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The Inventory Management System using RFID: Requirements Management

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Abstract: This research was conducted to examine requirements management criteria needed in producing the inventory management system and to understand and take advantage of the opportunities of RFID afford as mechanism towards better inventory management. The goal is to improve the management of the conventional inventory system, by developing the computerized system with the involvement of RFID deployment. Interviews, magazines, articles, journals, books and outline documents are collected throughout the gathering of requirements and thus provide vital information to the research. The materials used to enable the capturing the present of items are RFID tags attached to items and RFID reader connected to the computer. The techniques are created in order to capture the items being tagged and store the necessary information of the items into database via the system. The overall approach was to keep track the availability of the items inside the inventory. Upon completion of the research, it is found that the aspects identified in requirements management provide the basis in producing the inventory management system and the product of the research is system prototype which is being demonstrated. Future works for this system are focus on the RFID utilization and establish the stability of RFID connection with the system so it becomes more efficient, more effective and consistent. Besides, it is recommended to broaden the scope, enhancing the existing functionalities, adding new valuable elements to the system and improve the attractiveness of the system interfaces.

Keywords: RFID, Inventory Management System, Inventory System Criteria, Stock Management System, Fast Food Restaurant

I. INTRODUCTION

The inventory management or inventory control refers to an attempt to balance inventory needs and requirements with the need to minimize costs resulting from obtaining and holding the inventory [1]. The most important objective of inventory control is to determine and maintain an optimum level of asset in the inventory. Wise control of inventory is often a critical factor in the success of businesses in which inventories are significant. The goal of inventory control is to be sure that optimum levels of inventories are available, that there are minimal stock outs, for example running out of stock, and that inventory is maintained in a safe place and is always readily accessible to the proper workers. As we already know nowadays, restaurants can be found everywhere. It is known to provide food services and drinking places that sell foods and beverages, although the size of the establishment and the range of foods, beverages, and services offered are vary. But, how they ensure the availability of their stocks in order to fulfill the customer's orders? Most items in their inventory can be categorized as perishable items which means decrease in value or usability of product over time due to the inherent characteristics of product, whereas obsolescence refers to loss in value of items [2]. Examples of such perishable items are fresh items, canned products, dairy items, meats, frozen items and so on. The inventory management helps the restaurant to decide in advance how to fully utilize these items. If a restaurant is getting supplies of minimum order quantities, it may not be much of a problem to store and use them before the expiry date, but in the case of large amount of order quantities, one has to be careful so that the storeroom space is not overcrowded and all the items are optimal utilized. This research involves developing a system prototype focused on managing the inventories which applies the technology of Radio Frequency Identification (RFID) where the primary focus is to help and manage the inventories for efficient stocks controlling. This system may be implemented in a storeroom of a restaurant to replace the warehouse to show the concept of tagging, tracking and checking of inventories inside the storage

The target users who are going to implement this system are those who have big restaurant and carry out the day-to-day operations of their stock inventory. Besides, the inventory management system embedded with a computer equipped with customized database and outfitted with an RFID reader to monitor inventories inside the storage. This inventory management system which includes RFID reader that is a system

to facilitates the tracking of objects, instead of traditional barcode scanning technology to keep track of the items in the storeroom. Primarily RFID is used for inventory tracking, to track items using EPC (electronic product code), that is unique identifier stored within an RFID tag contain a string of numbers and letters, consisting of a header and three sets of data partitions. The first partition of EPC identifies the manufacturer. Secondly, it identifies the product type (stock keeping unit) and the third is the serial number unique to the item [3]. This system become aware of its contents and it is capable of establishing direct contact between the user (person who responsible to count stocks) and the items. It will remind user if they are out of stocks of items in their storage or when stocks levels go below some set limits. Besides, it alerts user if there are stocks inside the inventory had passing their expiry date. As an inventory control tool, RFID can help the restaurant to wirelessly capture data concerned with the movement and status of items inside the storeroom.

A. Problem Statement

There are several issues aroused regarding to keep track of the stocks in conventional inventory management. In a large storeroom of a big restaurant, sorting or picking an activity is more time consuming and subjected to errors. For example, for issuing the items inside the storeroom, the person who is responsible to count the stocks has to find out whether the item is available are in there or not by physically moving into the stockroom. With the RFID systems, it ease the sorting and picking operations, as it capture real time, accurate information about the items availability in host computer database without physical movement [4]. RFID tags are read via radio frequencies and therefore it is not mandatory to place the items in a particular position to read it, and this can overcome the address problem above [5].

Besides, the stock clerks may miss to take record of what items need to be order and lead to the situation where items are not in stock or in other word, out of stocks (OOS), or they are in stock but cannot be found. Other factor that can contribute to an OOS situation is unpredictable customers present on a particular day which means more menu orders that can play a role in reducing items availability. However, other causes of OOS are more dependent on process compliance and information-sharing infrastructure between the retailer and the person who responsible to make an items order [6]. RFID can be use to avoid OOS situation. Because the RFID delivers real-time information about the inventory levels, it enables the stock clerk to act upon the reductions in out of stocks. Thus, operational inconsistency of the restaurant can be reduced and items availability at the storeroom can be improve in order to serve the customer [6]. In addition, a situation called shrinkage may happen where a portion of inventory may become unavailable to the owner of the restaurant due to loss, damage theft or spoilage. The longer inventory is there and the more there is, the more likely this is to happen. With the RFID technology adoption that operate at a distance, it reduce the costs associated with shrinkage [7]. Space is usually a critical factor in keeping inventory. It is important to have enough space to place the stocks and keep the storeroom from overcrowded [5]. Because of the need to support day to day of the business operation, a big restaurant orders a large quantity of one item and thus can lead to problems finding an item when they need it at that particular time. Because of large quantity of items, the stock clerk may not realize some of the items have been reach the expiry date and this can cause wasting. With the implementation of RFID, the target is to keep the stocks as low as possible and avoid the need of large space of storeroom.

The conventional storeroom does not provide any features or alert message that can help stock clerks to know or alert with the current status inside it. Sometimes they might not know that there are few items inside it need to be removed due to out of date or inventory needs replenishment. Alarm message is one ways that inventory can be monitor. With the RFID-tagged items, it will allow storeroom to track and count of inventory in real time and making sure that the store clerk alert when the total inventory drops below a certain level [6]. Not just that, it will notify the store clerk when there are stocks had passing their expiry date. The high levels of inventory monitoring obtained using RFID can benefit the business operation and can facilitate the productivity gains and quicker responses [8]. Inventory management involved person to record, move, count, store, retrieve, and post it to the ledger. Checking each stock against a list of stocks is a routine that should be performed a number of times in a month. At the very least, inventories in a big restaurant should always be checked every day and compared against book stocks account or quantities listed as on hand in the computer or manual ledger. Because of taking inventory more than once in a week and looking at stocks over shorter period of time while updating of stocks, often results in human errors or processing errors. With RFID system, it can track the stocks in real time without product movement or human involvement and update the information in database dynamically [5]. Most items in inventory of a big restaurant involved perishable items. These items have a limited useful life and if it is not handling properly, it may get spoil and its useful life reduces. If this reduces life information of items is not updated, then it may be possible that an outdated item gets delivered to a customer. In such a case, there may be an additional cost of replacement of item and also loss of trust of customer [9]. Such spoilage could be reduced simultaneously with automating inventory management, by using RFID technology for item identification. During the interview with Mr. Tajul who is the Operation Manager of Shakey's Pizza (Jusco Kepong outlet), he did agree with those problems stated above because he is also facing the same problems while managing the stocks inside the storeroom especially the situation where items are not in stock (OOS) by the time the workers need them in preparing the menu ordered by customers. In addition, he said they often have the situation of surplus and shortage of stocks. This situation results because they did not sure how to measure the customers for certain days especially on weekend, school holidays and festival season. They running out of stock if ordered small quantity of stocks and if instead ordered a large quantity, then later it would become a wasting to them if the stocks are not fully utilized, plus most of the item stocks are categorized as perishable items. All the problems that are stated above are not resolve yet because the conventional inventory management does not provide any features that can help people to solve the problems they encountered regarding to keep track of the stocks in the inventory.

B. Objectives of Research

This research study has two main objectives that have been accomplished at the end of the research. The objectives are:

i) To identify the requirements criteria of the inventory management system.

Study the system's necessities and user requirements, including how users want to manage the items such as adding new stocks, updating the existing stock data, deleting stocks, finding stocks information and generating the report of stocks in inventory. The analysis covered the rationales and reasons for the RFID deployment in controlling stocks and how RFID technology will be used in regards to inventory system.

ii) To verify and validate the requirements of inventory management by demonstrates the prototype of the inventory system.

During the requirements analysis phase, current problems and business processes, as well as the requirements criteria that are related to the inventory management have been examined properly, because the initial set of system requirements will be transform later by demonstrates the system prototype. At the same time the prototype is build up, ideas in business environment that are close to reality was tested and provide the proof of concept of the research study.

C. Significance of Research

Effective management of an inventory management calls for getting the right items at the right time to the right place and in the right condition. Therefore, this research constructed an inventory system which is intend to assist the owner of the restaurant or the store clerk and makes their routine to organize their inventory become systematic. By implementing this system, it will help the owner of the restaurant to track individual items with serialized data. This serialized data is to make each item has its own unique identifier or serial number and store information such as manufacturer, batch or lot number, weight, destination and so on [10]. The RFID will enable to keep accurate account of each item in the inventory so that the owner knows which item has been used and which one has been sitting in inventory for a long time. RFID tracks the individual items by associating the unique Electronic Product Code (EPC) number to a database and the benefits we can achieve from the serialized date are better inventory control, reduced loss, and improved customer satisfaction. Besides, RFID allows the stock clerk to capturing the information in real time [10]. With regards to this research, the system captures the serial number of the individual item and the information can be updated into the database. By capturing the real time information, the owner can reduce waste, reduce errors in counting stocks, optimize materials use, and at the same ensure the availability of the items.

RFID technology also has the potential to eliminate the human intervention [10]. Its unique characteristics enable RFID to sense the presence and movement of items and assets without requiring and relying on human assistance. Keeping stock activities require the store clerk to check the available of items one by one from the shelf. From the logistics perspectives, RFID can automatically verify the flow of items, identifying what it is, where it came from by identifying the manufacturer, and so on. The benefit of having fewer human hands involved is fewer errors, reduction in operating costs and the cost of restaurant management associated with human workers such as stock clerks or order fillers.

Conventional inventory system limits tracking of items while being calculate. With the RFID system, it gives a total visibility of item movement in inventory [10]. This may help the stock clerk to make early decisions about the inventory capacity based on what they have in inventory at any point in time and when low inventory is detected, qualified replenishment demand can be generated automatically [11]. It partially or completely eliminates time and effort required for counting the stocks. This results into reduction of total lead-time for arrival of stocks [5]. RFID enable automatic tracking in inventory [12] which helps the restaurant for better safety and quality control of their items. Tracking system helps restaurant to isolate the source and extent of safety or quality control problems. It also means avoid serving the customer with unsafe or poor-quality items, which in turn reduces the potential for bad public relations and accountability. The better and more precise the tracking system, the faster the stock clerk can identify and resolve food safety or quality problems.

D. Scope of Research

The primary scope of this research will be focus on the managing and identifying the inventory of the stocks or items inside the inventory by using the concept of RFID which is tagging, tracking and checking. It will demonstrate the concepts of RFID which for inventory controlling. There will be eleven (11) features included in this system; adding new stocks, edit stocks, delete stocks, find stocks, stocks notification, generate report of stocks as well as viewing, printing and export the stock report, and the security aspect was also included where the users need to login first before they can be accessed into the system. They can change their password or adding new user in security setting.

This system is a windows-based form and builds using the Visual Basic.Net (VB.Net) scripting language. The external device RFID is used where the RFID tagging will make the checking of items quicker, more accurate and provide a database of information about each item. The database used in this system is Microsoft Access. The main users of this system will be the person who is responsible to keep track the inventory status of stocks inside the storeroom such as stock clerk or order filler which they are responsible to count, prepare and maintain the stock records necessary to keep items for inventory running smoothly. This system assist them to manage their stocks effectively and in a convenient way by helping them to remember the items that need to be stock up inside the storeroom and inform them if items need replacing or if the stocks have passed the expiry date. It ensures that the inventories are properly record, maintain and balancing the inventory needs.

The level of identification for RFID tagging using in this system is pallet-level tagging. This level of identification is important because it depends on the constraints, for example the researcher decided not to apply the item-level tagging, because in case of the raw stock that is going to be processed or where the physical shape of the stock is going to be changed, item level tagging is not relevant.

II. LITERATURE REVIEW

A. Introduction to Inventory

"Inventory" for many small business owners is one of the more visible and tangible aspects of doing business. Raw materials, goods in process and finished goods all represent various forms of inventory. Each type represents money tied up until the inventory leaves the company as purchased products. Likewise, merchandise stocks in a retail store contribute to profits only when their sale puts money into the cash register. According to [13], in a literal sense, inventory refers to stocks

of anything necessary to do business. These stocks represent a large portion of the business investment and must be well managed in order to maximize profits. In fact, many small businesses cannot absorb the types of losses arising from poor inventory management. Unless inventories are controlled, they are unreliable, inefficient and costly. Many companies have been under pressure to streamline their inventory, minimize large inventories, and cut holding cost on inventory. In the past, inventory management has focused on not running out of supplies. This caused companies to stockpile large amounts of stocks. The extra goods would be to protect them from going out of stock. According to retail historian, Robert Spector, a critical factor for merchants is that they have to have a good inventory system. If the merchants do not have a good inventory system, they will not be able to forecast demands with any kind of accuracy. This might result in them running out of stock frequently [14]. [13] stated that, successful inventory management involves balancing the costs of inventory with the benefits of inventory. Many business owners fail to appreciate fully the true costs of carrying inventory, which include not only direct costs of storage, but also the cost of money tied up in inventory.

Inventory Management System deals with how the inventory has been controlled. Inventory control refers to [15] which monitoring the availability of material, assigning it to demands that has arrived and placing orders for replenishment of the product. All these activities may not happen continuously, or even in all time period. Inventory control is employed in the context of "pull-based" or replenishment-based systems where the trigger for placing an order is the current inventory status which in turn is related to the demand for items in recent periods.. In retailing, inventory management attempts to provide high demands and high profits to the company as well as good services and fresh items to customers at low cost. Inventory models are commonly used to determine when and how much to order while optimizing the overall organizational goal, for example, maximizing the net profit [15], benefits of inventory management can be reached by the use of "information technology and the construction of integrated inventory information systems". Concerning the use of information systems (IS) to integrate business processes across the inventory, various studies have shown that an internal integration should precede the external integration with suppliers and customers [16].

B. Technology Overview of RFID

RFID is a generic term that is used to describe a system that transmits the identity (in the form of a unique serial number) of an object or person wirelessly, using radio waves [3]. RFID uses radio signals to exchange data between a tag (also known as a transponder) and a read/write device (commonly called a reader or interrogator). Tags consist of a wireless chip and antenna that are housed in a label or other protective casing and attached to the item that is to be identified. The tag may be active, which means it has a battery to power its own transmission, or passive, which transmits using power received from the reader in the form of electromagnetic waves [18]. RFID can be used for many common warehouse and Distribution Centre (DC) inventory management operations, including receiving, put away, picking and shipping procedures [19]. According to [20], the active tags have longer read ranges making them appropriate for asset management and real-time location systems (RTLS). Passive tags have a shorter read range and are smaller and less expensive than active tags making them the tag of choice for most supply chain applications. The most common tag types used in warehouse and distribution center (DC) operations are passive adhesive "smart labels" applied to cases and pallets. A typical smart label has an RFID tag encoded within the label material, which is printed with text and bar code to support legacy operations. Chips and antenna can also be encased in more rugged tags to provide permanent asset and location identification or withstand exposure to high temperatures, industrial solvents, impact, and other conditions that make bar code or other forms of data collection impossible. [21] said that readers have antennas for sending and receiving signals, a processor for decoding tag information, and may have additional software for more advanced data processing. Antennas may be separate from the processor and connected by cable for additional placement and configuration flexibility. There are many types of RFID readers. The most common include mobile readers integrated into handheld computers or mounted on vehicles, and fixed position units, which are typically mounted at dock doors and conveyor lines.

RFID's suitability for use in industrial environments is just one of the attributes that set it apart from bar code and other automatic identification and data collection (AIDC) technologies [22]. One of the most significant is that no direct line of site is required between the tag and reader to exchange data. This enables tags to be read if they're not perfectly aligned with the reader, and even to be read through packaging material. Readers can also identify multiple tags simultaneously. Companies can take advantage of these attributes to reduce labor requirements with automatically triggered reads and unattended, high speed reading processes. RFID tags offer secure, rewritable memory, which can be used to improve visibility, security and provide other advantages as stated by [6]. Most RFID tags are read/write, and many have memory that can be partitioned so that some portions can't be changed (such as a serial number) while other portions can be updated, with transaction histories, storage records, pedigree information or other variable data. According to [23], Electronic Product Code (EPC) of RFID technology provides a standardized, unique serial number for each RFID tag. Many new inventory processes are emerging to take advantage of unique, standardized and secure serialization that EPC provides. Another characteristic of RFID technology that is useful for warehouse and distribution center (DC) operations is its read range. [21] said, depending on the tag style, antenna design, frequency and other variables, passive tags can be read from near contact to approximately 20 feet away. Active tags offer even longer range and are sometimes used for yard management and container tracking applications.

Frequency is one of the biggest variables affecting RFID range and performance. According to [12], nearly all RFID systems used for warehouse, distribution center and supply chain applications operate on one of three major frequency families: 13.56 MHz high frequency, common for short range (up to about 1 meter) reading; 860-960 MHz UHF, which includes the well-known EPC global Gen 2 standard and provides range of up to 20 feet; and 2.45 GHz microwave transmission, which is used in active tags that provide long range reading [18], commonly used for identifying cargo containers. Of the three, UHF technology is by far the most common and best suited for the majority of manufacturing and logistics needs. High frequency (13.56 MHz) technology is widely used in other applications and is a viable option for short-range applications. It is often promoted for item level tagging, such as

for product authentication and retail shelf management [3] also stated that Ultra High Frequency (UHF) technology offers the range, speed, security and cost-effective equipment that many material handling, warehouse and manufacturing applications require. The EPC Gen 2 UHF standard was created specifically to support supply chain applications. EPC Gen 2 operates in the 860-960 MHz range, so it can be used throughout the world and poses no interference risk to IEEE 802.11- standard wireless networks (although interference is possible from older, 900 MHz wireless LANs). It supports high-speed reading, provides enough read range for most distribution operations, encodes Electronic Product Code (EPC) numbers, which provide unique serialization, and makes additional memory available to users [21] found that the companies which they researched such as Wal-Mart, Best Buy, Marks & Spencer, METRO Group, the U.S. Department of Defense and other leading RFID adopters are embracing Gen 2 and requiring their suppliers to apply Gen 2- compliant tags on shipments. Numerous RFID industry professionals, market researchers and analysts predict Gen 2 will become the dominant UHF protocol [24].

RFID can be used for many common warehouse and DC inventory management operations, including receiving, put away, picking and shipping procedures [19]. RFID has high return on investment potential when applications take advantage of its reading characteristic to overcome previous limitations or to enable new business processes. With RFID, items can be monitored and identified at process points where other forms of data collection are impractical because of environmental or cost limitations. Factor in the ability to encode unique, secure serial numbers on tags, and it begins to become clear how RFID can lead to new levels of visibility in inventory and supply chain operations. Reduced inventory levels, storage, handling and logistics expenses follows from improved visibility.

C. RFID Application to Inventory Management

Effective inventory management depends upon consolidating, integrating, and analyzing data collected from many sources such as, distribution centers and warehouses. Conventional tracking systems require manual intervention, which is labor intensive, time consuming and error-prone [5]. Radio Frequency Identification (RFID) technology offers the potential to greatly improve inventory performance due to its ability to provide rich and timely information that increases visibility [25] and control over the inventory. By using RFID technology, it gives significant advantages over the conventional methods. The first advantage is the inventory monitoring and asset visibility (smart shelves). In a replenishment-based system, whenever the total inventory at a warehouse or distribution center drops below a certain level, the RFID enabled system could place an automatic order. RFID-tagged products will allow stores to track the location and count of inventories in real time. This will better monitor demand for certain products and place orders to prevent an out-of-stock situation. The high levels of inventory monitoring obtained using RFID can particularly benefit the fast moving consumer goods (FMCG) industries.

The second advantage gained is the PoS Data. On the retailing side, RFID technology at the point-of-sale (PoS) can be used to monitor demand trends or to build a probabilistic pattern of demand. This application could be useful for apparel industry or products exhibiting high levels of dynamism in trends. With the implementation of RFID technology, we can reduce the Bullwhip effect. Exaggeration of demand in upward direction in a supply chain network is termed as Bullwhip effect. Due to tracking limitations of conventional systems it may not be possible to get accurate information on actual sales of items; that will amplify the magnitude of the bullwhip effect. If RFID systems are used for information collection, accurate and real time information on product sale can be captured and used for decision making. This will definitely help to reduce overall bullwhip effect. Reducing bullwhip effect would benefit industries where instances of supply-demand imbalances have high costs attached to it [5]. Conventional systems limit tracking of items while being transported. RFID system gives a total visibility of product movement in the supply chain. This may help to make early decisions about inventory control in case there is any interruption in the supply. It partially or completely eliminates time and effort required for counting while loading/unloading the items. This results into reduction of total lead-time for arrival of an order. Pharmaceutical industry, perishable product industry could use RFID systems for reducing lead-times that will help to increase total useful shelf life of items. In a warehouse, sorting/picking activity is more time consuming and subjected to errors. For example, for issuing of items from a store, a person has to find out whether the item is available in store or not by physically moving to the location. Items issued should be kept in a particular position (bar-code upward) in a pallet for scanning/billing purposes. RFID systems ease the sorting and picking operations, as it captures real time, accurate information about product availability in host computer database without physical movement. RFID tags are read via radio frequencies therefore it is not mandatory to place the items in a particular position to read it. This could be helpful for effective warehouse management.

A perishable product has limited useful life and if it is not handled properly while transporting, it may get spoiled and its useful life reduces. Such spoilage could be reduced simultaneously with automating inventory management, by using RFID technology for product identification in the inventory management. RFID system can track the items in real time without product movement, scanning or human involvement [26]. Using active RFID tags it can be possible to update information on it dynamically. Using RFID technology for data collection and some appropriate inventory algorithms for replenishment decisions [27], many warehousing processes can be automated such as, receiving, picking, and ordering. Various enterprise applications, for example enterprise resource planning (ERP) packages [24], can be configured and linked to RFID technology for direct and on-line collection of data. It could be possible to combine RFID and bar coding technology for tracking of items to take competitive advantages of both the technologies.

RFID implementation will depend on the cost of change to the new technology as well as the benefits accruing from exploiting some of the possibilities that the technology brings. Several issues should be considered for successful RFID implementation. Level of tagging has a greater influence on total RFID related costs. Tags can be applied [28] at item level, case level or pallet level. It is important to select appropriate level of tagging for a particular type of application. Tags can be applied at pallet level for less valued items, for example, auto spares parts, or fast moving consumer goods (FMCG) items [15]. Case level tagging would be appropriate for per-

ishable items in which expiry date for all items in a case is same. Pallet and case level tagging would be useful for warehouse management. The tags could be applied to individual items for tracking of high valued items, for example, gold ornaments, baggage tracking.

III. RESEARCH METHODOLOGY

Basically, there are four phases involved in this research studies; 1) problem identification and planning, 2) requirement gathering, 3) requirement analysis, and 4) prototype development. Fig. 1 below shows specifically outlines the activities, tools used, and deliverables in each phase. The phases carefully being followed allow this research achieved all the required scopes and objectives.

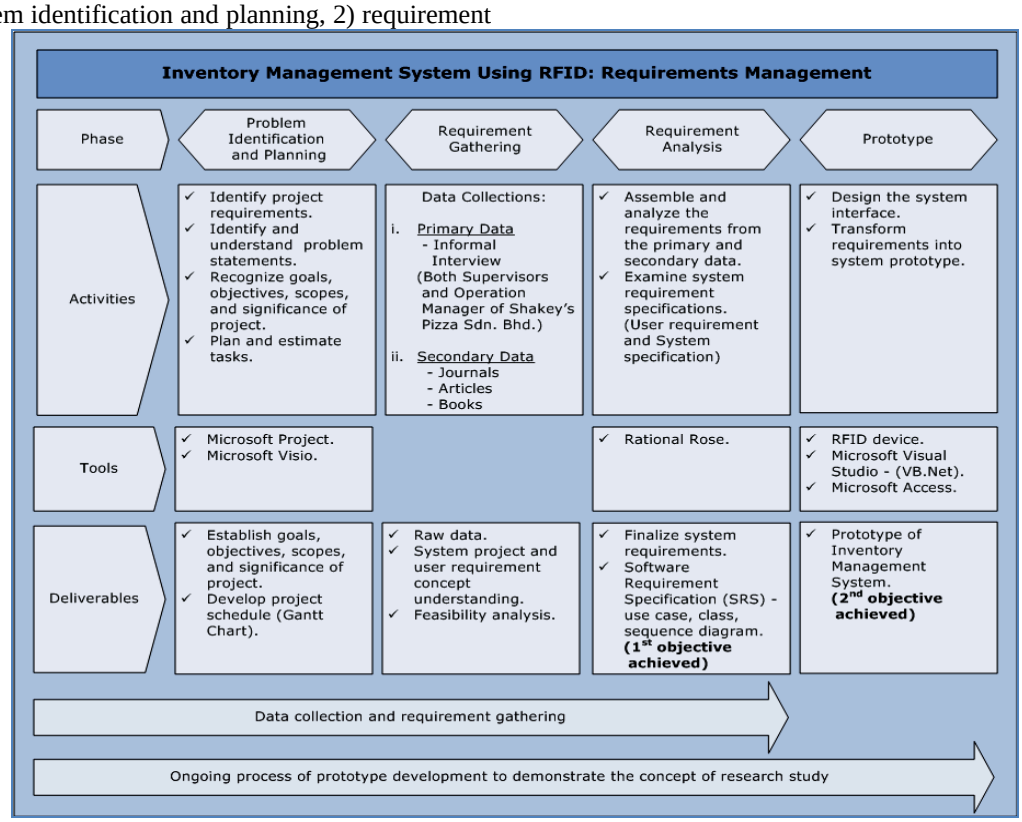

Figure 1. Overview of Research Approach and Methodology.

In the first phase, the current problems are studied properly because it provides the context for this research study and typically generates questions which the research expect to answer. After clearly understand the problem statement, the goals and objectives of this research study are established.

RFID technology in inventory management is a rather new application. It became clear that in the requirement gathering process, this research methodology is more to the collection of qualitative data as it hard to expect finding a representative sample of participants for a quantitative data. Therefore, a combination of primary sources and secondary sources are provided for this research. Primary sources of information are from informal interview. Information from the Internet and computing magazines, contribute as a secondary sources.

Requirement analysis had been done as the third phase in this research studies. The final selection of the requirements which is RFID specifications and its characteristics that being used together with the inventory management are documented in Software Requirement Specification (SRS) that covered Use Case Diagram, Class Diagram and Sequences Diagram, constructed using Rational Rose tool. These requirements will be used later as a reference during the rest of the project development and thus, need critical thinking of precise, brief and fixed of requirements analysis

As for the final stage, the system prototype is built according to the stated requirement specifications. It is crucial to make sure that the system is compatible with the platform and hardware including the RFID device which used to detect the unique serial number items and store it in the database. So, during the development, this inventory system is ensured to cope with the RFID device specification. Development of this system prototype involved the uses of Visual Basic.Net scripting language and Microsoft Access as the database. At the end of this phase, the second objective which is to verify and validate the requirements of inventory management by demonstrates the prototype of the inventory system is achieved and the system completely delivered.

IV. FINDINGS

Assumptions and deductions are being made to fully satisfy the objectives of the research. It is important to clearly specify what have been found throughout the research. The achievement would be described based on the following objectives:

A. To Identify the Requirements Criteria of the Inventory Management System.

The purpose of Requirements Analysis is to obtain a comprehensive and detailed understanding of the business need and to break it down into discrete requirements, which are then clearly defined, reviewed and agreed upon with parties involved. During Requirements Analysis, the structure for the application is developed, providing the foundation for all future design and development efforts. The quality of the final product is highly dependent on the effectiveness of the requirements identification process.

Information is gathered from the stakeholders identified. The stakeholders need to explain what they have experienced with the current system and acquired their understanding in regards of their particular knowledge area. The tools used in this requirements elicitation include traditional methods which is stakeholder interviews. However, modern tools that are better equipped to handle the complex and multilayered process of requirements elicitation is used which are use cases, activity diagrams, and graphical user interfaces (GUI).

The stakeholders are being interviewed came from two main different areas of knowledge. The first party is Operation Manager of Shakey's Pizza Sdn. Bhd. (Jusco Kepong outlet). Second is both of research's supervisors. The discussion has helped a lot as the 2nd interviewee had experience and knowledge in RFID technology area. He explained the potential constraints and problems that will arise when deploying RFID as well as the benefits and advantage that can be gained using the RFID technology.

Besides, he added that RFID covered four main concepts that are tagging, tracking, checking and security. RFID tags that attached to the particular item enable the tags communicate with the RFID reader through radio waves, where the reader pass the information about the item into system. The concept of tracking enables every items being tracked simultaneously at one time while concept of checking is about the information of particular item can automatically being checked without human intervention. He added that RFID system is also distinguished by their frequency ranges. Low-frequency has short reading ranges and use less power compared to high-frequency which offering long read ranges and high reading speeds. Radio waves behave differently at different frequencies, so he said it is important for me to choose the right frequency for the right application during developing the system.

Furthermore, he also mentioned about the strategy of forecasting, which is the process of estimation the unknown situations. Integration with RFID through the inventory system can help the owner of the restaurant to make timely decisions in the face of uncertainty about the future. With the help of RFID, the owner can come out with the better decision making because due to RFID ability, it can provide rich and timely information that increases visibility, control over the inventory and ease the sorting and picking operations as it captures real time. RFID applied to the identification of inventory information, can produce a better forecasting used in the practice of inventory management to support day to day business operation.

Information gathered is not only covered from the view point of the developer but also from the perspective of the end-user who is not a technical expert. The researcher decided to interview the person who has experience in handling inventory management and familiar with the written procedures regarding purchasing, receiving, inspection, and handling stocks. The interview session is conducted with Operation Manager of Shakey's Pizza, Mr. Ahmad Tajul Ruslee Termizi on August, 2 2008.

From the interview, the synopsis of common problems in managing inventories being identified. These problems were based from several issues highlighted as below:

- The way of storing/ recording information – Human errors or processing errors in counting the stocks. It being recorded in paper forms and lead to waste resources.
- The way to retrieve information - Sorting or picking stock is subjecting to errors and time consuming. Count the stock by physically moving into stockroom.
- Categorizing information - Each stock has its own category and need to be properly labeling. Checking each stock compared against a list of stocks in forms which lead to waste of effort.
- Space of storage - More stocks, more space area to place the stocks.
- The way of inventory monitoring – Stocks get spoiled before being used. May influence theft or damage. It becomes worse when do not realize if stocks are being stolen.

B. To verify and validate the requirements of inventory management by demonstrating the prototype of inventory system.

This research intends to demonstrate a prototype of Inventory Management System based on the management requirements of inventory. The prototype development is based on the functional requirements of the system. The requirements gained are summarized in Table I.

Table I. System Requirements

Activity	*Requirements*		
	Entity	***Attribute***	***Process***
A) Manage Stock Records 1. Adding new record of stocks 2. Updating stock records	Stock	✓ Stock Code ✓ Stock Name ✓ Stock Type ✓ Stock	✓ Get Stock ✓ Check Stock ✓ Add Stock
3. Delete stock records 4. Find current stocks in inventory 5. View stock information 6. Print stock information		✓ Description ✓ Vendor Name ✓ Expiry Date ✓ Quantity ✓ Unit Price ✓ Total Price	✓ Update Stock ✓ Delete Stock ✓ Find Stock ✓ View Stock ✓ Print Stock

B) Vendor Information 1. View Vendor's Company Name	Vendor	✓ Vendor Id ✓ Vendor Company ✓ Stock Code	✓ Get Vendor ✓ View Vendor
C) System User 1.Authenticate user 2. Create new user 3. Change user password	Admin	✓ Username ✓ Password	✓ Get Password ✓ Verify Login ✓ Add user ✓ Change Password ✓ Logout

Refer below for sample interfaces of the system.

i). *Login Page*

The first page of the system is the login page. The person who is responsible to manage the stock records in inventory needs to provide the correct username and password before they can access into the system.

Figure 2. Login Page

ii). *Add New Stock Page*

Fig. 3 is used to add new stock data in the inventory system. Admin needs to enter the port number first before the RFID reader can be used to read the serial number of tags. The port number used in this system is COM15. After that, Admin click scan to detect the serial number of RFID tags. The serial number automatically appears in the Stock Code field and this Stock Code belongs to the individual stock item. This procedure same goes to the Update Stock, Delete Stock and Find Stock. Admin then can fill the other data regarding the particular stock. After success in adding new stock in the system, the record of the stock appears at the stock information in the same page.

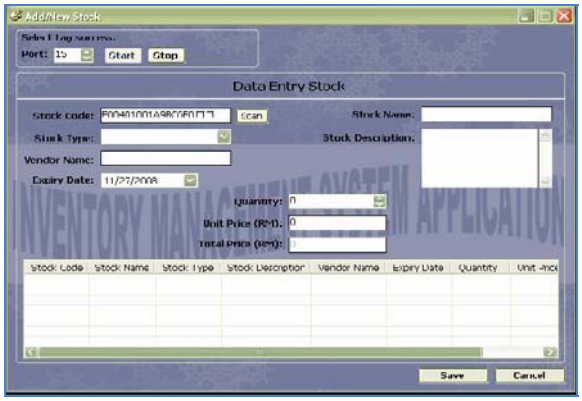

Figure 3. Add New Stock Page

iii). *Find Stock Page*

Fig. 4 shows the page used by Admin when he wants to find the current stock records in the inventory. Admin can find the stock records based on the Stock Code, Stock Name and Stock Type. If Admin click Scan, the RFID reader reads the serial number of the RFID tags and Admin must choose to find data order by Stock Code since the serial number of stock appears in Find Data field. Otherwise, if Admin want to find stock records based on Stock Name or Stock Type, he can simply insert name or type of stock in Find Data field.

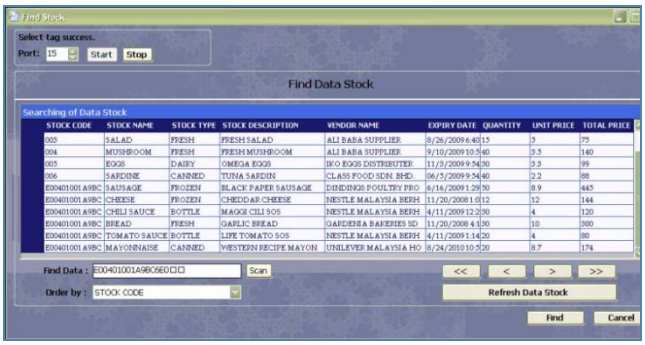

Figure 4. Find Stock

iv). *Reminder Page*

Fig. 5 is used to give notification to Admin when there are stocks inside the inventory need replacement or the stock has reached its expiry date. Admin will add notification in comment box and the comment will appear in the calendar. Whenever Admin open this page and go to the particular month, then popup message will be displayed to notify the Admin whether the stock is expired or need replacement.

Figure 5. Stock Notification

v). *Stock Report Page*

Fig. 6 displays all the stock records in inventory management system in a form of report. Admin can also print and export the report to the format available such as PDF, Microsoft Word, Microsoft Excel or Crystal Report.

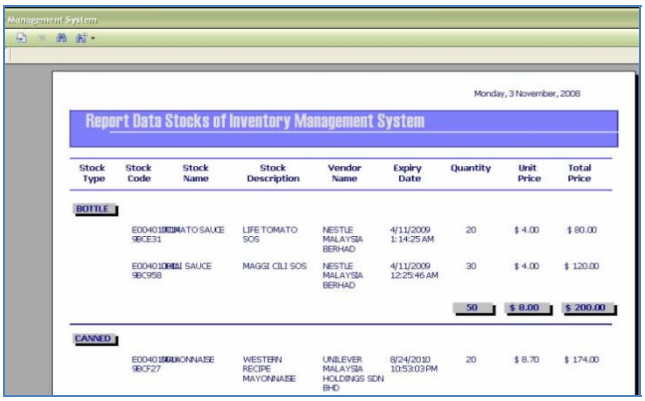

Figure 6. Stock Report

V. CONCLUSIONS AND RECOMMENDATIONS

Throughout the research studies, the problems in organizing stocks in conventional inventory management was identified before providing the solution, where the conventional inventory system still using the manual way of doing management on inventory records - numbers of paper forms are being used, files need to be labeling to differentiate each paper stock forms and when these records getting increase, the filing cabinet use for storing them need to be added. Therefore, the researcher has developed understanding with the true facts of the current situation to place this subject research in context. A set of procedures that consist of several phases is implemented to show the workflow during this research. It contains five phases which are problem identification and planning, requirement gathering, requirement analysis, and lastly is prototype phase. Each of these phases plays an important role that is well designed to produce a good research. The specification of hardware and software also been explained where they are used in developing this system prototype.

This system and the RFID device have some limitations and constraints that are needed to consider. Also, described below are the problems during the prototype demonstration:

- The RFID reader is not stable since the researcher needs to configure the serial port each time to perform the functionality of modules in the system.
- The RFID reader sometimes may and may not detect the RFID tags.
- RFID tags cannot be attached to items either on plastics, aluminium (metal) or even paper. If the tag attached to those types of items, then the RFID reader cannot identify the serial number of tag and unrecognized characters will appear on the system.
- RFID tag needs to be placed on the RFID reader each time to tracking the items. This situation preventing the researcher from capturing stock information in the real time.
- The researcher only provided with ten RFID tags by the vendor and causes limitation during the refinement of system prototype in order to do testing and demonstration.
- The inventory management system will suddenly open up its source code without any error displayed when the RFID reader cannot read the RFID tags, but this situation may happen occasionally.

Although the system prototype is successfully demonstrated, it is still needs some improvement and enhancement. For those who may wish to extend this line of research for the future work, the researcher suggested that:

- Configuring the serial port is done once so that all the functionality of modules can be demonstrated simultaneously without wasting time to reconfigure the serial port.
- Enhancing the existing functionality of modules for example, at this moment, the stock report can be generated only query by stock type. Later, for the additional features, the users can choose to print the report based on their interest such as stock name, vendor name, or produce the stock report in particular month, or week.
- Adding new valuable modules to the system such as Sales Order, Purchase Order, Shipping, Vendor Details and also broaden the scope from this simple inventory management system to warehouse inventory management system.
- Improve the attractiveness of the system interface.

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