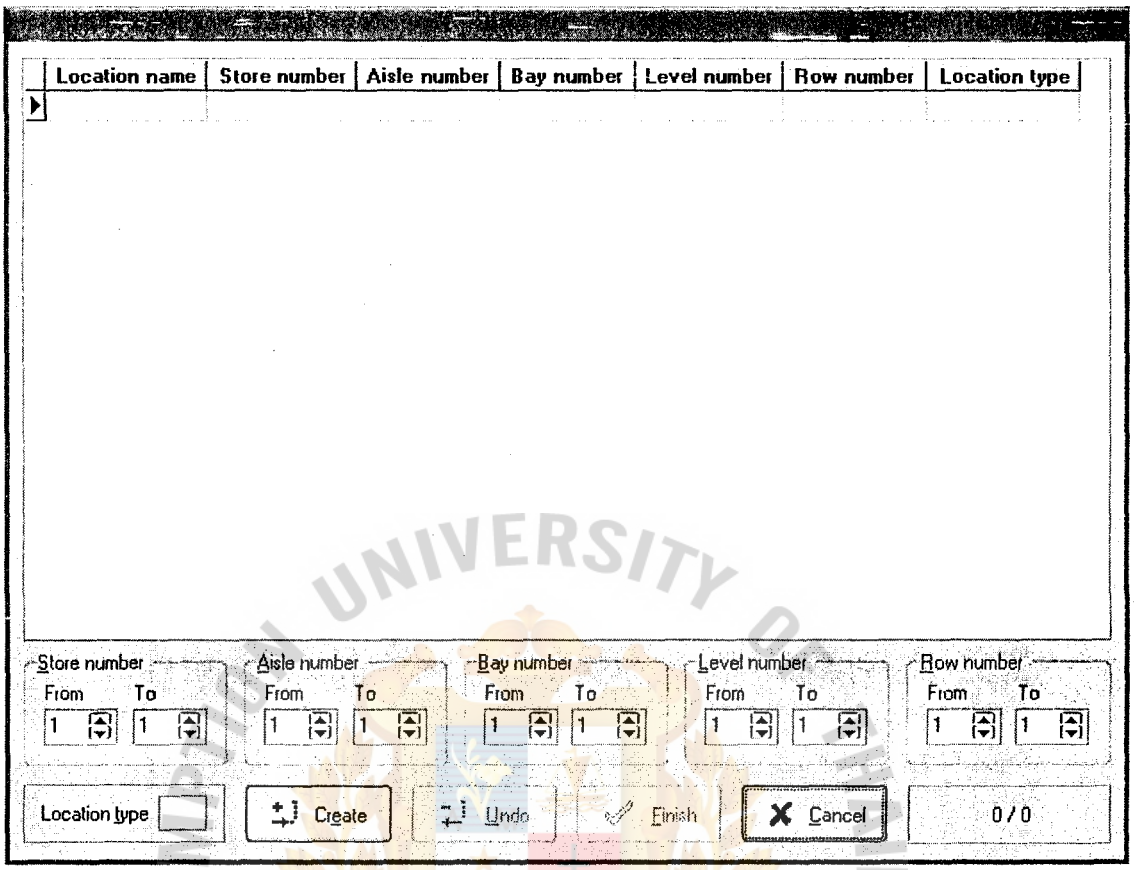


Figure 3.11. Define Storage Screen.

The data will be entered in the field in the lower part of the table, then these data will be put in the upper part of the table by clicking Create.

Store number: the number of stores in the warehouse. The maximum number of stores in a warehouse is 9.

Aisle number: the number of aisles in a store. The maximum number of aisles that a store can contain is 99.

By number: the number of bays in an aisle. The maximum number of bays is 999.

Level number: the number of levels contained in a bay. The maximum number of levels is 99.

Row number: the number of rows in an aisle. The maximum is 2 rows on both sides of an aisle.

Location type: used to classify the kinds of goods stored in the warehouse. This type is characterized by alphabetic letter A, B, C...

Create: click button to generate data after a certain structure entered.

Undo: delete only the data that has just been created one step before.

Finish: click to confirm that the warehouse configuration has been completely defined. Be careful in this step, it should be sure before confirming because once the configuration defined the function Define storage locations will disappear.

Cancel: all data created at the beginning will be deleted. To define configuration of the warehouse, new data has to be entered.

3.7.3 Registering authorized users to the system

A user can change password and security level for himself/herself as well as all other users who have the same or lower security levels. He / she can also remove the above-mentioned people, and of course, including himself/herself. In addition, an authorized user can register new users too, given that their security levels are just equal to or lower than his / hers. All these can be selected from Manage users in Action menu:

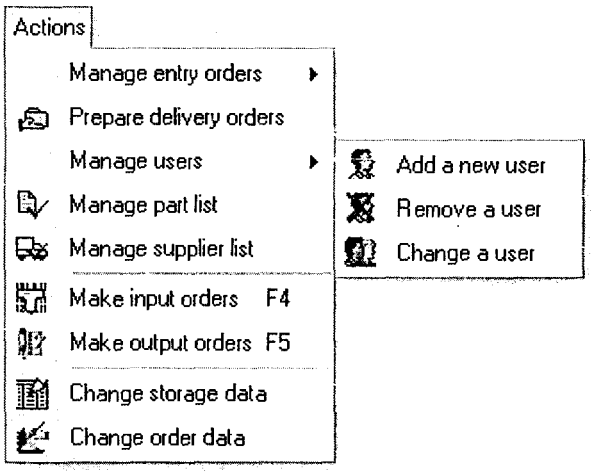


Figure 3.12. Manage Users Menu.

To be able to work with the program, a user has to be authorized and registered to the system. At the very beginning when WMS is just installed, there is a default user account that has administrative role. This default administrator can define all other authorized user accounts, change user roles as well as set them unauthorized if necessary. The administrator can only authorize the lower level compared to his level. The administrator can also change password himself or change to the lower level. A lower level does not authorize higher. Note that the changes are effective when the user logs out the working environment.

To add a user into the list, the administrator chooses Add a new user from Action menu. A popup will appears as follows:

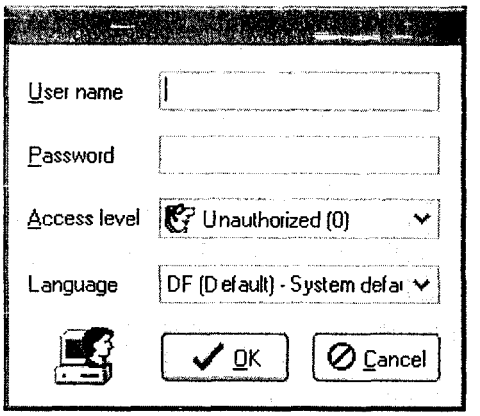


Figure 3.13. Add New User Dialog.

The information of the new user consists of User name and Password. Besides, the Access level and Language have to be chosen correctly. The program has 5 levels from 0 to 4, the highest level will be the administrator of the lowers.

The administrator reserves the right to delete the user of lower level. To delete a user out of the list, choose Delete a User from the Action menu. A dialog will be as follows:

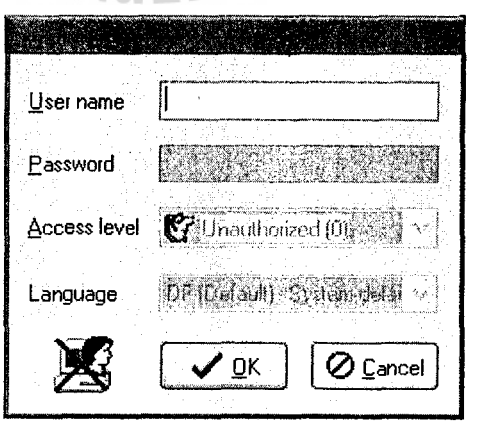


Figure 3.14. Delete User Dialog.

Here, the User name is only needed. The deleted user has no right to enter the program any more. In order to work with the program again, the user has to be added to the list.

In case a user wants to change password or level of using (to lower level only) or the administrator wants to change password of a certain user in order to suspend this user from using the program, the function 'Change a user from the Action menu' is used for this purpose. The dialog for this is as follows:

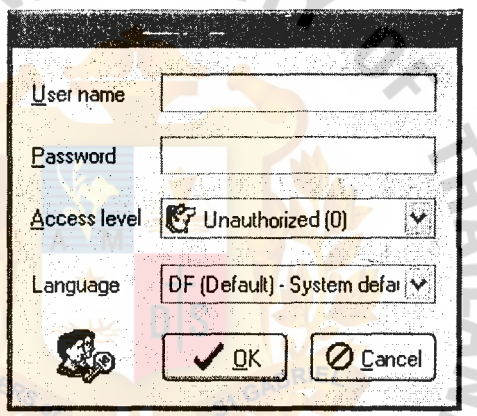


Figure 3.15. Change User Data Dialog.

In the dialog the user enters the User name but Password and/or Access level can be changed. This change will be effective when the user logs out of the working environment.

3.7.4 Registering goods to be used with the system

Because WMS keeps track on all goods (or parts) that will be stored into / delivered out from the warehouse, it is necessary to register all parts' data to the system in advance. Any incoming goods will be checked against registered part list to see what kind it is and whether it can be stored inside

the warehouse (For example, to see if storage places of the warehouse are suitable for storing them securely). If after some time some kinds of goods are not stored in the warehouse anymore, we can just easily remove them out of the part list. The registered part list is very useful when we want to check in detail what we have inside our warehouse.

Before entering the list of goods the user should create a supplier list containing some information of suppliers such as name, address, telephone number, e-mail address etc. Moreover, the supplier code will be enclosed to the goods to be stored.

To create the supplier list, choose 'Manage Supplier list' from Action menu, a dialog for entering information will appear.

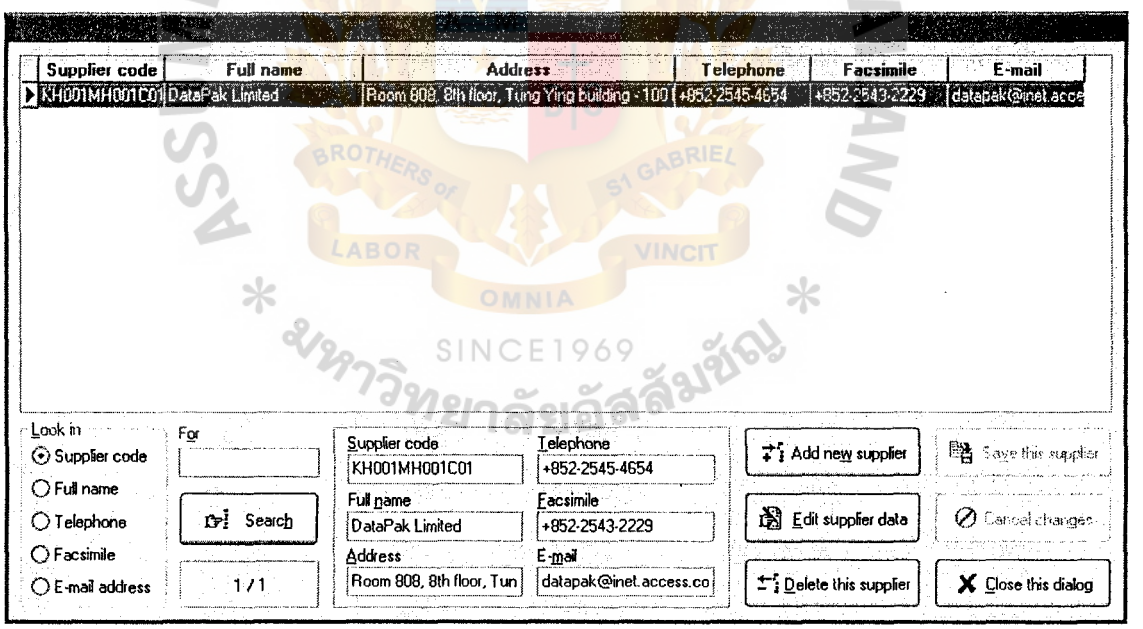


Figure 3.16. Manage Supplier Dialog.

Look in: in case of a long list, this function WMS helps the user to find out a certain supplier quickly by using search criteria as listed in the box.

For: the information to be searched.

Search: execute the searching process.

Supplier code: this code will be set by the manager or some one who has authority to do that and this one will be enclosed to the goods to be stored in the warehouse.

The user enters some information that relates to the suppliers such as name, address, telephone number, facsimile number, e-mail address.

Add new supplier: in order to add a new supplier this button has to be pressed first and then enter the required information.

Edit supplier data: In time, information of suppliers may change, therefore this function helps the user to correct some related information of supplier by highlighting a supplier and pressing this button.

Delete this supplier: choose a supplier and press 'delete' to eliminate a supplier out of the list.

Save this supplier: when information of a certain supplier is entered completely this button is to be pressed to save that information.

Cancel change: this function will restore the previous information and reject the changed information.

Close this dialog: to close the dialog any time.

In order to input goods into the warehouse, the goods items have to be managed carefully. The list of goods contains all information about the goods including pictures to minimize the mistake. Manage part list from the Action menu is to make a list of goods. The dialog for entering goods information is as follows:

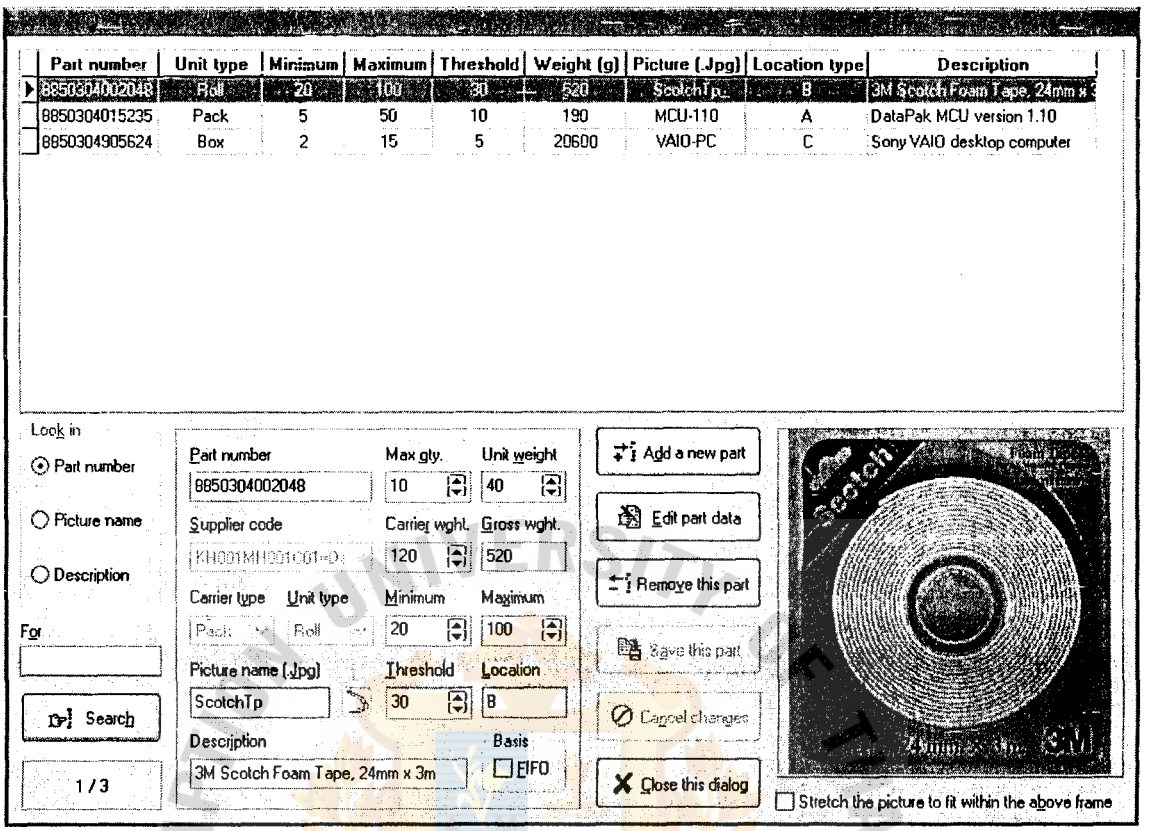


Figure 3.17. Manage Product Dialog.

In case of a great deal of goods, of course, the program supplies search criteria to find the right information by entering information to be searched in 'For field', choosing a criterion search in 'Look in field' and finally pressing 'Search' button.

Part number: A numeric code that helps differentiate the goods from others. Although it can be any combination of numbers, maximum 13 digits are supported by WMS, it is recommended to use EAN-13 barcode that usually found on the goods container. If it is the case we just need to put the cursor into this Part number input field and scan the barcode to enter data here.

Supplier code: This code is assigned to a certain suppler by warehouse manager or some one who has the authority to do it in order to manage the

suppliers easily. The code is obtained from Manage supplier list as shown above.

Carrier type: WMS supports many standard goods carriers that are usually found in practice such as Pallet, Tray, Tote, Bin, Box, Bag, Pack. The carrier can contain one or more units.

Unit type: The program has also supported many kinds of goods unit types comprising: Carton, Box, Pack, Bag, Reel, Roll, Bottle, Jar.

Max qty: Maximum number of units per carrier, maximum 9,999 supported.

Unit weight: Specified in gram (g), maximum 999,999 supported.

Carrier weight: The weight of carrier, specified in gram (g), maximum 9,9999.

Gross weight: Gross weight of goods units and its carrier, supported in gram (g). You don't have to mention about it because it is calculated automatically from the combination of Max qty, Unit weight and Carrier weight.

Minimum quantity, Maximum quantity and Threshold quantity: These data are very useful for warehouse management when we want to know which part needs to be replenished as soon as possible due to shortage. Because we do not want to store too many units of a part, and we also want to be able to fulfill delivery orders, we will have to choose these values carefully. One way to do this is using experience; another is making statistic calculation on history data.

The software will constantly monitor the number of available units of each part to be able to show you, when necessary, which needs attention. Although attention will be raised when a part is falling shorter than Threshold, the software will still allow delivery of that part until none

remained. This makes sure that while you are ordering more units, delivery orders for that part will still be fulfilled.

Picture name: If you use pictures, here is the name of the file to be stored inside system database. Its extension will be automatically .Jpg, since WMS automatically converts any picture you use into this format to save space, so you do not need to include extension while typing name. On the right you will see the picture of current part, and, in case you need to change it, just click the small button on the right of the Picture named input field:

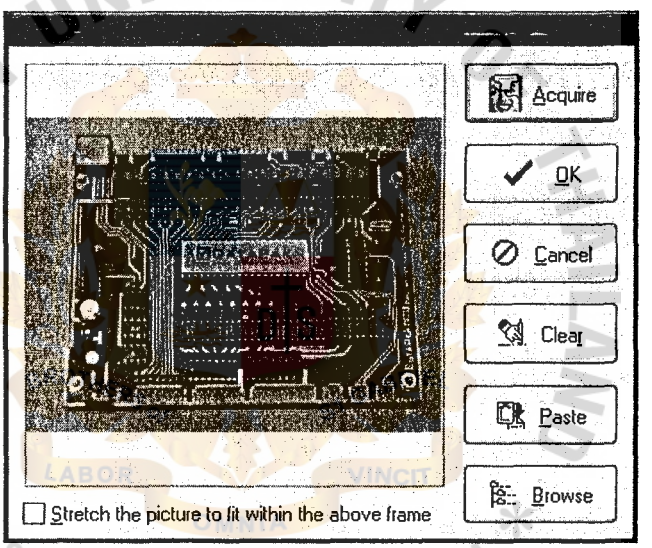


Figure 3.18. Import Picture Dialog.

As shown in the dialog above, there are 3 ways to import a picture into system database:

(1) Acquire: To scan it from a picture scanner (Any type of picture scanner possible)

(2) Paste: To get it from Windows® Clipboard

(3) Browse: To read it from a disk

Normally, with barcode scanning we nearly eliminate the risk of mistake, and the combination of barcode scanning and picture we can completely eliminate mistake. Therefore, this combination will help users to manage goods in warehouse without a mistake.

Location type: Suitable type of location inside the warehouse that can be used to store this new part. Note that location type here has to exist inside the warehouse; otherwise any incoming unit of this part will find no location to stay.

Description: Explanation on what kind of goods this part is.

3.7.5 Preparing entry orders

When we need to order goods for storing in our warehouse, we need to inform the WMS about incoming orders and their details. It is similar to making orders to our suppliers because it informs them what to send and in what quantity to us. The preparing entry order process here follows the same concept to let WMS know what to check when it receives incoming goods from our suppliers later.

In order to store goods in the warehouse, the program needs to be informed about incoming orders and their details. It is similar to making orders to suppliers because it informs the program what to be sent and in what quantity to the warehouse. The preparing entry order process here follows the same concept to let the program know what to check when it receives incoming goods from our suppliers later.

To make the orders, choose Prepare entry orders from the Action menu or choose Entry orders from the Toolbar. The dialog for working is as follows:

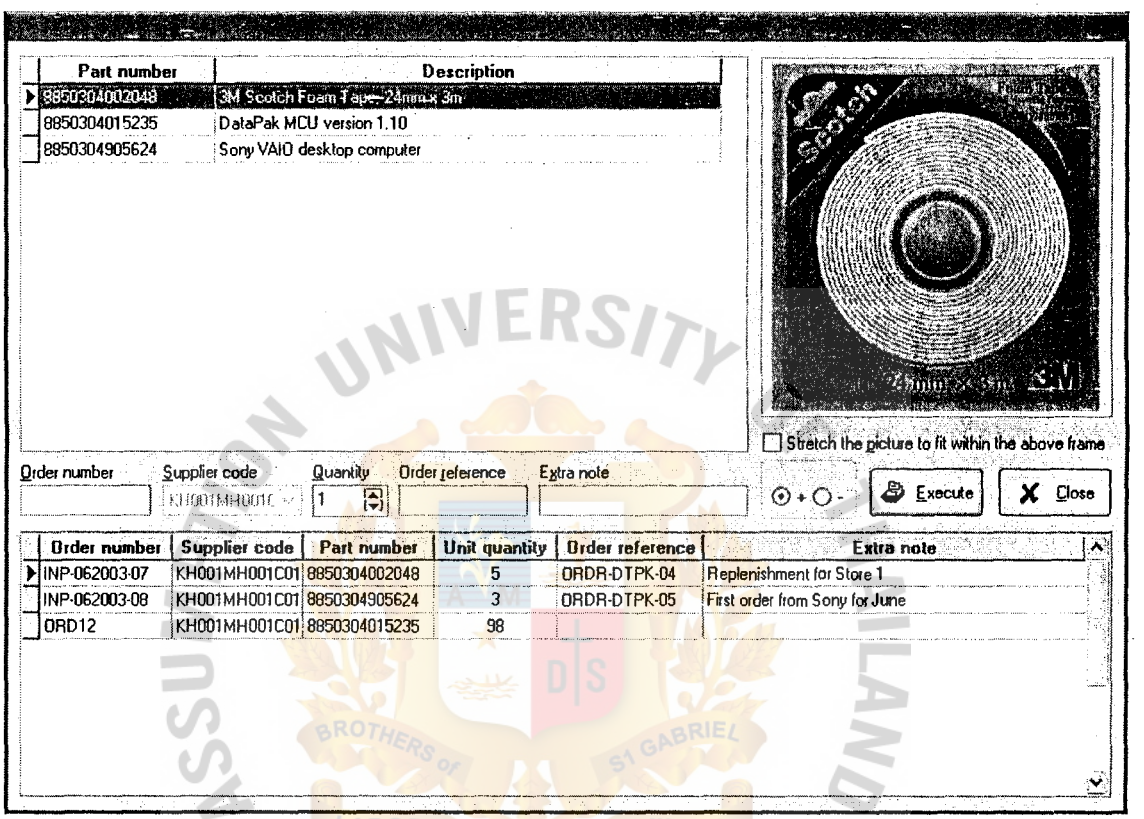


Figure 3.19. Entry Preparation Dialog.

To execute the orders, the user performs the following steps:

(1) Choose items of goods listed in upper table in the dialog.

(2) Check the radio box (+)

(3) Enter information for ordering in Order number, Quantity, and some others in appropriate field.

(4) Click Execute button to put the items of goods into waiting list.

Note that, after performing the orders the items of goods will be listed in lower part of the dialog. However, these items have not been sent to the warehouse actually.

In order to remove the items out of the waiting list, (the actions are similar to above for the items in the waiting list) check the radio box (-).

3.7.6 Printing barcode labels

By applying barcode labels, which contain necessary management data, on the goods, we can use the barcode scanning to eliminate typing errors and make stock auditing process easier.

Choose Printing barcode labels from the Action menu or choose Barcode labels from the Toolbar. A dialog appears as shown in the example below:

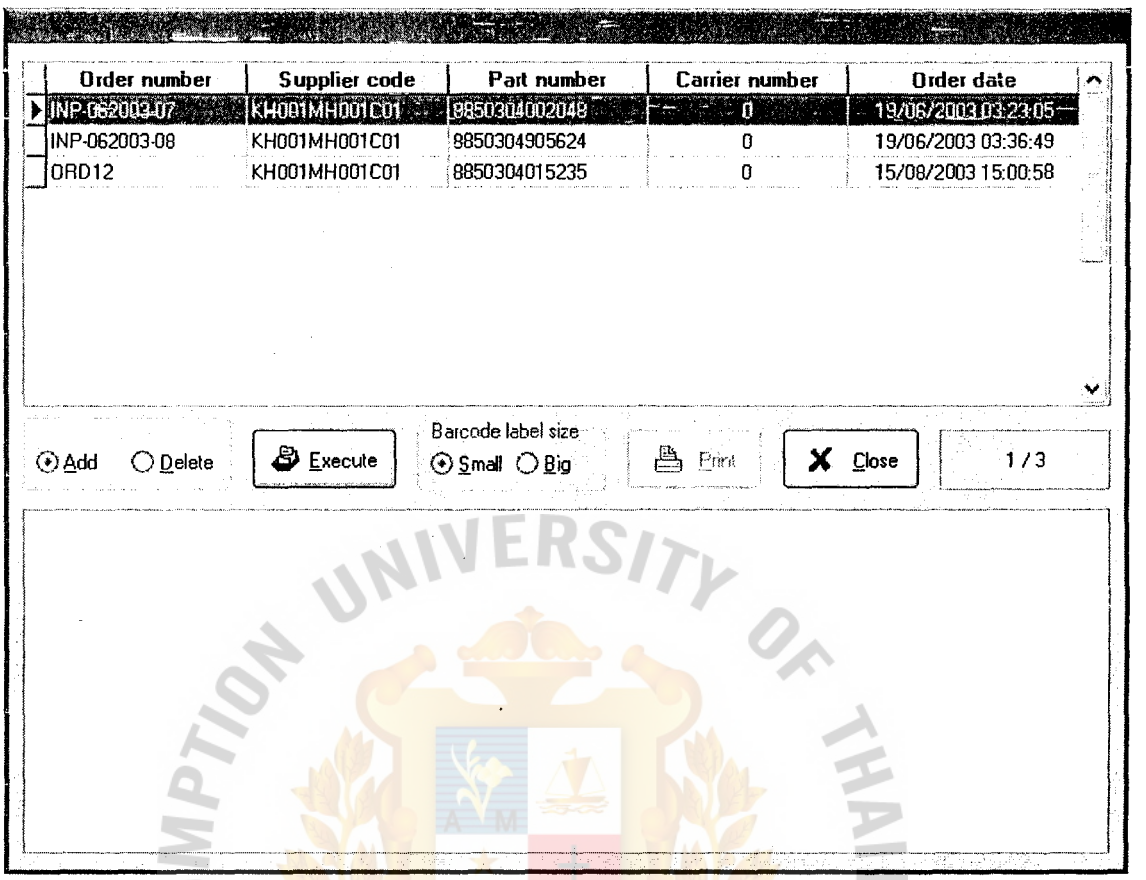


Figure 3.20. Print Barcode Dialog.

The items in the waiting is above and the items for printing barcode will be in the under part of dialog. To make a barcode printing list, the user chooses the items in the waiting list, then chooses radio box Add and finally click Execute button, the chosen items will be moved to waiting list. Depending on the size of available barcode label the user can choose Small or Big.

To print out barcode labels, choose Print button.

3.7.7 Making actual input of ordered parts

Upon incoming of ordered parts, the user has to check data against entry orders in the waiting list by choosing Input orders on the toolbar or

Make input orders from Action menu or pressing F4. The dialog for this function is shown in the diagram:

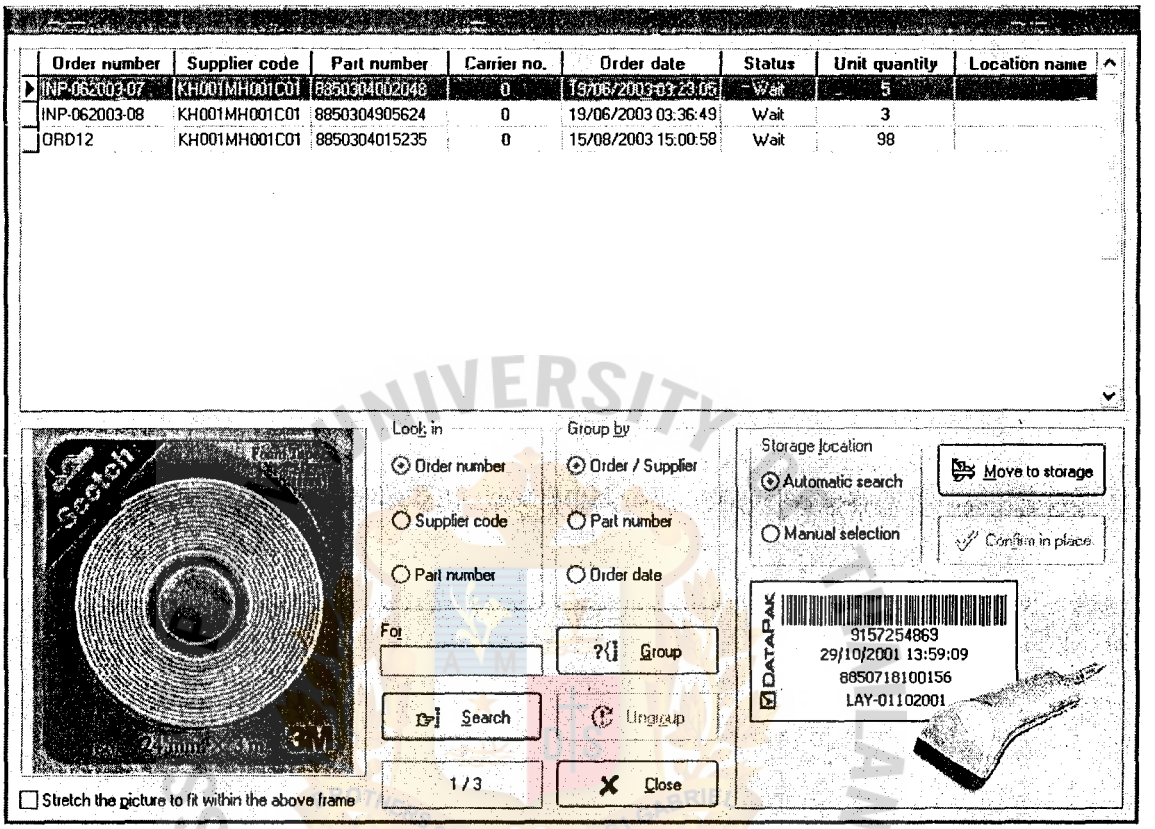


Figure 3.21. Input Dialog.

The program supports the search criteria in Look in field. In addition, the program also supports a function for grouping items of goods after barcode labels are printed in Group by field.

Automatic search: searching for storing goods will be automatically performed by the program.

Manual selection: the locations for storing goods will be chosen by the manager or the user.

Move to storage: after choosing the items of goods listed and clicking this button, the program will execute the orders to move goods into the warehouse. Note that, this step is only a process to move goods into the warehouse. The Status column in the dialog shows the actual status of goods.

Confirm in place: when the moving of goods into the warehouse is done, click this button to confirm that it is physically in the chosen location already.

Units that are marked Wait or Move will still stay in the list and will only be removed when the user selects them and presses Confirm in place to mark them Done.

3.7.8 Preparing delivery orders

When the manager receives orders to deliver out some goods kept inside the warehouse, the manager needs to let the program know it in advance. The reason for this is similar to preparing entry orders: to allow the program find the right goods from the right locations in the warehouse.

To make an order to deliver goods, choose Prepare delivery orders from the Action menu or Delivery orders on the Toolbar. The dialog for making orders is as follows:

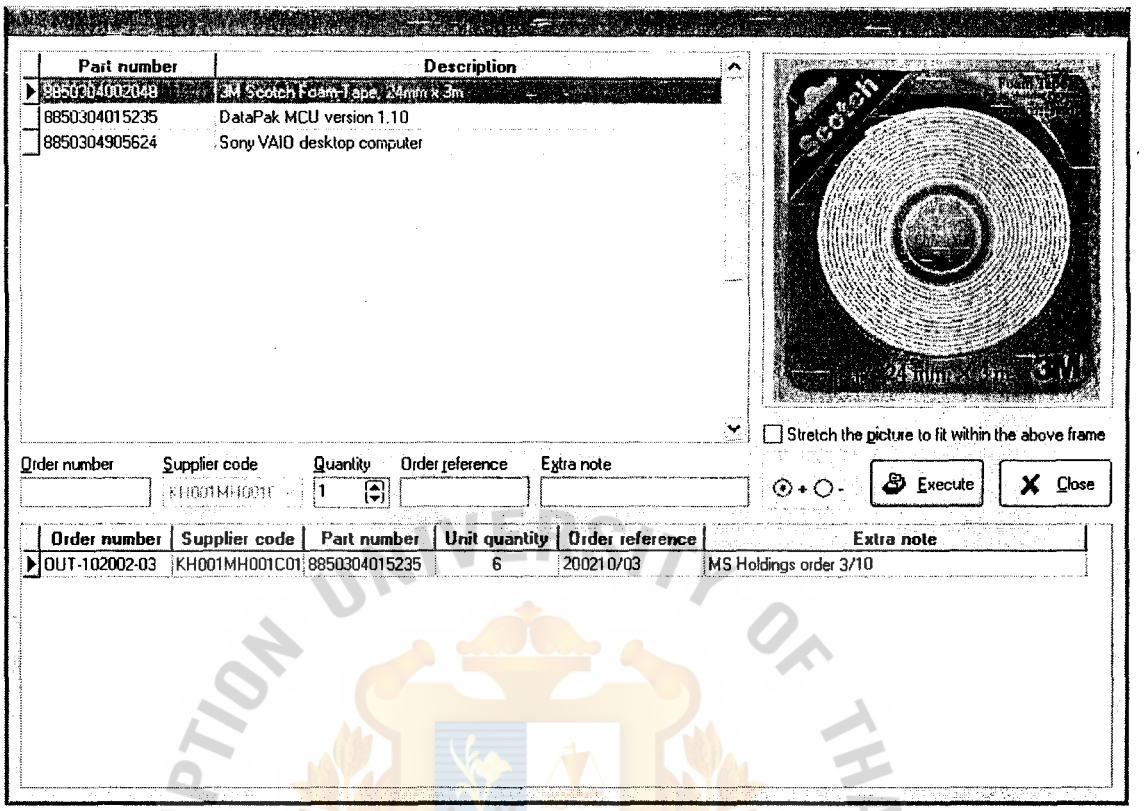


Figure 3.22. Delivery Preparation Dialog.

The upper part of the dialog contains a list of goods stored in the warehouse and lower part is a list of goods that will be ordered for delivery. To choose a list of goods for delivery, the user performs the following steps:

(1) Choose items of goods from the warehouse by highlighting them.

(2) Enter Order number, Quantity and other information in appropriate field.

(3) Check the radio box (+)

(4) Finally, click Execute to perform the command.

The chosen items will be transferred to the delivery list in the lower part with the required quantity and included information.

In order to delete the items out of the delivery list, choose the items that will be deleted and choose radio box (-), and finally click Execute.

3.7.9 Making actual output of ordered parts

When it is time to send the ordered parts out, or when we want to book ordered parts out to prevent them from being taken by other orders, this function is needed.

Choose Make output orders from the Action menu or Output orders on the Toolbar or F5. Below is the example:

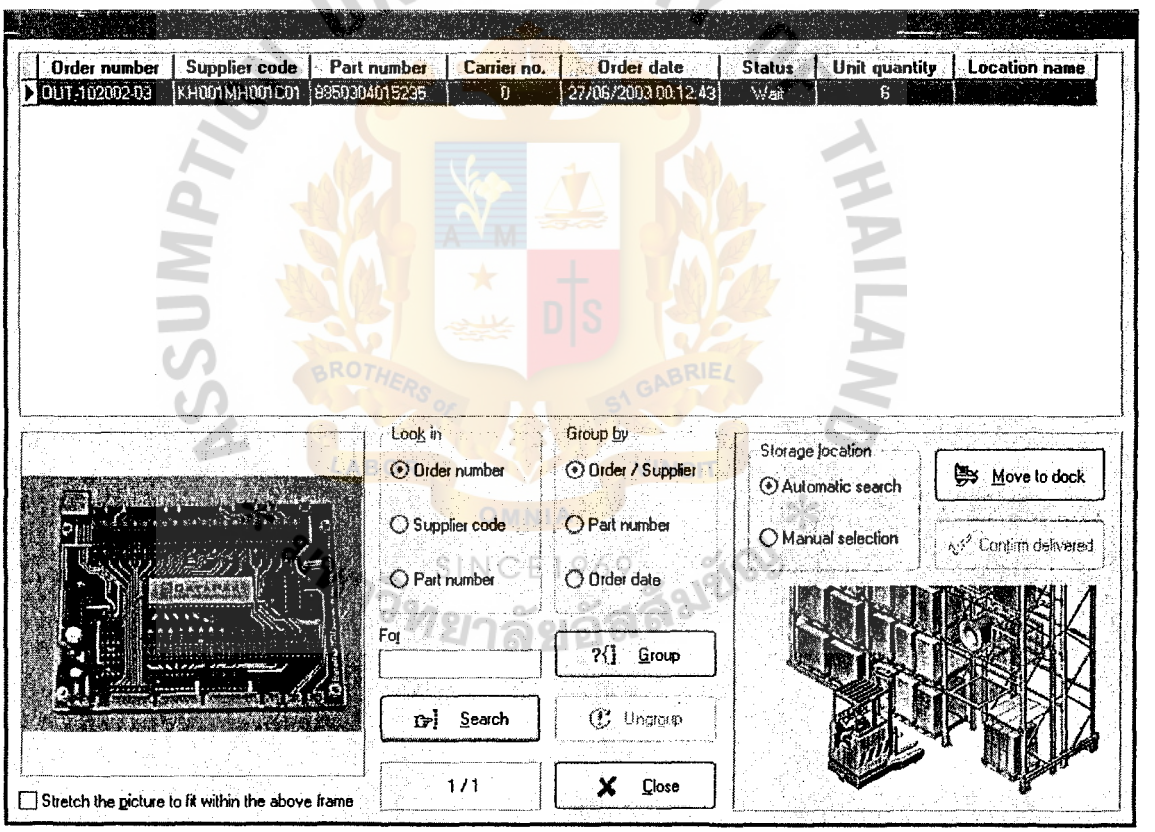


Figure 3.23. Delivery Dialog.

The functions in this dialog are similar to Making actual input of ordered parts.

3.7.10 Changing data of entry / delivery orders

Data of entry / delivery orders are changeable. This feature is for the users who have sufficient authority only to change some data if necessary. Selecting Change order data from the Action menu. A dialog for this function is shown below with items listed:

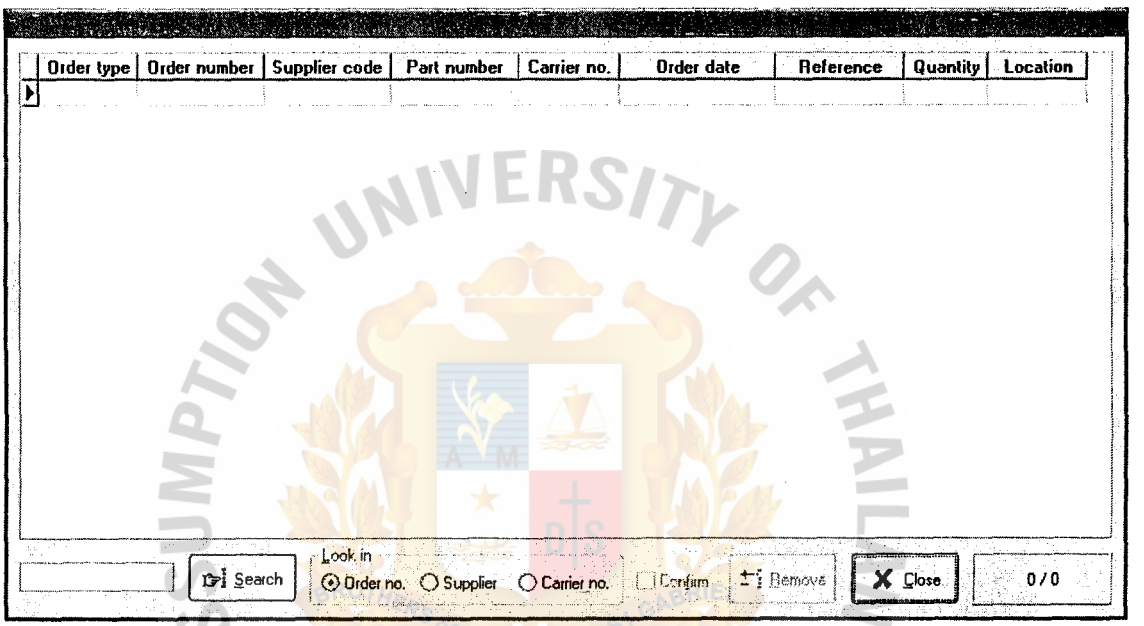


Figure 3.24. Change Order Data Dialog.

In case you want to change any above item, you just highlight it, then check the check box Confirm and finally choose Remove. The item will be deleted out of the list of order.

Note: the status of an order can be changed only in one direction: Done-Move-Walt.

3.7.11 Changing data of storage locations

In some special cases, a user with sufficient authority wants to manually alter the data associated with storage locations in the warehouse, this function is for this purpose.

Selecting Change storage data from the Action menu. The dialog shown below will appear to allow the user change status of a location (Full, Empty, Booked- In, Locked, and so on), its type and a note associated with it:

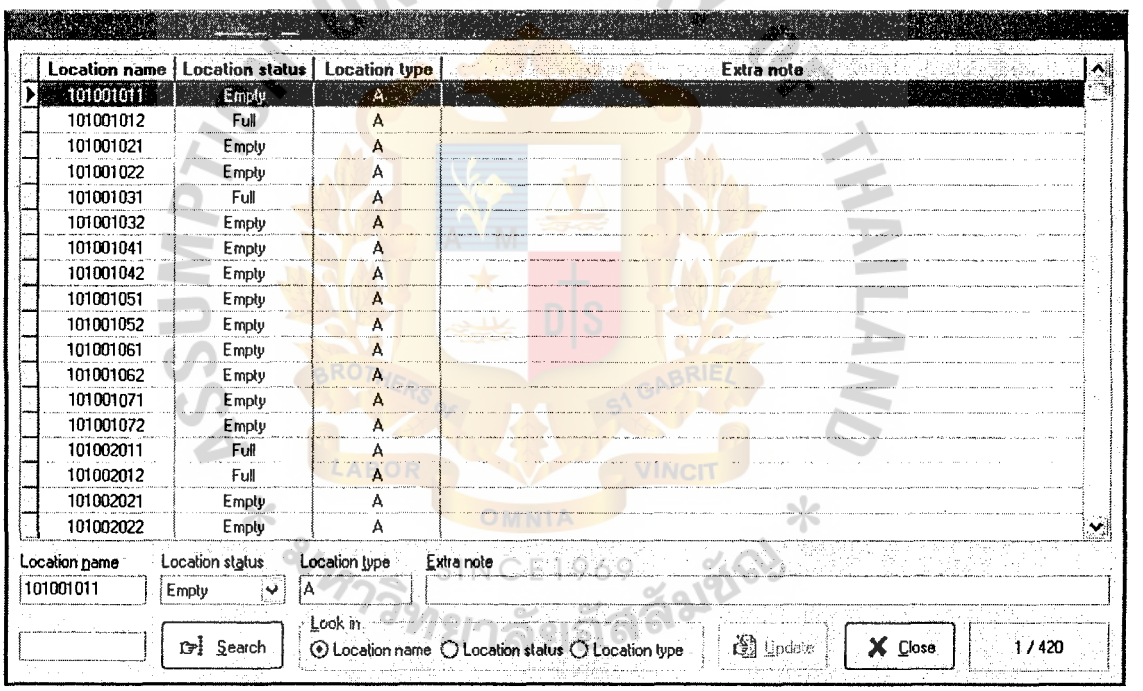


Figure 3.25. Change Location Data Dialog.

After all corrected data related to each location entered, choose Update to change the previous status. This procedure is repeated for all locations that are necessary to be changed.

3.7.12 Changing the interface language

The default interface language of the program is English. This function is used to change from the default language to another. The program only supports one more language other than the default language, namely Vietnamese. In selecting Change default language in the Settings menu, the dialog for the language changed is as follows:

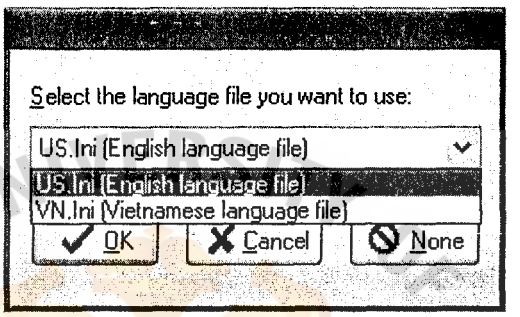


Figure 3.26. Change Language Interface Dialog.

After choose the necessary language, click OK to change.

The user can choose any interlaced language as long as it is defined in the database.

One of the highlighted features of the program is creating any new language that is not available in the program. To create a new interface language for the program the user has to follow the following steps:

(1) Install new font that is necessary for the new language.

(2) Translate all text form the default language to the new one.

(3) Choose Change default language in Settings menu to load the new language.

To create a new language, choose Make new language file from the Settings menu to create a file that contains text for interface within the program:

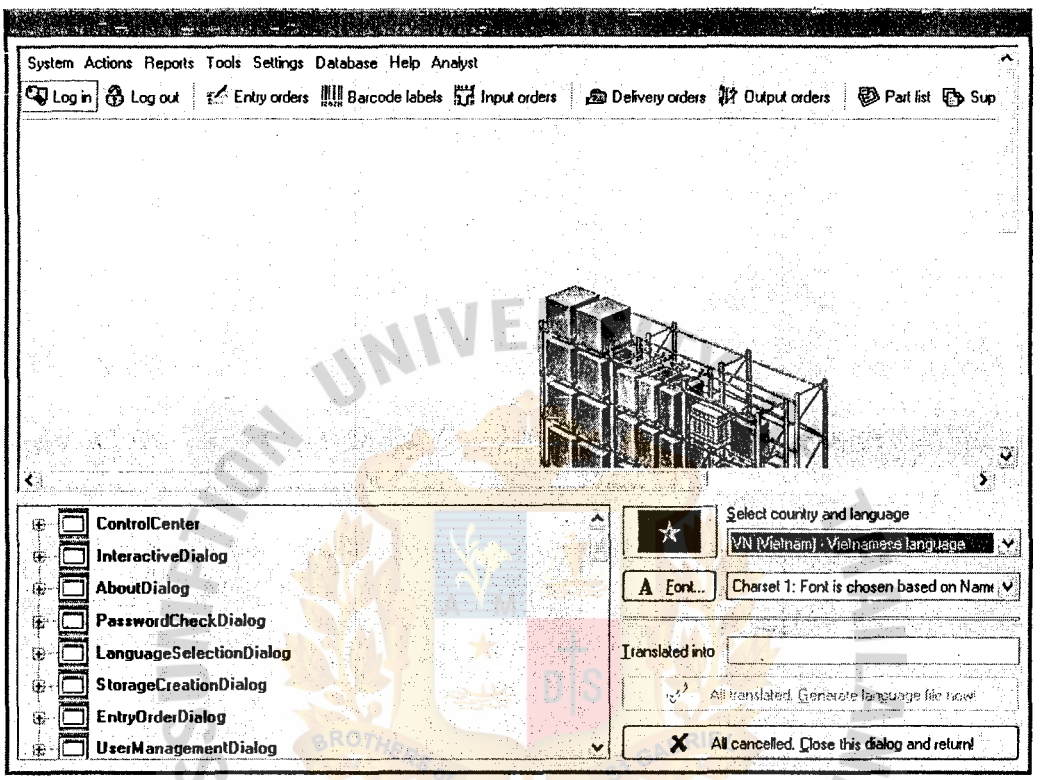


Figure 3.27. Modify Text Interface Dialog.

In the lower left corner that contains text, the user chooses text and translates it into the required language line by line with the appropriate choice in Select country and language as well as in Font.... Note that the program will automatically make a new file with the name comprising short forms of capital letters in the field of Select country and language with extension of ini. The new language file will be saved in the directory where the program has been installed, for example C:\Program Files\Warehouse Management System\Language. After all the texts have been translated into

the new language, click All translated Generate language file now to save in file. If the user selects All cancelled, Close this dialog and return, all entered data will be lost.

3.7.13 Changing the time duration of user action and order logging

The program supports the function of changing the time duration of user's action and order logging. Logging helps management to review all users actions and past orders but it is also space consuming, therefore we should specify a suitable time duration for keeping past records.

Choose History recording limit from the Settings menu. There will be some options which are as follows:

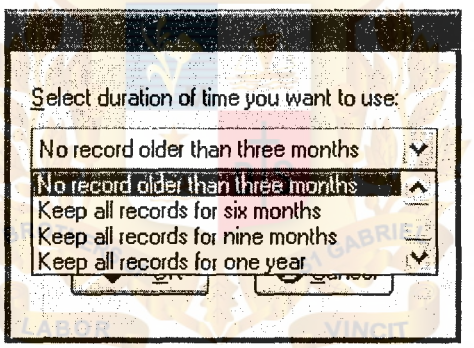


Figure 3.28. Change Time Duration Dialog .

Note that the new time duration will affect the way the program which stores past records in the next run of the software only.

3.7.14 Compacting the system database

Due to frequent changes inside the database, for example when more goods units are added in or removed out, or orders are put into or deleted from waiting list, the system database will become bigger since the deleted data are not physically removed but just marked as unused. If the size of

database is fairly big, it will slow down the whole system because of disk accessing time, especially on the computers having slow disks or old CPUs.

By letting the software affects its database, meaning to physically remove unused data, the database size will be smaller resulting quick response time.

By choosing Compact database from the Database menu, the program will execute this function automatically.

Note that this process may be quite time-consuming so we should only do this when the system becomes noticeably slower.

3.7.15 Exporting the system database

To facilitate connection to other software inside Window®, we can export content of any of the four (4) system database files using standard data exchange format CSV (Compatible with database software and Spreadsheet software).

Choose Export database from the Database menu:

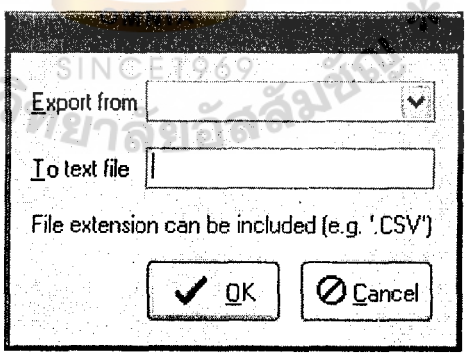


Figure 3.29. Export Database Dialog.

Export from: the user can choose the appropriate list for exporting.

To text file: location and name of the file to be exported.

3.7.16 Making backups of the system database

This is a very important task in warehouse management because by keeping database backups frequently, we eliminate the risk of losing all warehouse management data, say, due to disk crash, hardware failure, or even fire.

On request, the software will immediately make a backup of its database and save into the system Backup directory in a sub-directory named after current day of week. For example, the day when we choose to make backup is Wednesday, and the directory where we installed WMS is C:\Program Files\Warehouse Management System, so a duplication of the system database will be saved into C:\Program Files\Warehouse Management System\Backup \Wed directory on the request.

Choose Backup database from the Database menu to do this function. Note that the program does not keep record on what date the backup was made because it assumes that users will make backups at least once a day. Therefore there will have database backups for maximum a week only. The user must move backups into other places or media with proper naming should you need to keep backups longer than that.

3.7.17 Printing storage location labels

The program supports the function of printing storage location labels. As a productivity tool, location label printing feature of the program will help users to apply barcode on storage locations inside the warehouse. This will be useful for warehouse staffs when checking locations against requested ones in input / output orders. Apart from visual check on

alphanumeric characters, the users can also use a mobile barcode reader to read these labels thus eliminating errors and shortening time.

Choose Location labeler from Tools menu. It is shown in the diagram below:

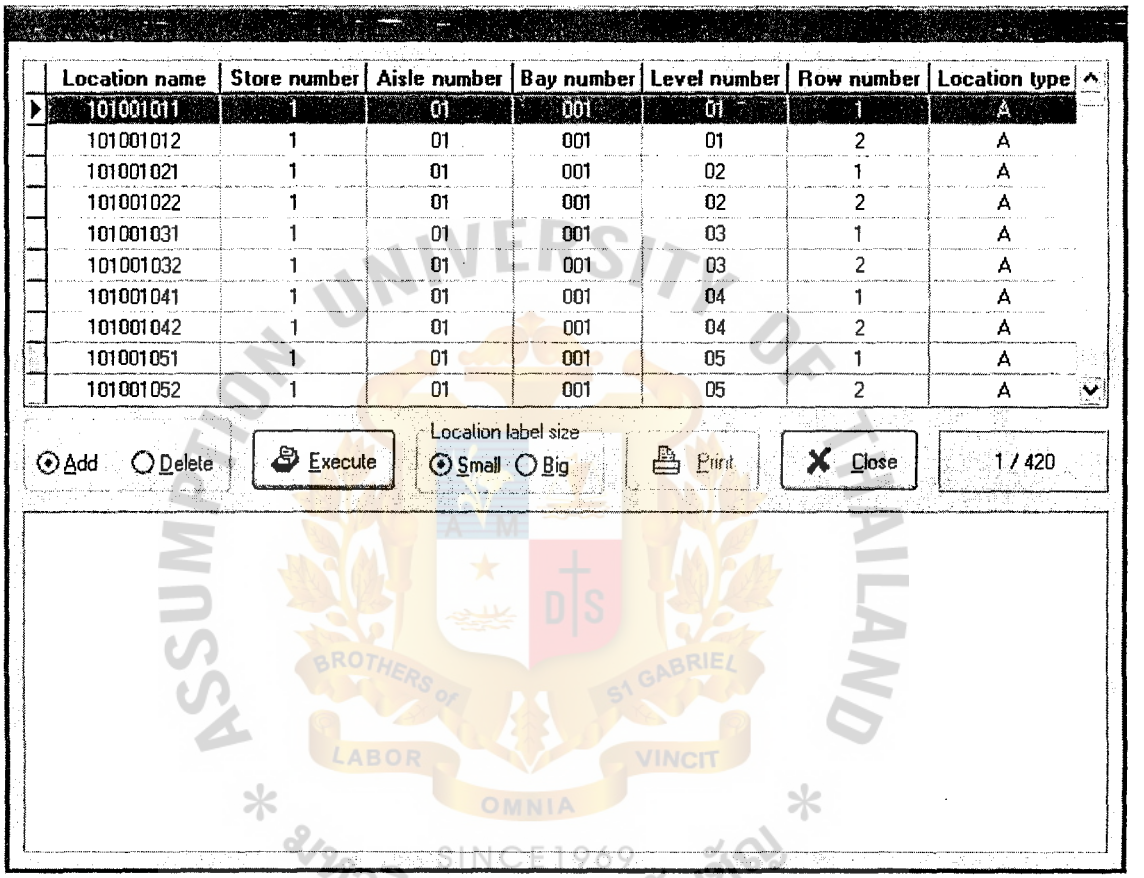


Figure 3.30. Print Location Label Dialog.

3.7.18 Reading reports

WMS supplies a built-in report reader to read the reports made by WMS.

Report reader helps the user to read the quick report file created by the program in a formatted form.

Choose Report reader from the Tools menu. The form will be as follows:

Figure 3.31. Report Reader Screen.

3.7.19 Reporting parts list

Registered part list is the list of goods registered before being stored with information as in Manage part list. Choose Registered part list from the Reports menu. The dialog for this is as follows:

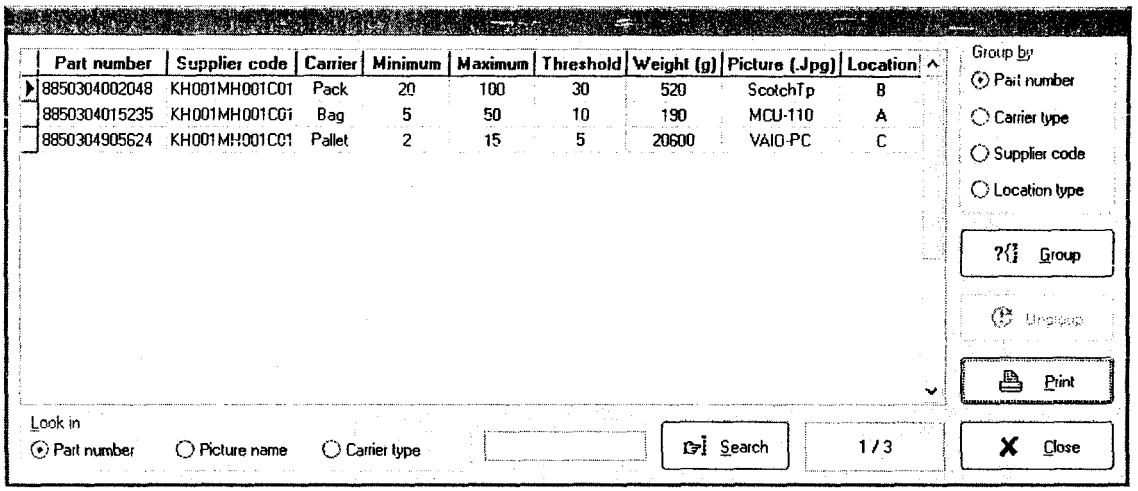


Figure 3.32. Create Product Report Dialog.

3.7.20 Reporting parts that need replenishment

Low inventory list helps the user to know what parts will need replenishment (At least once a day recommended), for example to start ordering new units from our suppliers. Select Low inventory list from the Reports menu. The dialog for this is shown below:

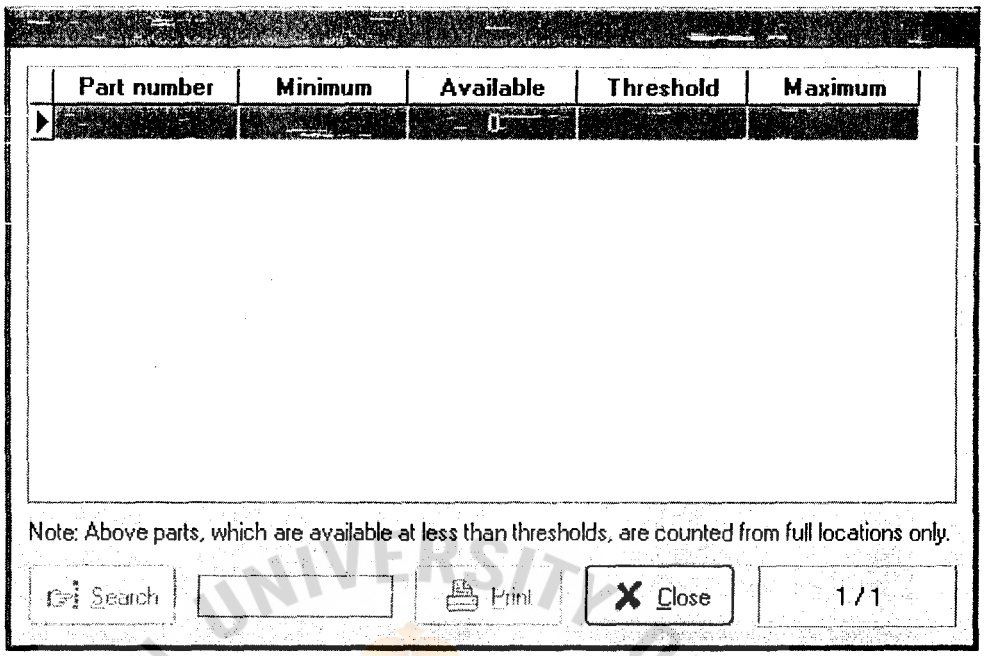


Figure 3.33. Creating Replenishment Report Dialog.

Note that, available units are counted from locations that physically contain goods and are not booked out nor locked. That also means what is shown here really is available for delivery.

3.7.21 Reporting past and currently waiting orders

This function is used to trace the input/output orders in the past as well as the current waiting orders. Choose Recorded order list from the Reports menu. It can be seen in the dialog below:

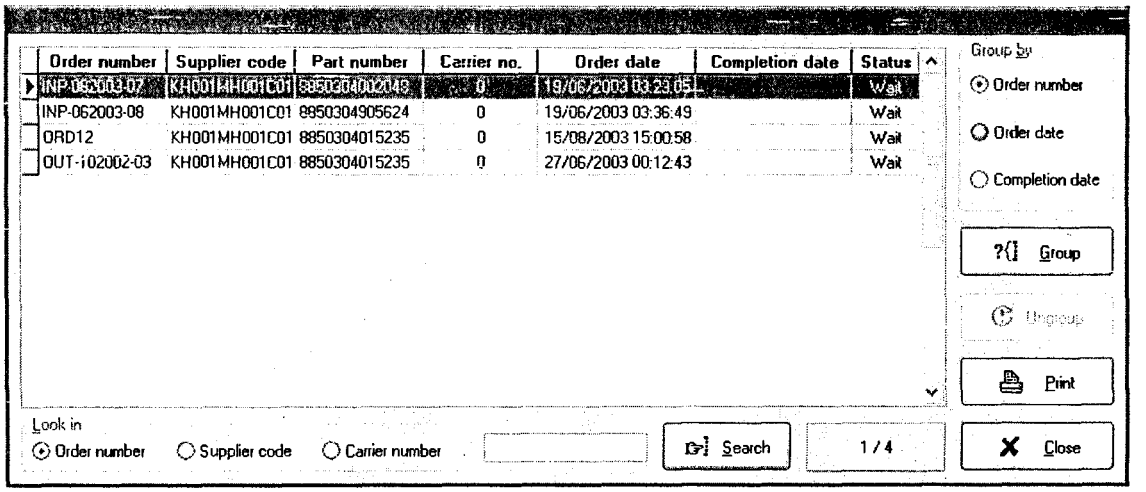


Figure 3.34. Creating Order Report Dialog.

3.7.22 Reporting registered users

Registered user list is used to manage the list of users who have authority to work with the program. To see this list, select Registered user list from the reports menu. It is shown in the dialog below:

Figure 3.35. Creating User Report Dialog.

3.7.23 Reporting status of storage locations

Storage location list is to report the current status of storage locations whenever the manager needs to know the status of storage locations inside the warehouse. By selecting Storage location list in the Reports menu, a dialog will appear as follows:

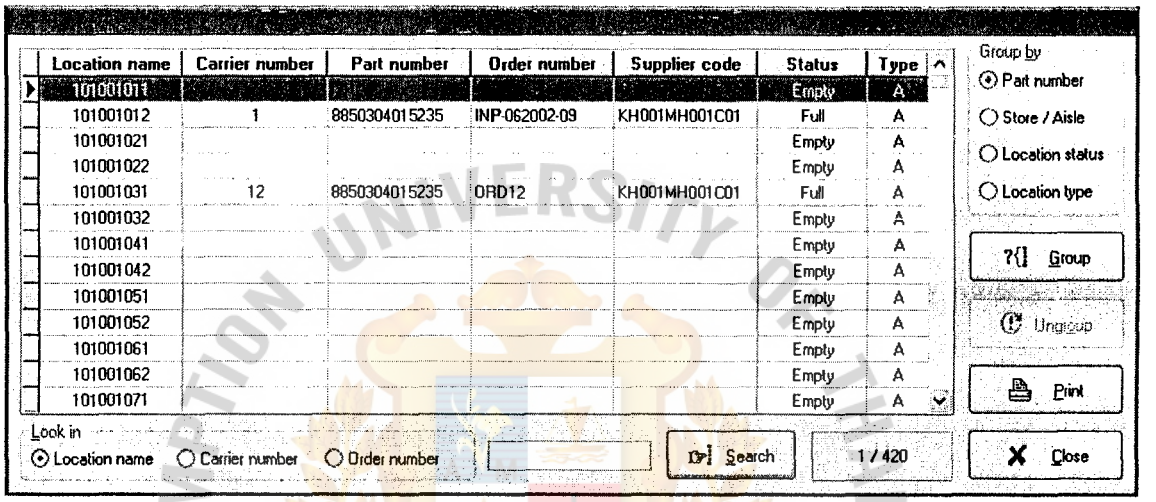


Figure 3.36. Creating Location Report Dialog.

By choosing an element inside "Group by" the user can shorten the list in which any goods having the same property will be put in one group. This is easier to observe and classify goods.

3.7.24 Reporting stock balance

Stock balance is to report detailed input/output activities and inventory status. Choose Stock balance report from the Reports menu for this. It is shown in the following dialog:

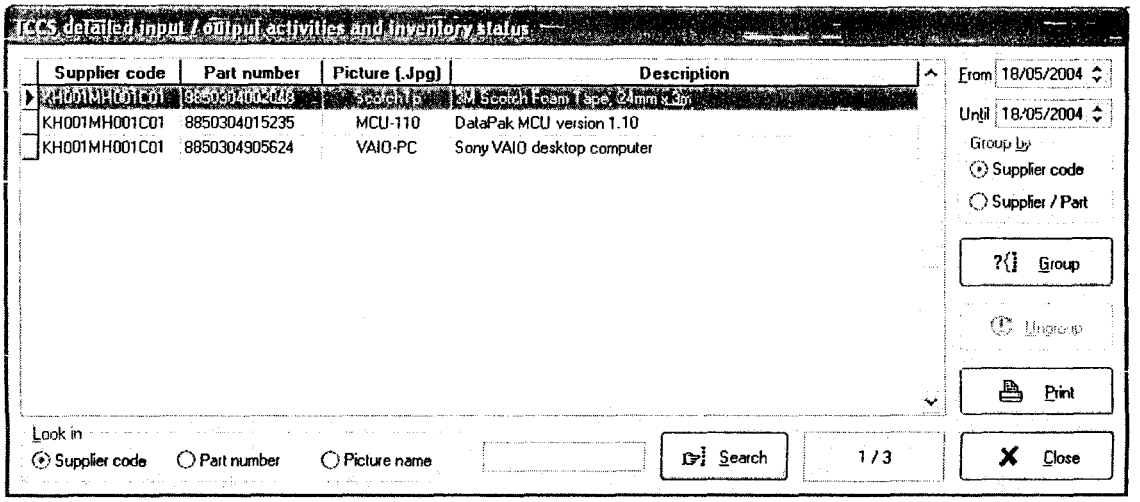


Figure 3.37. Creating Inventory Report Dialog.

3.7.25 Reporting suppliers list

Registered supplier list shows all suppliers with some related information. To see this list, choose Registered supplier list from the Reports menu. The dialog of this list is shown below:

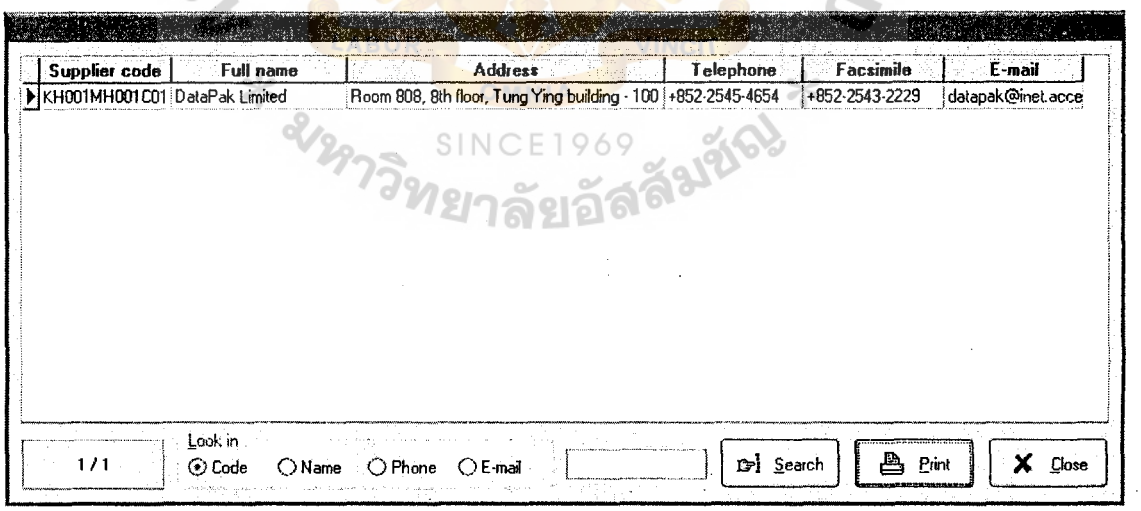


Figure 3.38. Creating Supplier Report Dialog.

3.7.26 Reporting the storage status

Status report will help the user to monitor the actual status of the warehouse such as the percentage of the warehouse used as well as the remained space.

Select Storage status report from the Reports menu, is shown below:

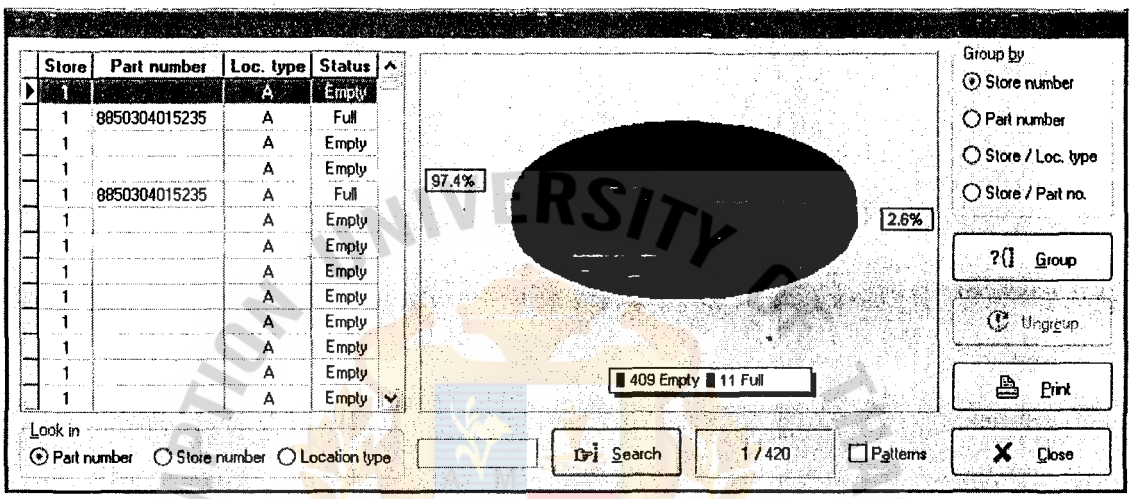


Figure 3.39. Creating Storage Status Report Dialog.

3.7.27 Reporting user actions recorded

After some time a supervisor or a manager may need to know who have been doing what and when with the software, that is the time when we need to see Action list, which is invoked by selecting Historical action list from Reports menu:

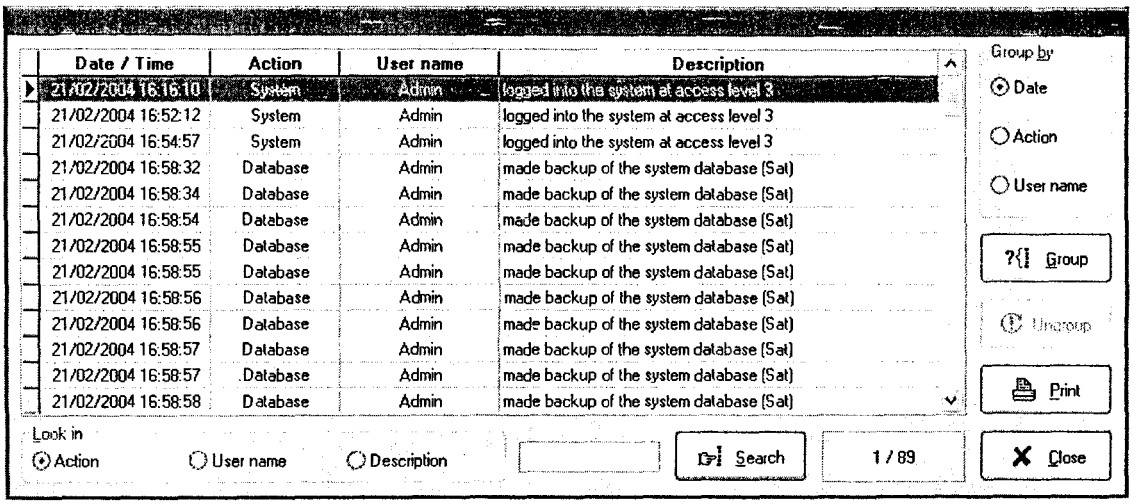


Figure 3.40. Creating User Action Report Dialog.

3.7.28 Restoring the system database from backup

We might need to do this when some accidental cases happen. Selecting Restore database from Database menu will instruct the software to help us. On request, the software will ask the user from what backup is restored in the database:

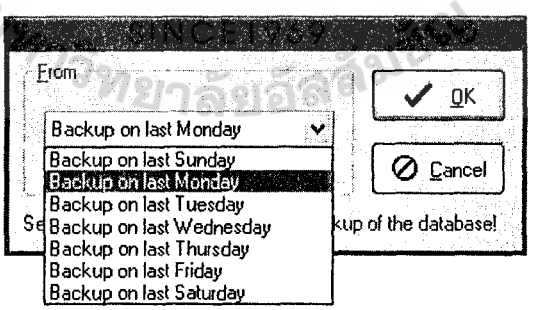


Figure 3.41. Restoring The System Database Dialog.

3.7.29 Stop working with the system

After finishing his/her work, a user should inform the system that he / she is no longer working to let it stop recording user actions. This is very important because by doing this, any action done later to the system database will not be responsible by that person (Unless he / she starts working again). Pressing F3 or selecting Log out from System menu or choosing System logout on the Toolbar or press Alt+F4 will instruct the software to start security checking process all over again:

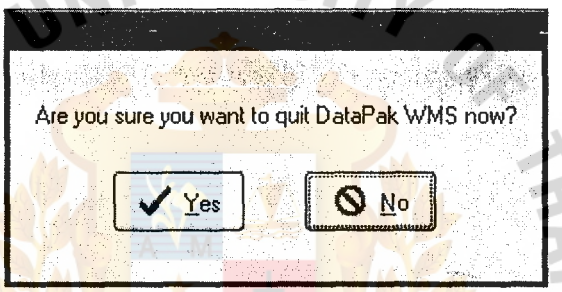


Figure 3.42. Exit System Confirmation

3.8 Hardware and Software Requirement

Running of the WMS is also supported via network for multiple operation terminals. The program installed on one computer can share with multiple users without conflicting. This function is very useful for remote working.

To run the program in this manner, the following conditions should be guaranteed:

(1) Supported network must be available.

(2) The computers have to connect together with the same protocol, for example, TCP/IP.

(3) The computer where the program is installed has to share the directory that contains the program. Database security

(a) Minimum requirements

(1) Personal computer (PC) Pentium 200 MHz, 64-MB RAM, 200-MB free space hard disk

(2) Microsoft Windows operating system Windows 98 or later

(3) Any black-and-white printer

(b) Recommended configuration

(1) Personal computer (PC) Pentium III 500 MHz, 128-MB RAM, 1-GB free space hard disk

(2) Microsoft Windows operating system (Windows 2000 or later)

(3) Any color printer

(4) Any barcode scanner with keyboard-wedge ability

(c) Optional devices and accessories

(1) Any picture scanner that conforms to TWAIN standard

(2) A4 standard sticker paper for barcode label printing, 24 and 44 sticker types

(3) A4 standard glossy picture-printing paper

(4) Uninterruptible Power Supply (UPS)

3.9 Database and Access Security

(a) Database security

(1) System database is password-protected thus eliminates risk of exposing data to unauthorized person.

(2) Database activities are done in a way that makes the system failsafe when accidental situations happen, such as power failure or computer hangout.

(3) Database can be backed up and restored at will to maximize recovery possibility. Usually maximum 7 backup copies of database are provided (7 days), however customer can also keep more elsewhere. The most up-to-date copy is always kept in the system main storage place.

(b) Access security

(1) Every user of the system has to be registered before they can actually log into the system and activate functions. A system user can register new ones, remove or change authority of existing ones only if they are his/her subordinates.

(2) All activities that involve security or change the way the software behaves will be carried out against security level of the users. These activities will be immediately recorded into the system log file and remain there for a predefined period of time for later examination.

IV. PROJECT COST JUSTIFICATION

4.1 Receiving Operation Data Entry

(a) Current Operations:

(1) Manual paper-based receiving.

(2) 6,000,000 characters per year keystroke entries to enter receiving results into the computer.

(3) 1.2 full time data entry operators.

(b) Proposed Operations:

(1) On-line real-time RF Receiving with bar code license plates applied to inbound inventory.

(2) Online bar-coded receiving can reduce this to 600,000 keystroke entries per year.

(3) Operators manually searching for put away locations to store inventory requires 110 hours per week.

(c) Potential Payback

(1) Assume that 1 error occurs in every 300 keystrokes which is an industry-accepted standard.

(2) Assume that a bar-coded receiving operation produces an error at the rate of 1 in 3,000,000.

(3) Assume the cost of 100 baht per error to pay for lost time to correct the inaccurate inventory.

(4) Annual error reduction of 18,000 errors @ 100 baht saves 180,000 baht per year.

(5) Eliminating 1 data entry operator saves 120,000 baht per year.

4.2 Receiving Operations A/R Error Correction

(a) Current Operations:

(1) A total of 1,000 errors per year were recorded (at returns receiving) causing problems which require a credit memo, RMA, customer invoice reconciliation or additional billing.

(b) Proposed Operations:

(1) Eliminate manual keypunching of inbound receiving records through online real-time RF Receiving.

(2) Assume 95% reduction in human errors involving data capture.

(c) Potential Payback

(1) Assume that each returns receiving error generates 700 baht in cost related to lost revenue and/ or time spent on A/R discrepancy handling.

(2) Annual billing error reduction of 950 errors. Each error costs 700 baht. Therefore, 665,000 baht can be saved per year.

4.3 Put away Operations

(a) Current Operations:

(1) 3 dedicated put away operators

(2) Operators require 120 hours/week to perform put away.

(3) Operators perform 1,500 put away per week.

(4) Forklift operator salary is 120000 baht + 20% fringe benefit.

(5) Operators manually search for and record put away locations on cards which are subsequently keypunched.

(6) Approximately 800,000 keystroke entries/year.

(a) Proposed Operations:

(1) Online real time RF Put away with bar code license plates applied to storage locations for validation.

(2) System-directed Put away.

(3) Replenishment and put away RF task interleaving.

(b) Potential Payback

(1) System-directed put away will reduce forklift travel time by 50%

(2) RF Task interleaving to provide 10% productivity gain.

(3) Estimated savings in put away labor of 40 hours/week = 120,000 baht per year.

(4) Data entry elimination of 800,000 keystrokes/year eliminates 2,667 inventory location errors @ 100 baht per error = 266700 baht per year savings.

4.4 Order Picking /Packing /Checking Operations

(a) Current Operations:

(1) 20 full-time dedicated order pickers and packers in a typical week.

(2) Packing performed as a separate function and requires 100% of product to be re-handled.

(3) Operators require 750 hours/week to perform picking and packing.

(4) Operators pick and pack on average 30,000 order lines per week: net rate 40 lines/hour.

(5) Operator salary is 120000 baht + 20% fringe benefit.

(6) All pick exceptions are keypunched into the system at shipment completion.

(7) 2 full-time checkers validate outbound order accuracy at loading dock.

(b) Proposed Operations:

(1) Online real time RF picking and packing into bar code license plated shipping cartons.

(2) Packing, application of shipping labels and paperwork remain unchanged but re-handling is eliminated.

(3) To reduce checking function 12 months after startup.

(c) Potential Payback

(1) Combined picking and packing with the use of RF terminal to yield a 20% gain in productivity to 48 lines/hour.

(2) 3 pickers/packers eliminated saves 360,000 baht/year.

(3) Eliminate 1.5 checkers in 12 months time for total savings of 180,000 baht/year.

(4) Pick exception keypunching:

(5) Activity will be eliminated but considered savings negligible since the supervisor is still required to manage outbound operations.

4.5 Replenishment Operations

(a) Current Operations:

(1) 2.5 dedicated replenishment operators.

(2) Operators require 100 hours/week to perform replenishment.

(3) Operators perform 1,200 replenishments per week.

(4) Forklift operator salary is 120,000 baht + 20% fringe benefit

(5) Operators manually search for overstock locations, execute and record replenishment tasks onto paper cards which are keypunched.

(6) Order pickers chase down replenishment operator when a pick slot is short on stock.

(7) Approximately 625,000 keystroke entries/year.

(b) Proposed Operations:

(1) On-line real-time RF Replenishment with bar code license plates applied to storage locations for validation.

(2) Replenishment will be system- directed in batch and dynamic mode.

(c) Potential Payback

(1) System-directed replenishment combined with task interleaving will reduce forklift travel time by 50%.

(2) Estimated savings in replenishment labor of 40 hours/week = 120,000 baht per year.

(3) Data entry elimination of 625,000 keystrokes/year eliminates 2,083 inventory location errors @ 100 baht per error = 208,300 baht per year savings.

4.6 Physical Inventory Count

(a) Current Operations:

(1) Facility shutdown for a total 4 days/year (once every fiscal quarter).

(2) 30 operators hired per count at double pay.

(3) Average cost including fringe is 1,000 baht per operator-day.

(4) Inventory count books are keypunched, resulting in 600,000 data keystrokes.

(b) Proposed Operations:

(1) Real-time system-directed cycle counting will be interleaved throughout day-to-day operations replacing our current cycle count methods.

(2) Eliminates need for physical inventory count.

(c) Potential Payback

(1) 120 operator days x 1,000 baht per day saves 120,000 baht per year.

(2) 600,000 data entry keystrokes yields 3,000 errors at 100 baht per error = 300,000 baht per year.

4.7 Inventory Levels

(a) Current Operations:

(1) Average inventory level of 200,000,000 baht.

(2) Inventory turns 3.6 times/year for an average day of 101 days in hand.

(3) Annual physical count reveals current inventory accuracy at 96.4%.

(4) Inventory carrying cost is 24%.

(b) Proposed Operations:

(1) Anticipate 99.9% inventory accuracy supported by RF and bar code tracking of inventory.

(c) Potential Payback

(1) 3.5% anticipated increase in inventory accuracy

(2) 3.5% x 101 days in hand = 3.5 days of stock currently lost and therefore may be eliminated.

(3) Total reduction in inventory of 7,000,000 @ 20% carrying cost provides savings of 1,400,000 baht per year.

4.8 Paper Reduction

(a) Current Operations:

(1) A total of 212,000 paper documents are annually transferred from the warehouse to the office for subsequent data entry; many of these documents are produced, duplicated or photocopied.

(2) Paper documents include pick/pack slips, receiver documents, cycle count books, and inventory movement cards.

(3) Assume 1 baht per one sheet of paper.

(b) Proposed Operations:

(1) RF paperless operations to eliminate all paper forms

(c) Potential Payback

(1) 212,000 sheets saved /year. A sheet of paper costs 1 baht. Therefore, 212,000 baht can be saved per year.

4.9 Picking /Shipping Accuracy

(a) Current Operations:

(1) A total of 650 RMA's were generated during the fiscal year due to picking, packing and/or loading errors.

(2) Each RMA returned generating additional transportation costs, handling costs, paperwork and re-shipment costs.

(3) Assume 1,000 baht cost per RMA.

(b) Proposed Operations:

(1) The use of RF and bar code scanning throughout picking, packing and loading will reduce errors from 650 to 30 RMA's per year.

(c) Potential Payback

(1) 620 RMA's / year eliminated at 1000 baht per RMA yields savings of

(2) 620,000 baht per year.

4.10 Mobile Equipment Usage

(a) Current Operations:

(1) A total of 6 battery powered forklifts are in use to primarily handle put away and replenishment.

(2) We are budgeting 1,400,000 baht for the purchase of a new forklift in the next 3 years to handle increased workload.

(b) Proposed Operations:

(1) Improvements in put away and replenishment productivity will eliminate the need of a new forklift.

(c) Potential Payback

(1) One time gain of 1,400,000 baht saved.

(2) 80,000 baht per year for related equipment maintenance savings.

4.11 Warehouse Space Capacity Utilization

(a) Current Operations:

(1) Outside storage capacity is required to store pallets for 3 months of the year during peak operations.

(2) Rental of space is approximately 3,000,000 baht per year.

(3) Transportation shuttle costs are 6,000 baht per load

(b) Proposed Operations:

(1) System-directed WMS, controlled SKU commingling of reserve inventory and reduced inventory levels will eliminate the need for outside storage.

(c) Potential Payback

(1) Rental and shuttle savings of 3,200,000 baht per year.

4.12 Outbound Transportation

(a) Current Operations:

(1) Average of 750 weekly shipments

(2) Average transportation cost per shipment is 3000 baht.

(3) No support tools to ensure shipment consolidation for orders destined to the same state.

(4) Lost LTL opportunities

(b) Proposed Operations:

(1) New order planning module to ensure LTL shipments are sent out for shipments> 150 lbs.

(2) Eliminate a minimum of 50 weekly shipments through consolidation.

(3) Estimate savings by 30% of shipment cost or 900 baht per shipment.

(c) Potential Payback

(1) Savings of 50 shipments @ 900 x 52 = 46,800 baht per year.

Table 4.1 Warehouse Management System Justification-Summary of Cost Savings.

ITEM	DESCRIPTION	Y 1	Y 2	Y 3	Y 4	Y 5
Receiving	Data entry function eliminated	120	240	240	240	240
	Date entry error reduction	90	180	180	180	180
	Billing and A/R error reduction	332	665	665	665	665
Put away	Put away labor savings	60	120	120	120	120
	Data entry error reduction	133	266.7	266.7	266.7	266.7
Picking / Packing	Picking & Packing labor savings	180	360	360	360	360
Checking	Checking labor savings	90	180	180	180	180
Replenishment	Replenishment labor savings	60	120	120	120	120
	Data entry error reduction	1,040	2,083	2,083	2,083	2,083
Physical inventory count	Eliminate physical count - labor savings	60	120	120	120	120
	Data entry error reduction	150	300	300	300	300
Inventory Reduction	Reduced inventory carrying cost	700	1,400	1,400	1,400	1,400
Paper Reduction	Eliminate paper forms	106	212	212	212	212
Picking/ shipping accuracy	Reduced RMA's / customer returns	310	620	620	620	620
Mobile Equipment Usage	Offset acquisition of forklift	0	1,480	80	80	80
Warehouse utilization	Reduce outside storage	1,600	3,200	3,200	3,200	3,200
Transportation	Shipment consolidation savings	23.4	46.8	46.8	46.8	46.8
Total Savings		**5054.4**	**11593**	**10193**	**10193**	**10193**
Loan Interest		5.75%	5.75%	5.75%	5.75%	5.75%
Net Present Value		4780	10367	8619	8150	7707
Total NPV		***39,623,000*** baht				

4.13 Cost Analysis

Table 4.2. The Proposed System Cost Analysis, Baht.

Item Cost	Quantity	Cost	Total
Hardware Cost:			
Server Computer IBM	1	80000	80000
Client Computer IBM	5	40000	200000
RF Barcode Reader	5	30000	150000
Printer Laser Epson	5	8000	40000
Scanner Epson	5	2000	10000
Software Cost:			
MS Windows 2000 Server	1	15000	15000
MS Windows 2000 Professional	5	4000	20000
WMS Development	1	160000	160000
Implementation Cost:			
WMS Coding	1	160000	160000
Testing	1	40000	40000
Training	1	40000	40000
Setup	1	40000	40000
Total Cost (Baht)			**955000**

Table 4.3. The Internal Rate of Return Analysis.

Year	Cost
0	-955000
1	5054400
2	11593000
3	10193000
4	10193000
5	10193000
IRR	621%

V. PROJECT IMPLEMENTATION

5.1 Overview of Project Implementation

When the proposed system has been analyzed and designed, several models are prepared to present the idea of the system. At the implementation phase, all design models of process, database, and network must be implemented according to the project plan. There are several tasks that must be assigned to project members who have specific abilities and knowledge according to their positions.

(1) Hardware acquisition and installation

Hardware requirement of both server and workstations must be acquired and installed on the site. These tasks are assigned to the system administrator or network staff.

(2) Software acquisition, development, and installation

Software requirements of both server and workstations must be acquired and installed on the computer. These tasks are usually assigned to system administrator or network staff. For the software development task, it is assigned to programmer. Before starting these tasks, they must study and understand the models that are designed by the system analyst carefully and follow the design documentation. It takes about 2 months to accomplish the development.

After these 2 major tasks are finished, the written application will be installed on the workstations. The application testing must be implemented, and it is described under the next topic.

5.2 Test Plan

The application of the proposed system must run smoothly without any errors. The error can be classified as follows:

(1) Logical error: it means the program returns the invalid results against the reality. For example, the record of one person who has the title "Mr." and gender "Female" is updated to database.

(2) Function Error: it means the program doesn't work according to the requirements, so it generates wrong results.

(3) Syntax Error: it means the program is written with mistakes that do not follow the programming language syntax. So it generates syntax error.

The application must be tested by many persons who are responsible for it.

(1) System Analyst:

System Analyst must review the application to check if it works properly according to the design documentation made by himself. He may assign any other person who is neither a programmer nor a user to test the application in order to protect any unexpected errors.

(2) Programmers:

Programmers must code and test the application that they have written. The application must contain error handling and input validation to protect any unexpected errors. Although the application is tested very carefully before the system actual operation, unexpected errors may occur during the system operation.

(3) Users:

Users must test the application to check if it functions properly according to their requirements. There can be more errors in the application when tested, because they don't know how to use it and try many different commands to interact with their system. For this case, the programmers will know where to write additional error handling modules to handle such errors.

There should be an error form that keeps the detected errors, the application name that has errors, the events in which errors occur, the name of testing persons, date, and description. Programmers will read the information to debug the application. After it is debugged, they must update debugging information in the form. The information must contain the name of programmer who wrote and debugged it, updated date, and error status. This form will ease the communication between testing persons and programmers.

5.3 Training and Documentation

Training and Documentation are necessary methods to help users understand the scope of the system and know how to use it.

(1) Training:

The training schedule must be arranged to train users within a specific period of time. Trainer should explain the system overview to let users understand the whole system before training them how to use individual application. For individual application, only a specific group of users who are responsible for it will be trained, because the system is divided into several functions that are operated by several groups of users.

Training must he done before the system actual operation, so users can operate the transaction without any interruptions.

(2) Documentation:

Documentation contains the system information, guidelines, user manual, and references. It must be easy to understand for the readers. Pictures and text explanation can make it much easier. After training, users can use the document to solve some problems or confusions that occur from using the new system.

5.4 Conversion

Data and Information from the existing system must be converted into the new system. The warehouse keeps the data in hardcopy format and file format.

(1) Hardcopy Format:

Users must key in the data from the data record program one by one. It can be called "Data Preparation". The data entry program must have input validation module to accept and update only valid data to database. The program must have rapid response time and shortcut key to make users feel comfortable to use it.

(2) File Format:

It can he converted and loaded into the database by data administrator. The problems may occur during conversion because data may have some invalid characters that database management system rejects. Data must be modified to have only valid data, so it can he converted into the new database without any interruptions.

VI. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions:

The objective of this project is to improve warehouse management which consists of receiving activities, delivery activities and inventory control. The proposed WMS achieved the objective and provided many following functions which are very useful to warehouse manager and warehouse staffs:

Highly precise input/output process: With combination of both barcode reading and picture verification, the error occurrence in data input to the software is completely eliminated.

Standardization as a way to gain: Through standardization, WMS provides quick learning time and transparent working procedures so that the cost of training is minimized. WMS can be bought as an off-the-shelf software package because it conforms to the standards the customers may have been familiar with.

Cost-effective solution: Since WMS is designed to be as standardized as possible (In terms of both hardware requirements and functionality) with the most useful features for warehousing job, the necessary expenses for its implementation are quite low.

Short implementation time: WMS can be used with your existing warehouse configuration in almost no time and it does not require special knowledge apart from that of simple warehousing job.

Low risk and minimum interference to existing system: Implementation of WMS does not require much change in the way the warehouse is being managed but instead provides complementary functions and consistent methods for its management.

Reliability and availability of information: All information needed for warehouse management and relevant decision-making tasks are available at all time (Such as goods availability, warehouse utilization level or order processing status).

Adaptability and flexibility: Whether the customer's actual physical storage systems have already existed or are about to be built, WMS can adapt itself with the ability to control goods with multiple units in one container. WMS can be of great help to many types of warehouses, companies, and third-party logistic providers, which have many different needs to manage their products.

Table 6.1. The Proposed System Performance.

Activity	Performance
Receiving process	5 seconds/product
Put-away process	5 seconds/product
Check stock process	1 second/product
Generate Report	1 to 30 seconds/report

6.2 Recommendations

The proposed system is considered as the major change for the warehouse staffs. It is important to let users understand the benefits and objectives of implementing the computerized system. Users must have enough basic computer knowledge to operate the application and the application itself must also be easy to learn and understand. In order to make the system run properly, preparation is needed in each area.

(1) Conduct user training to introduce the circulation system.

(2) Operate the system by running parallel with the existing system and comparing their result and correct any unexpected problems.

(3) Test the proposed system by:

(a) Testing each program during programming tasks

(b) Testing data by creating data test in each subsystem.

(c) Testing the system interfaces and all subsystems.

(d) Backing up and restoring tests to backup flies and restore the data

(e) Completing the documentation.

(4) Evaluate the system after it has been operated for one year based on the following areas:

(a) The efficiency of the proposed system in record keeping compared to the existing system

(b) A proper design should reduce the actual waiting time for receiving and delivery services.

Finally, for the trend of technology, the web-based application can be developed to increase the communication channels to suppliers and customers. The online check-stock request form or reservation form can be developed to let customers fill in the request before coming to the warehouse to satisfy customers' needs.

APPENDIX A

DATA FLOW DIAGRAMS

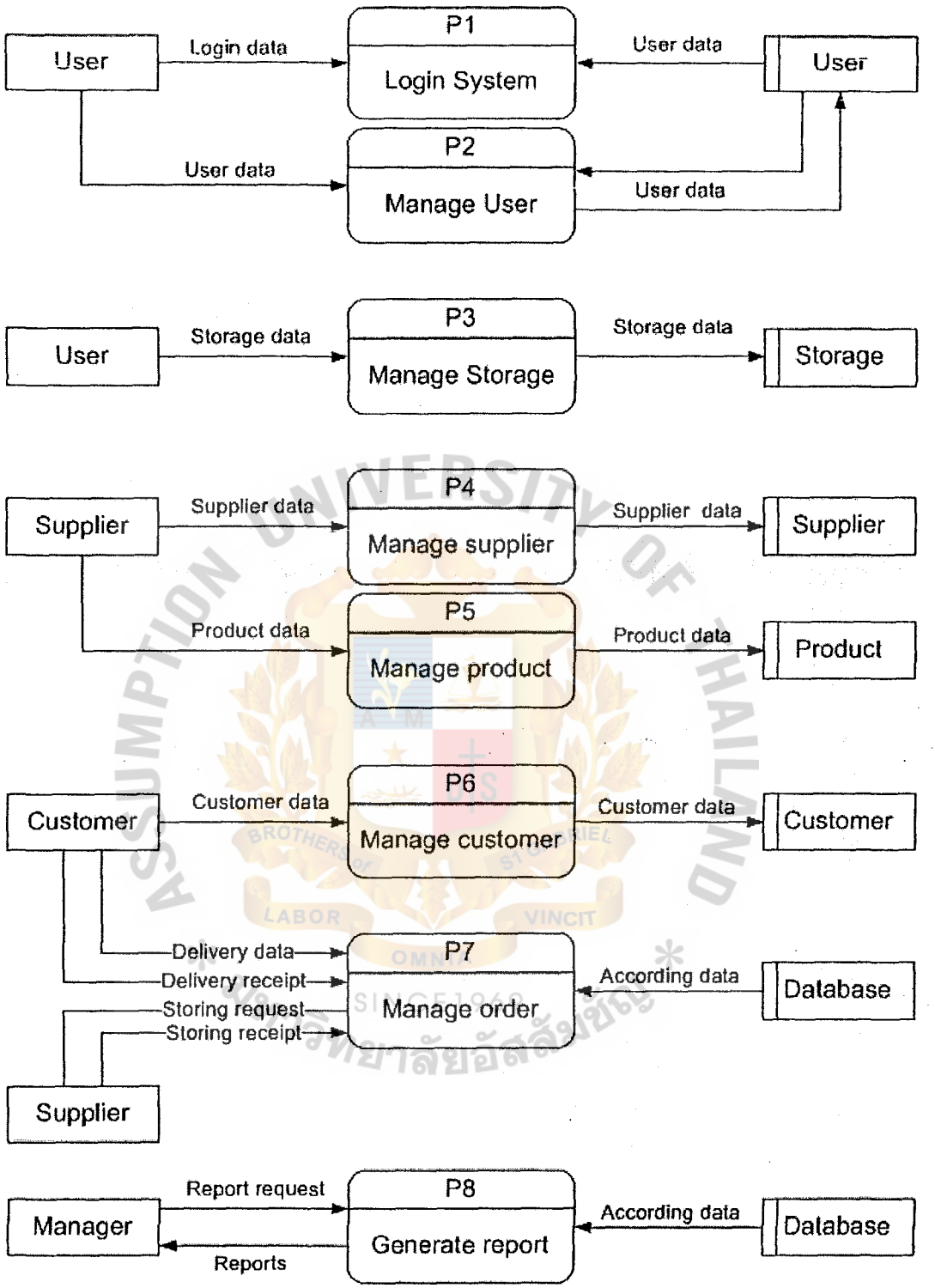


Figure A.1. DFD Level 0 of the Proposed System.

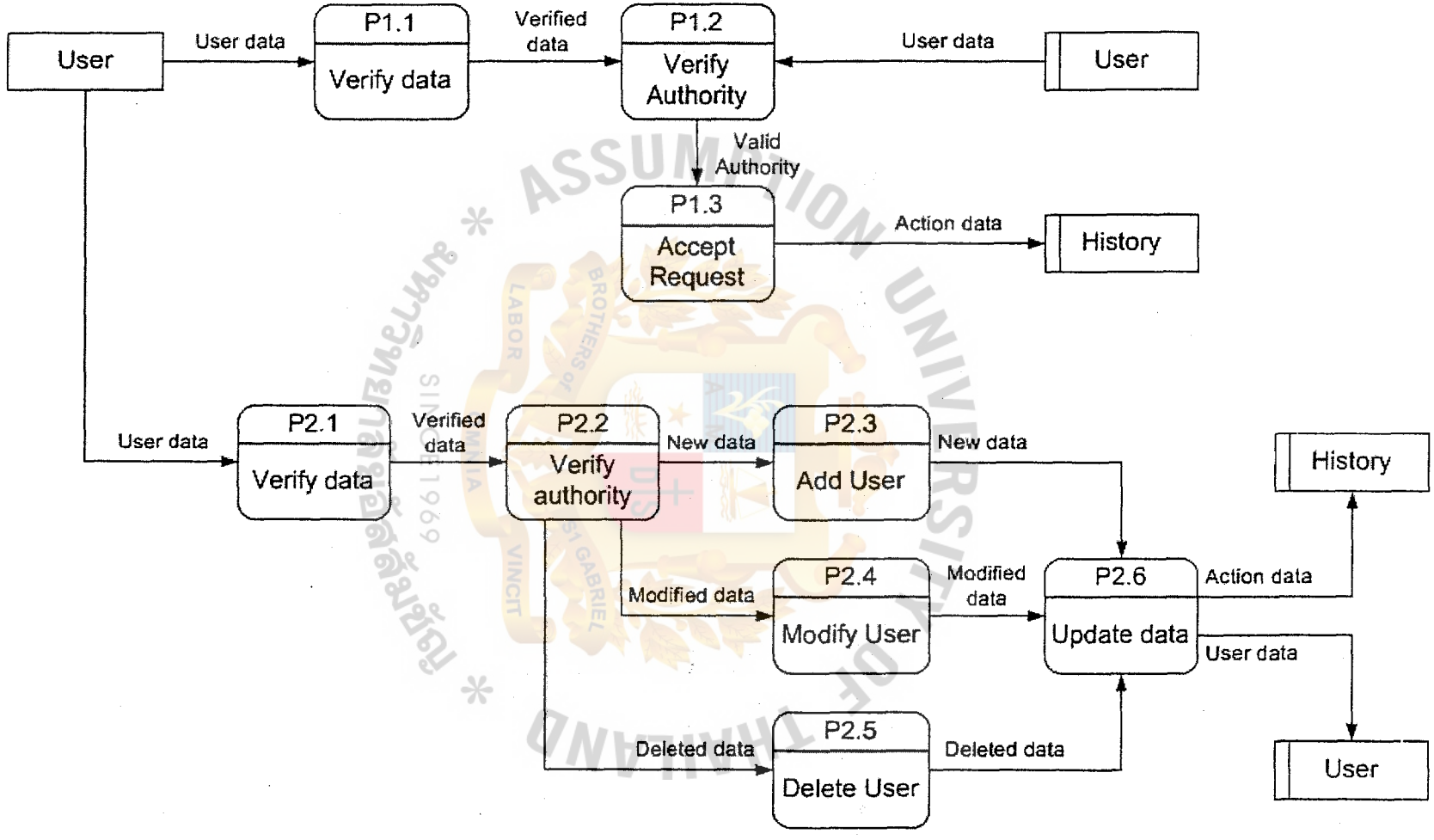


Figure A.2. DFD Level 1 of the Proposed System.

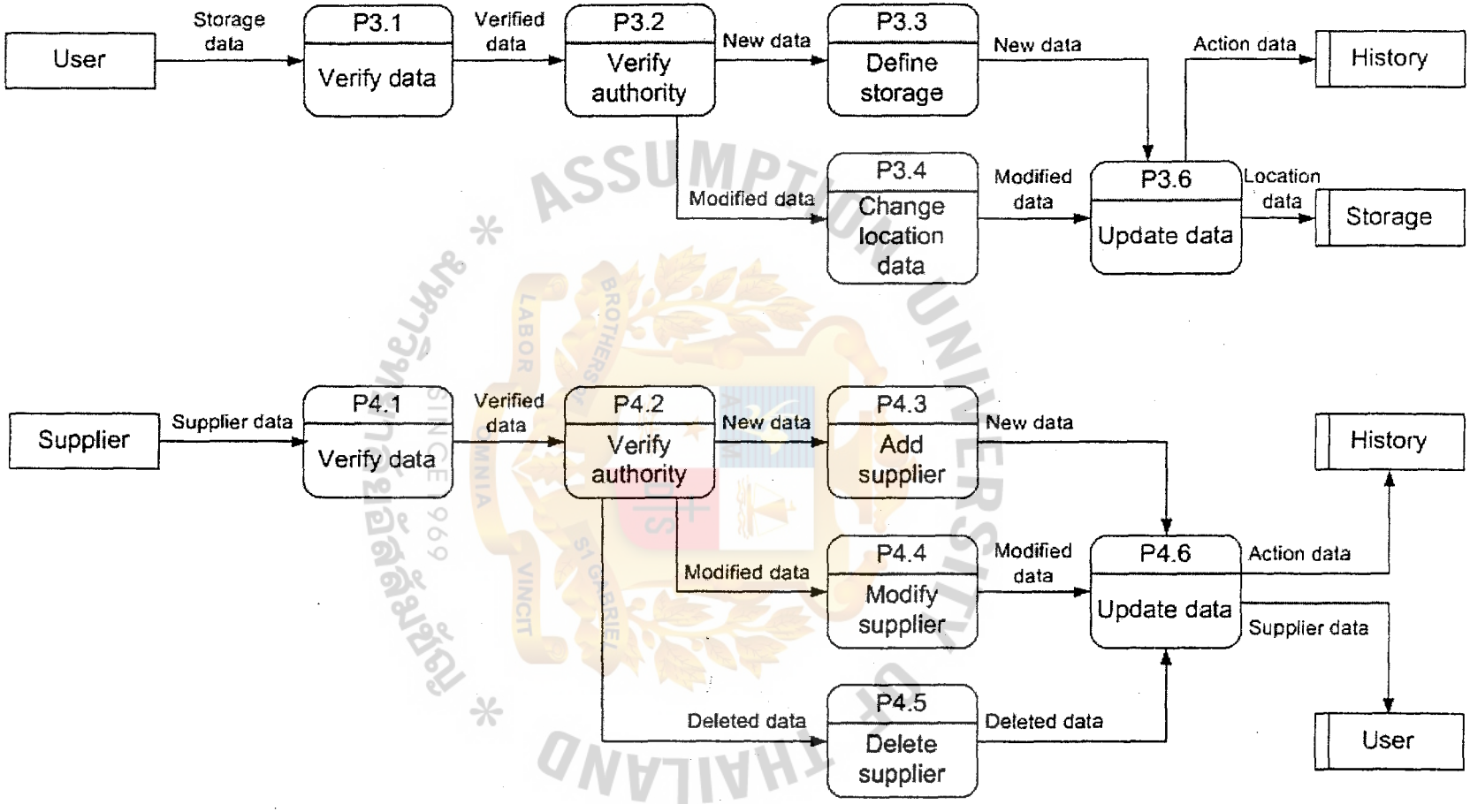


Figure A.3. DFD Level 1 of the Proposed System.

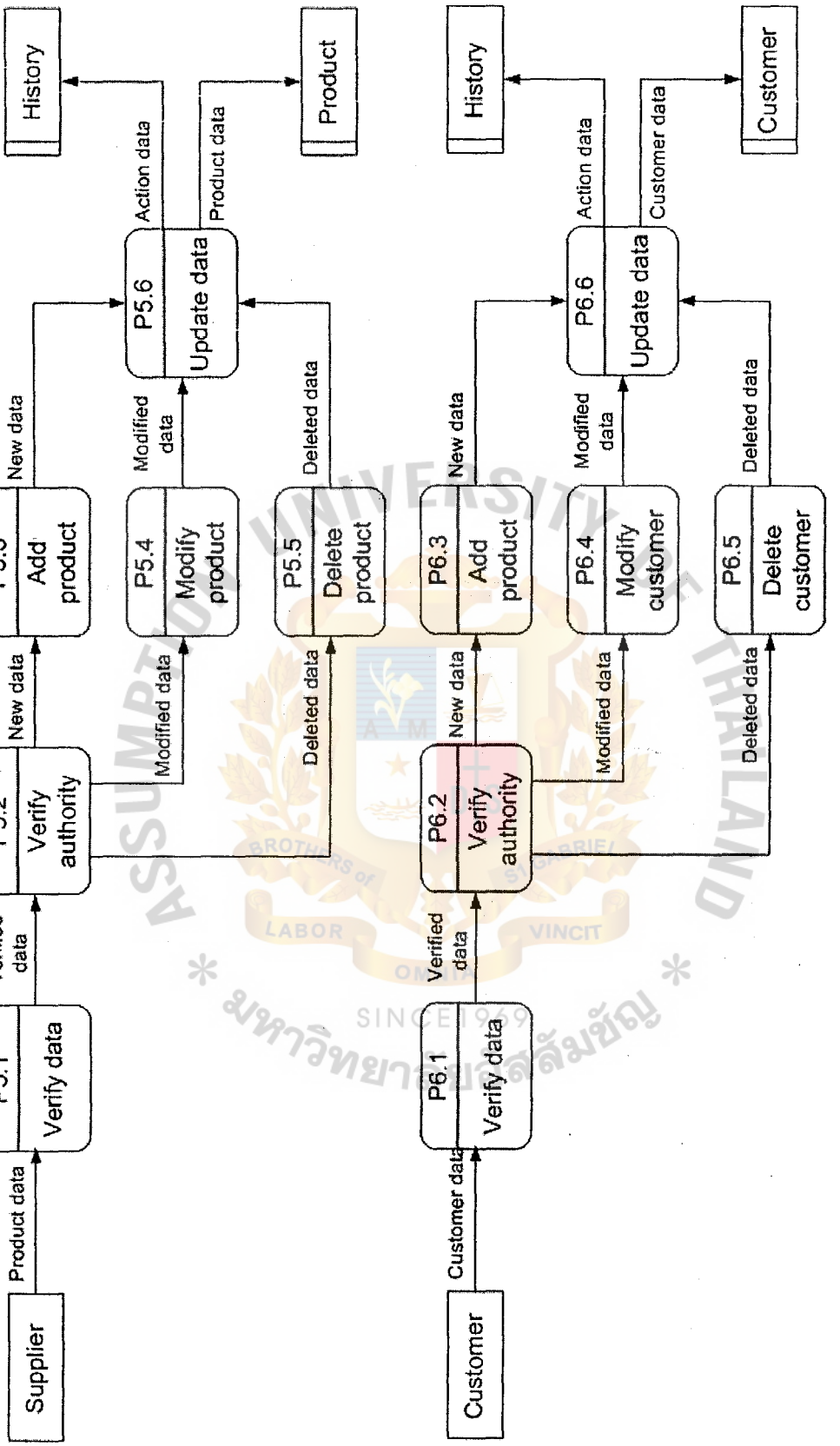


Figure A.4. DFD Level 1 of the Proposed System.

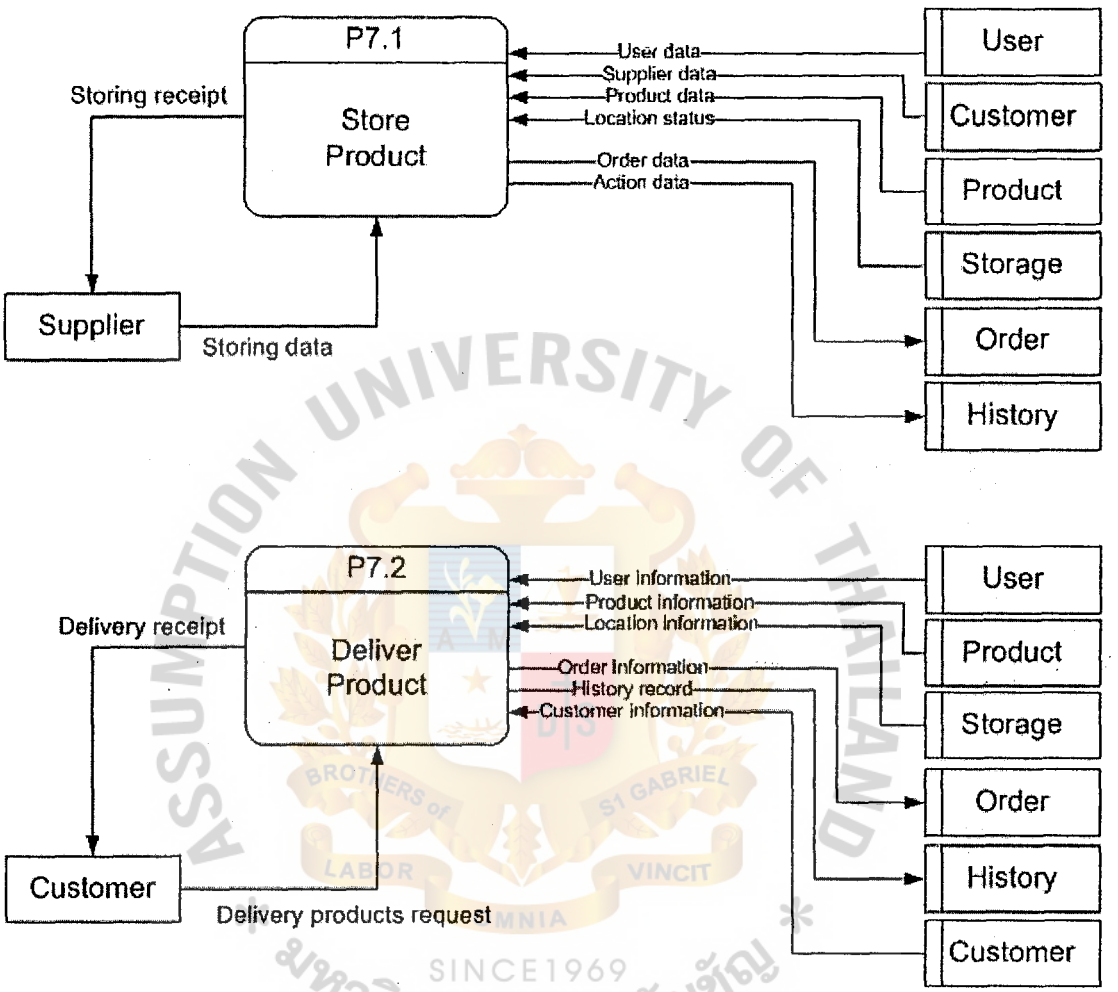


Figure A.5. DFD Level 1 of Managing Order Process.

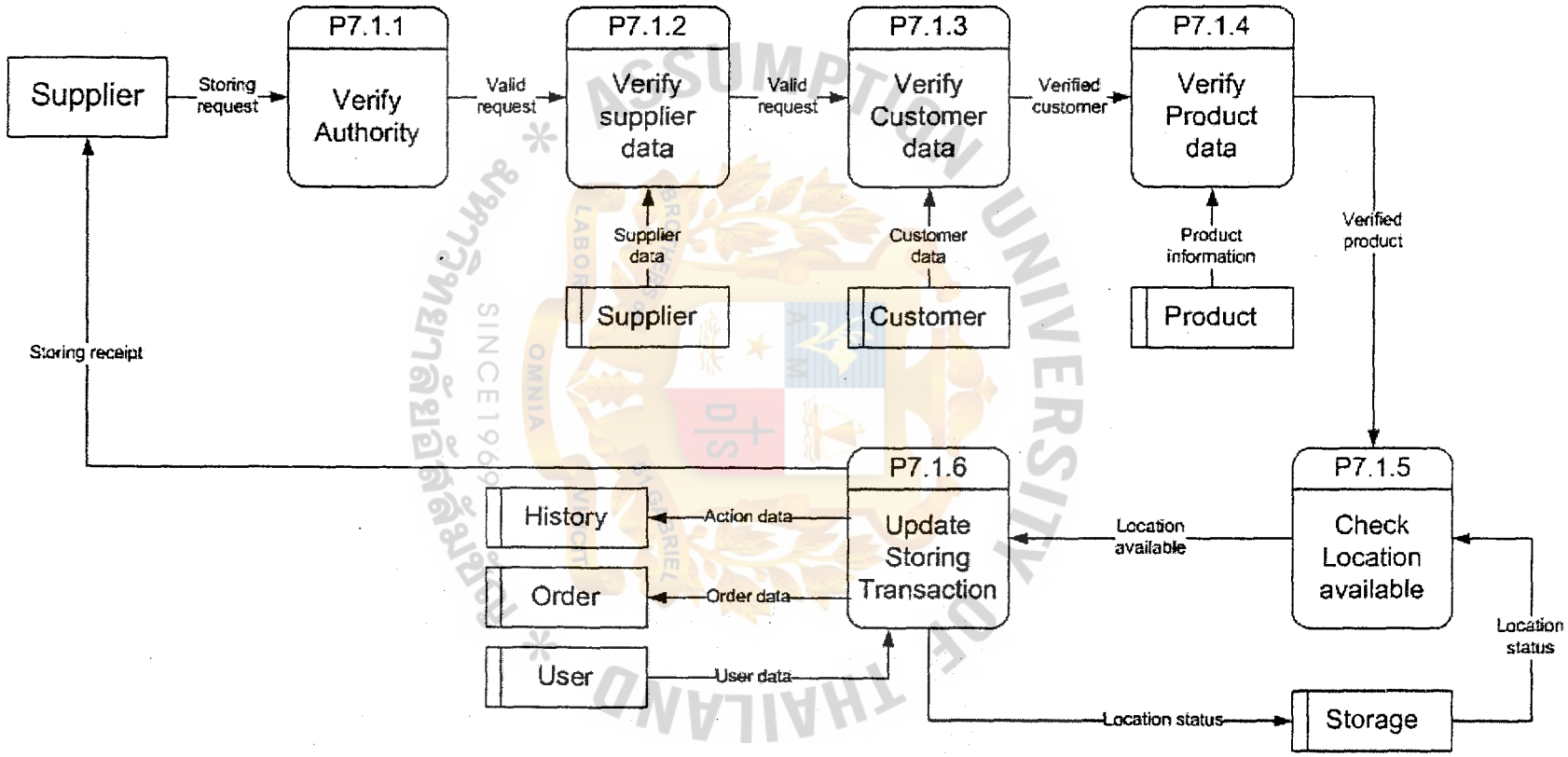


Figure A.6. DFD Level 2 of Storing Process.

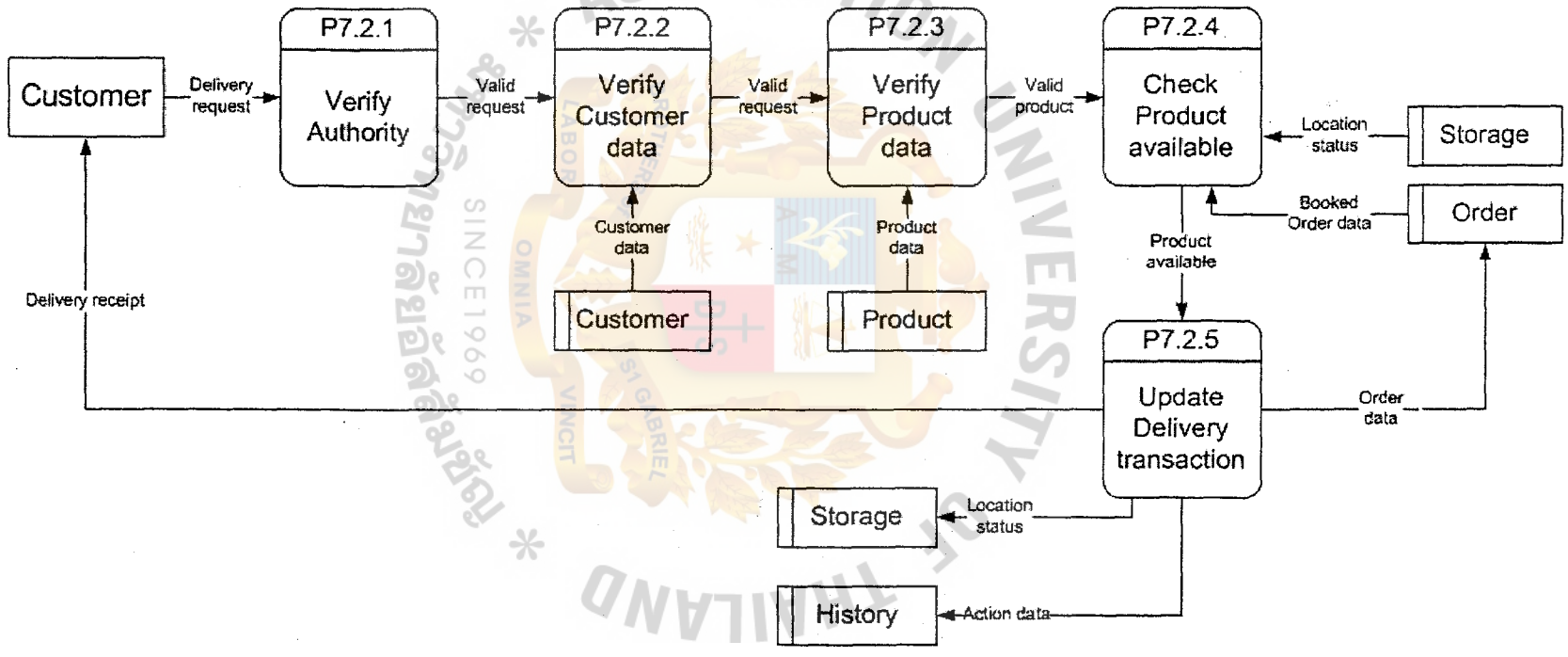


Figure A.7. DFD Level 2 of Delivery Process.

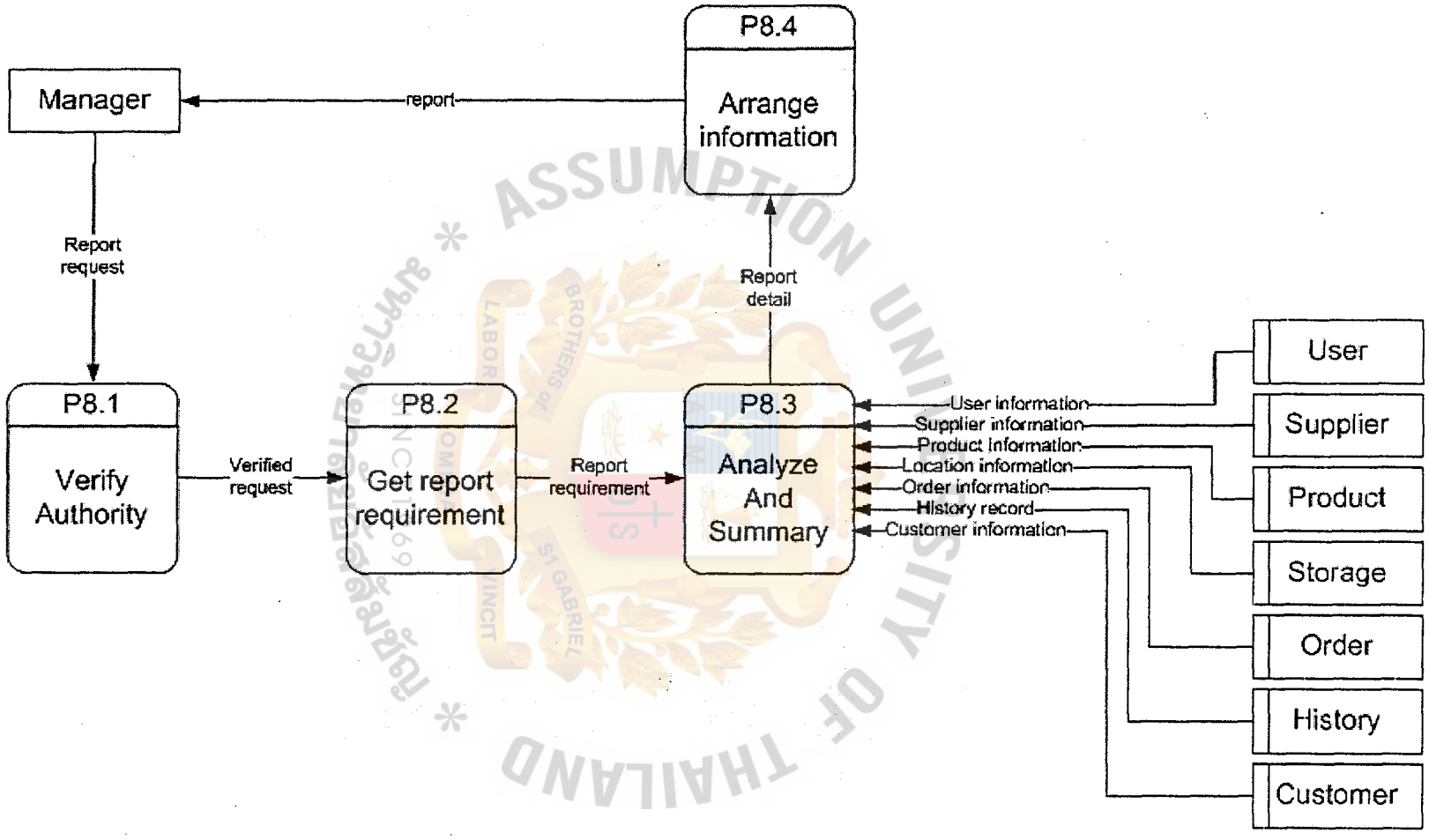


Figure A.8. DFD Level 1 of Generating Report Process.

APPENDIX B

DATA STRUCTURE CHARTS

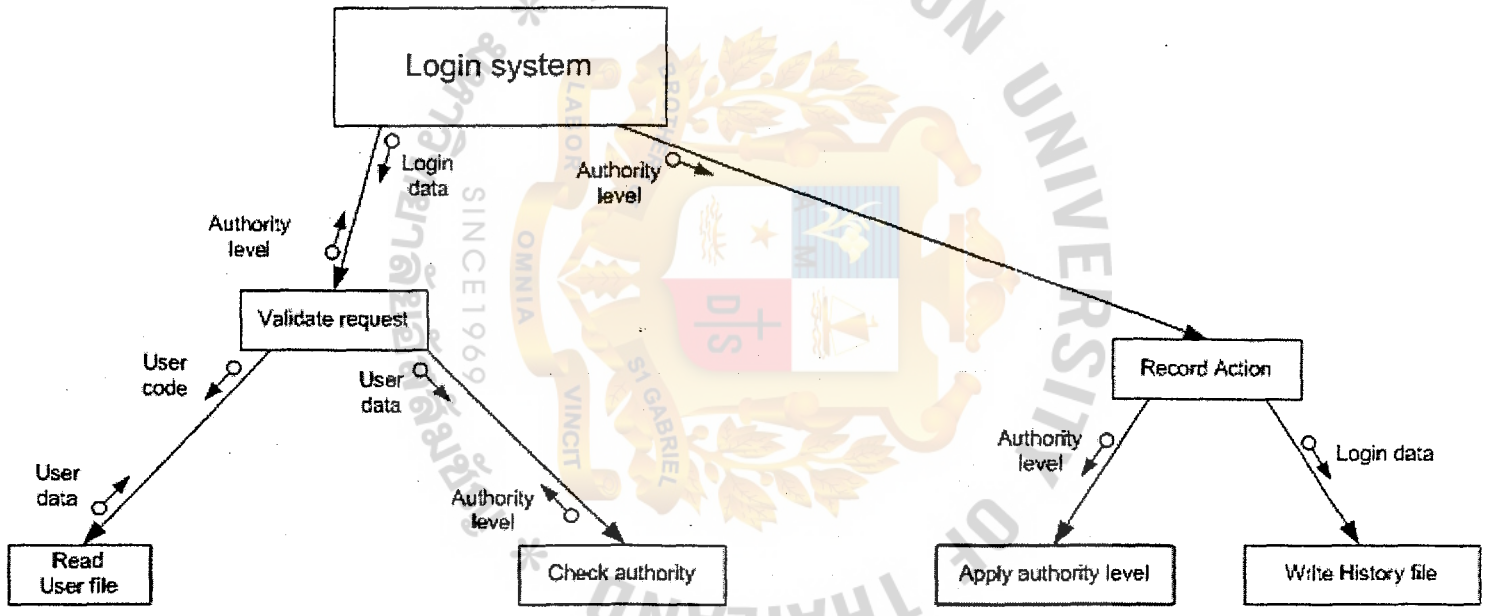


Figure B.1. Data Structure Chart of Login Process.

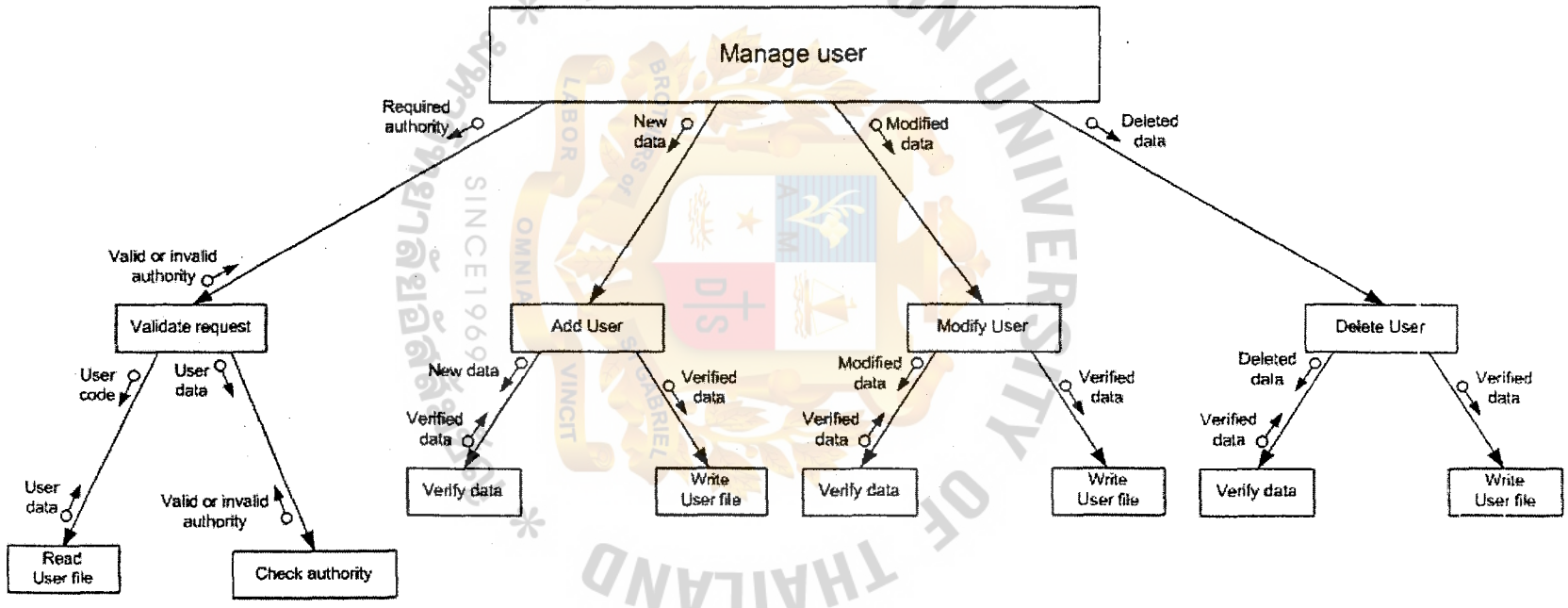


Figure B.2. Data Structure Chart of Managing User Process.

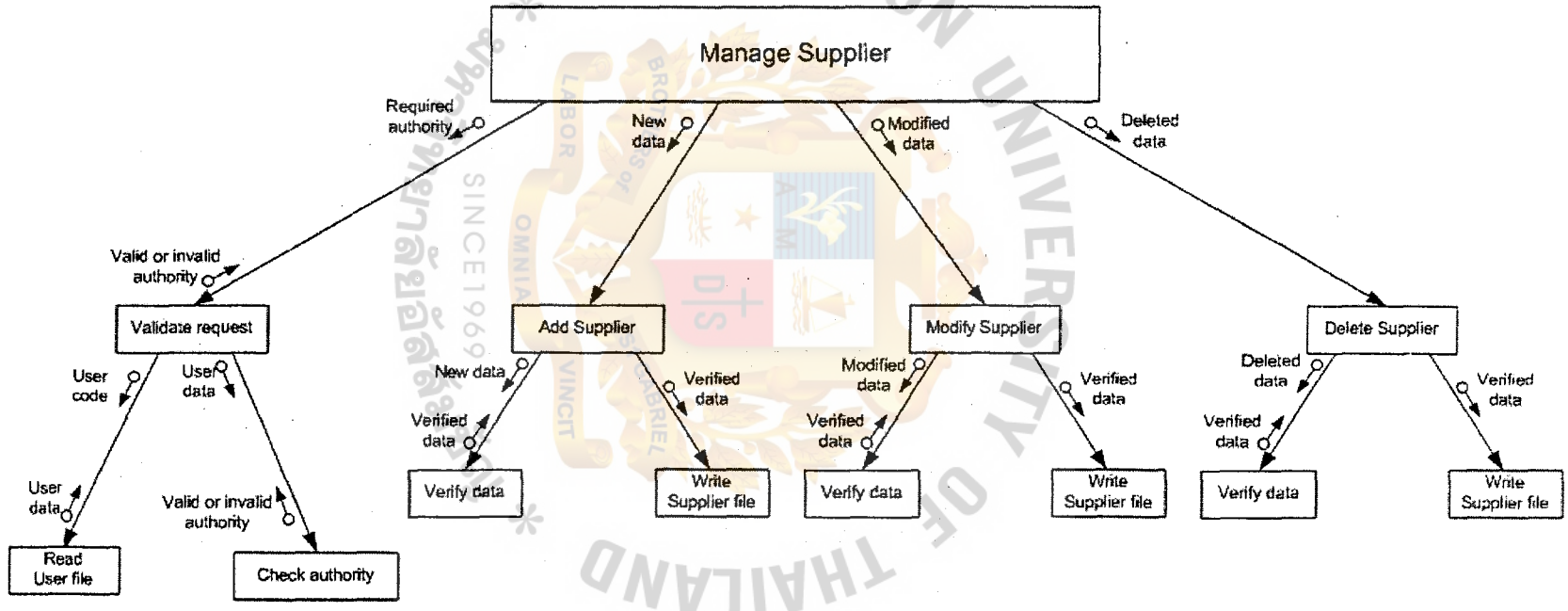


Figure B.3. Data Structure Chart of Managing Supplier Process.

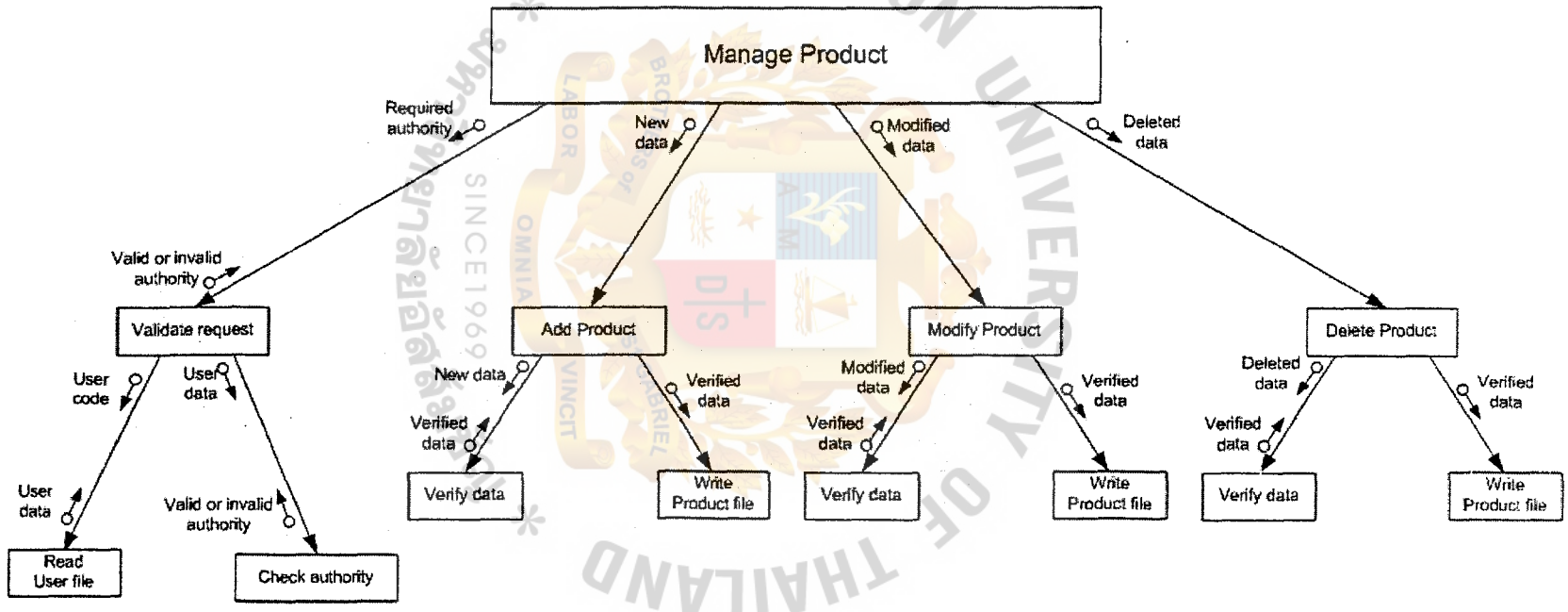


Figure B.4. Data Structure Chart of Managing Product Process.

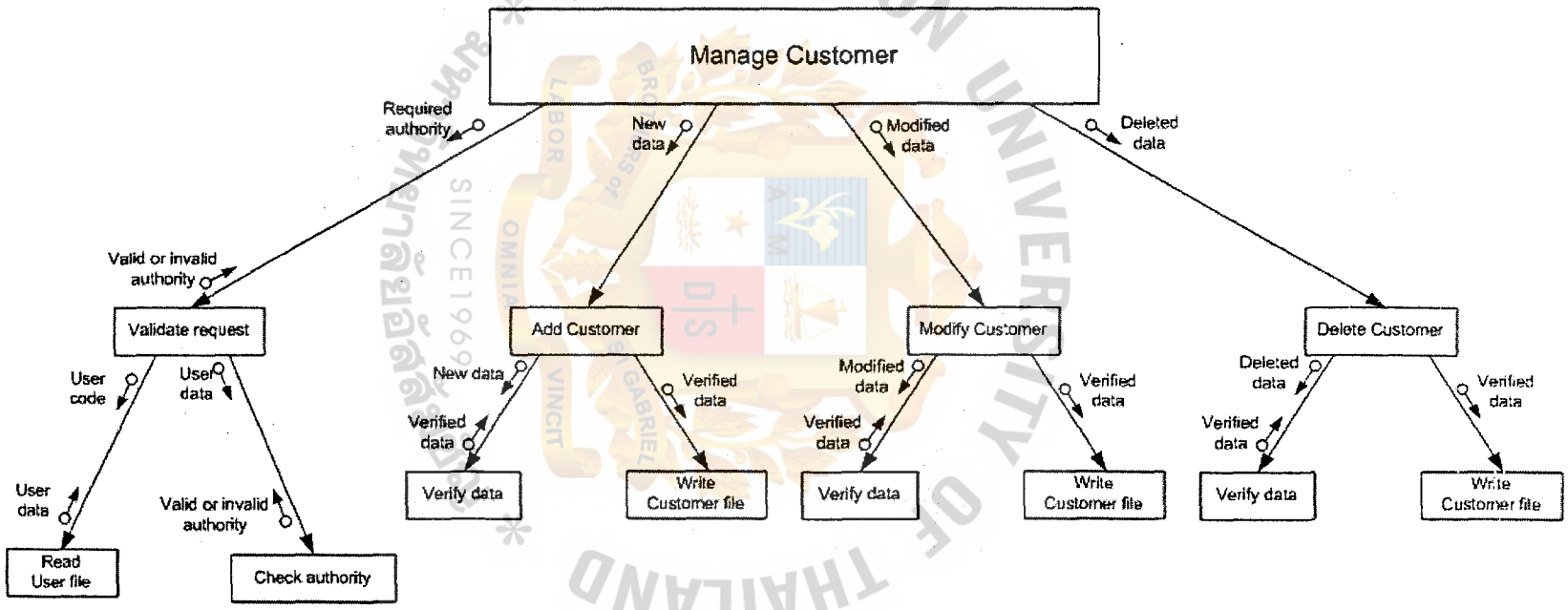


Figure B.5. Data Structure Chart of Managing Customer Process.

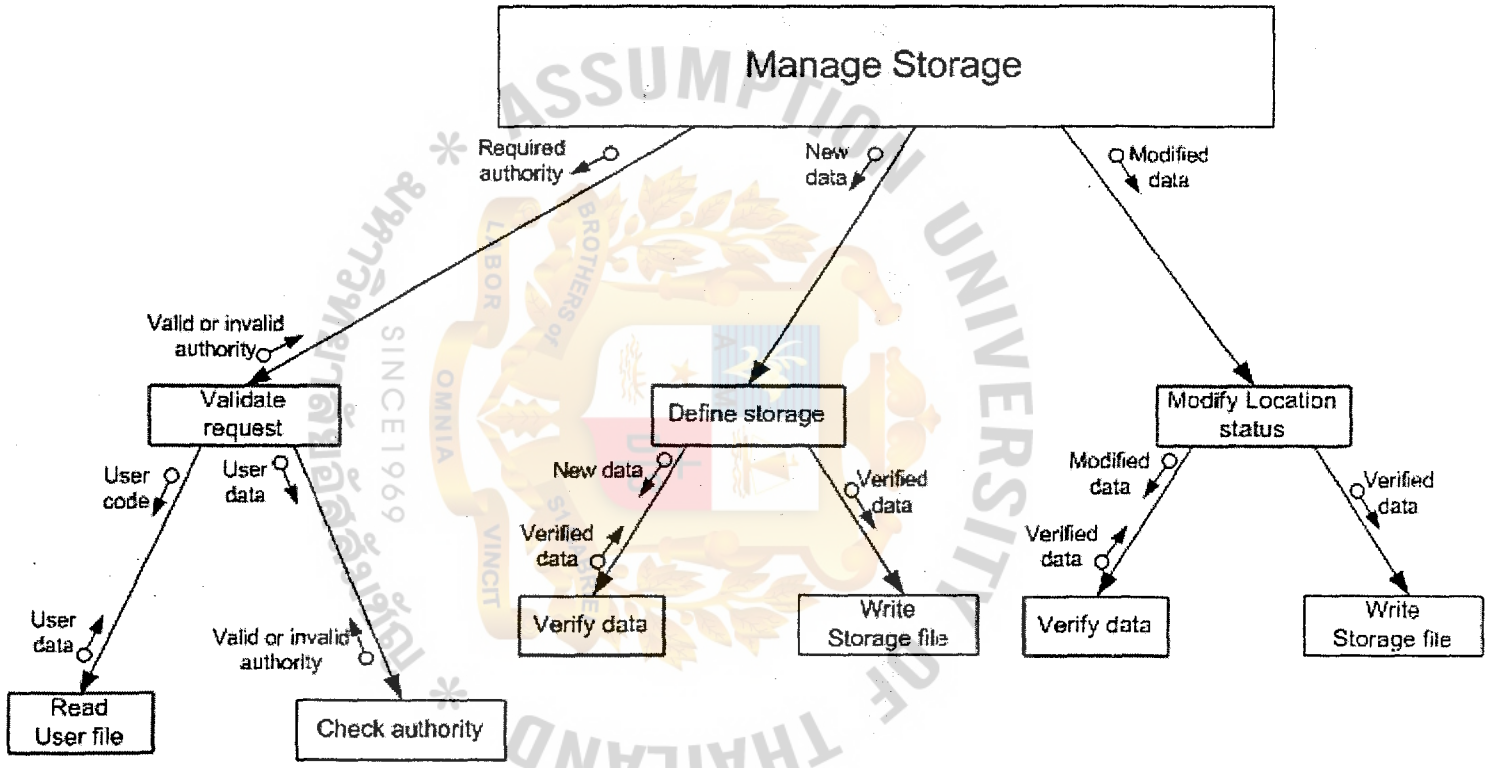


Figure B.6. Data Structure Chart of Managing Storage Process.

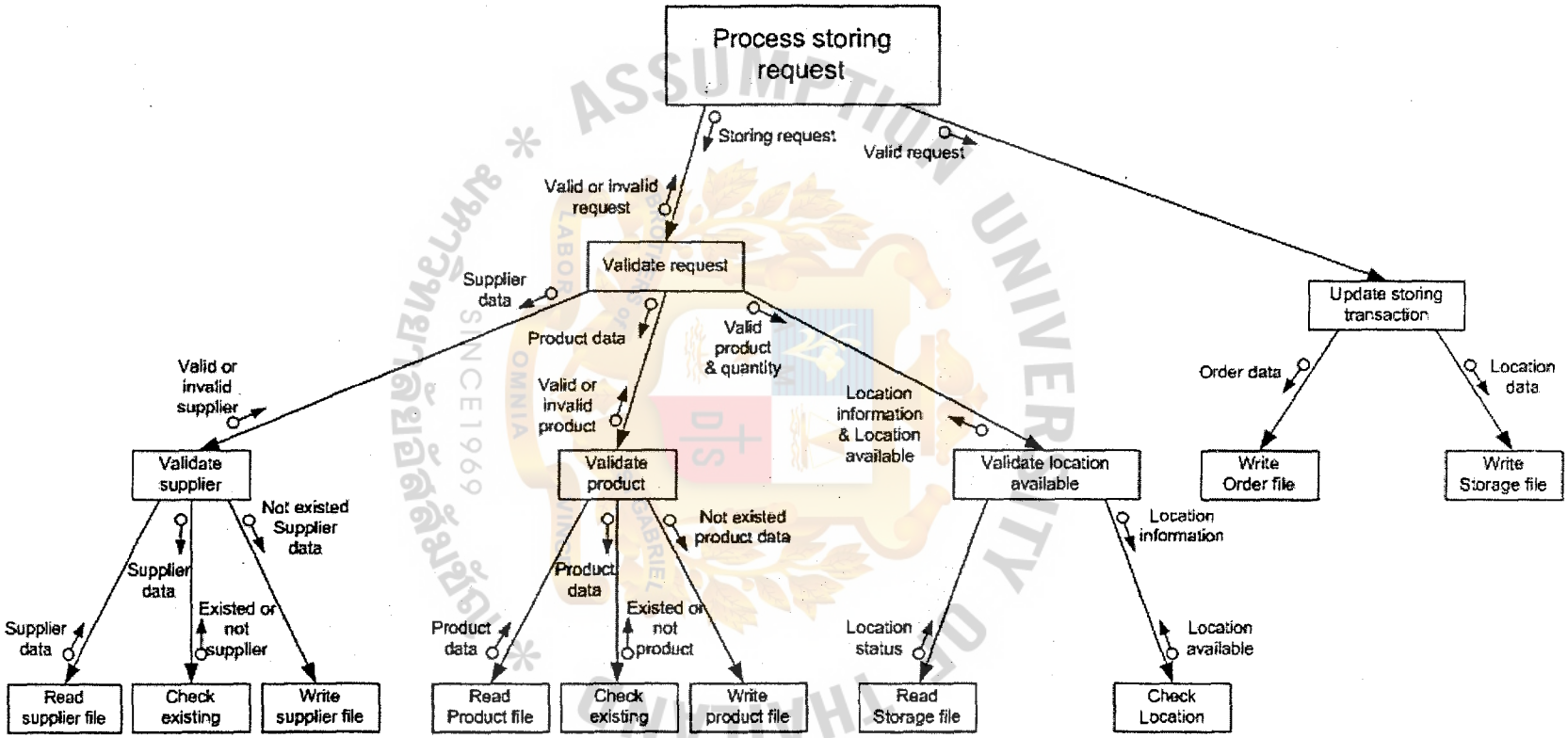


Figure B.7. Data Structure Chart of Managing Storing Process.

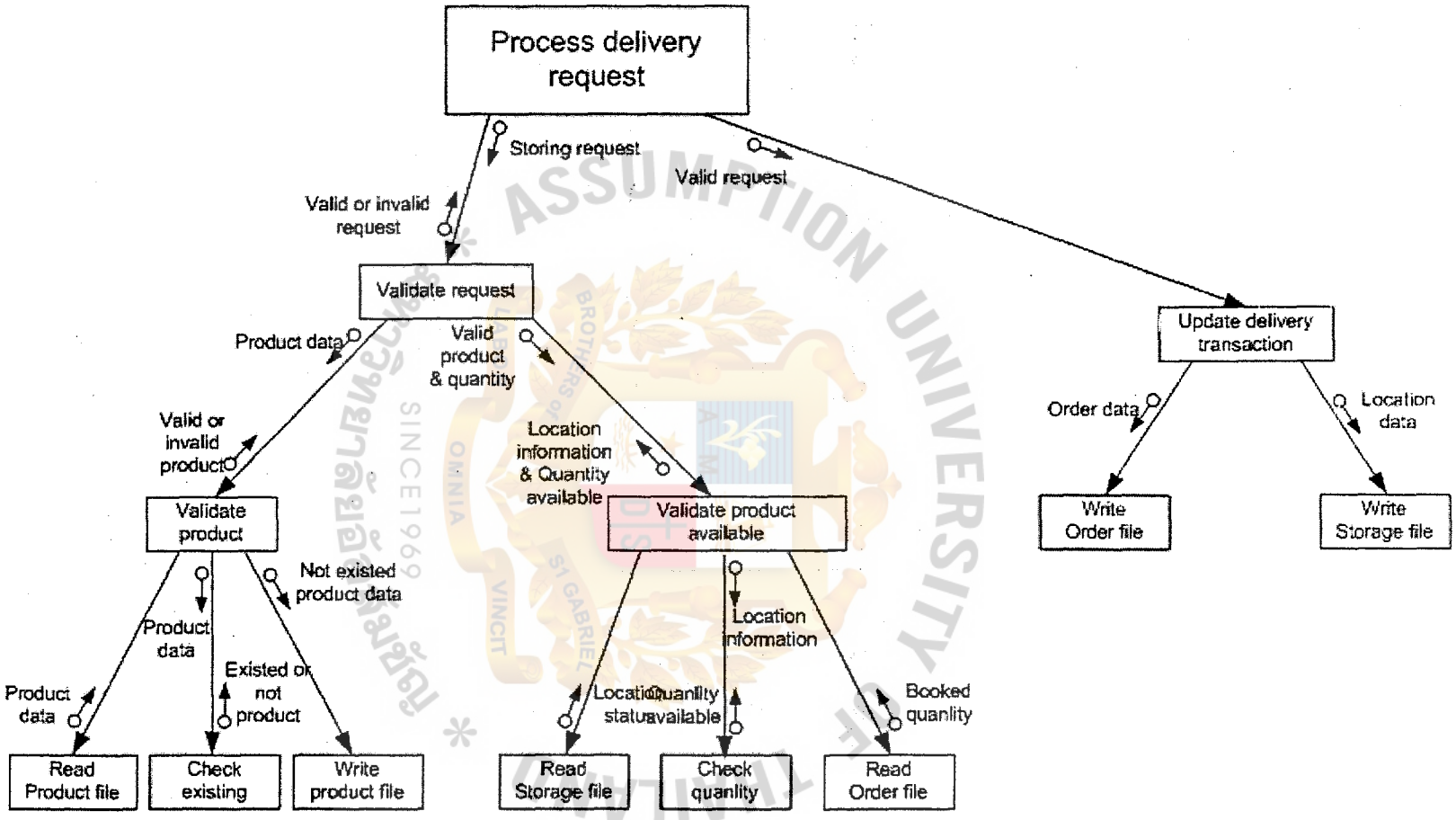


Figure B.8. Data Structure Chart of Managing Delivery Process.

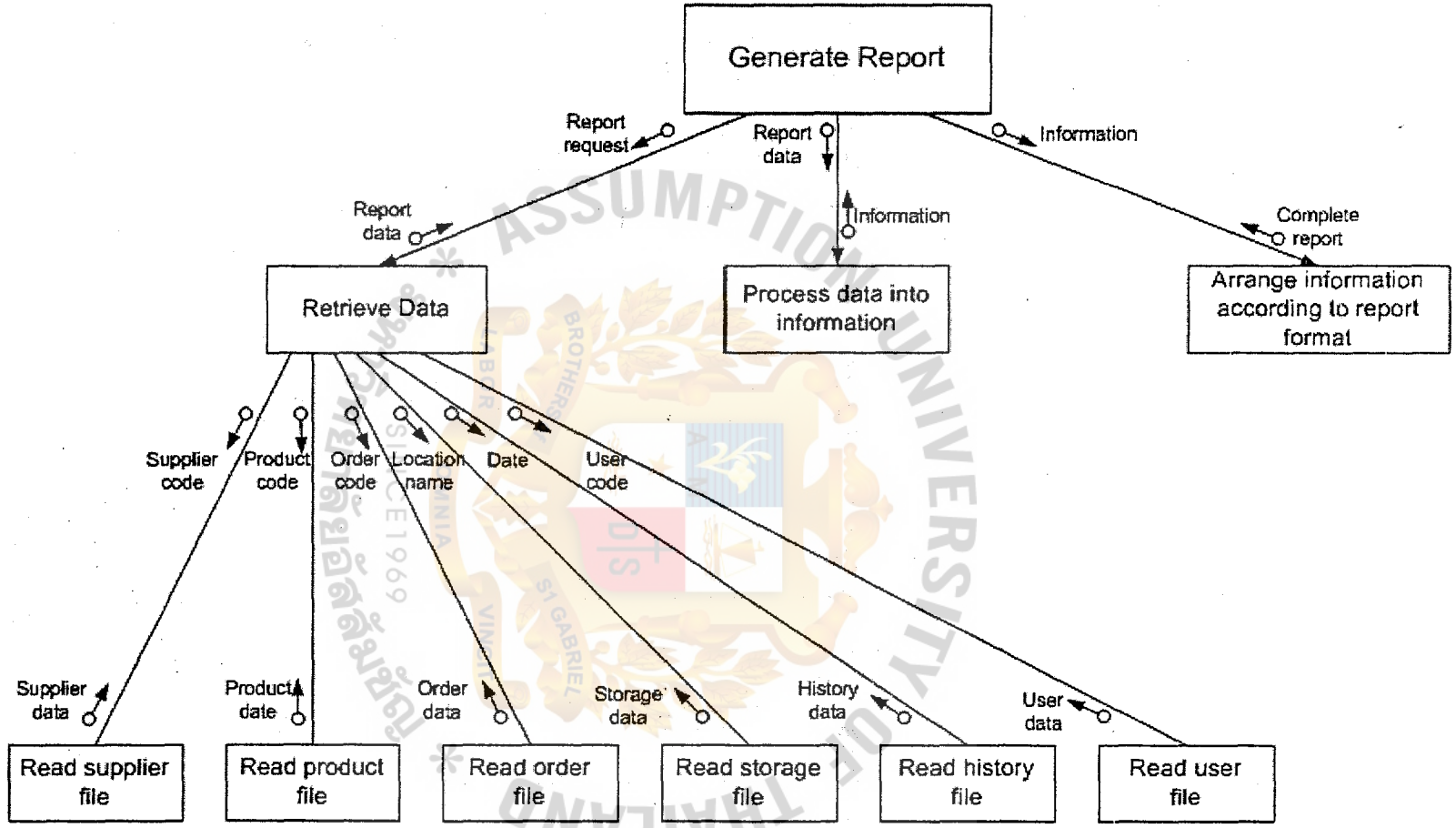


Figure B.9. Data Structure Chart of Managing Generating Report Process.

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