A PROBLEM ORIENTED APPROACH TO IMPLEMENTING AN AUTO SALES AND INVENTORY SYSTEM THROUGH AGILE METHODOLOGY

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ABSTRACT

In an investigation of an auto supply company's operations, it was discovered that their business process is prone to human error thus, resulting to inconsistent and unreliable historical information. This leads to inventory overstock which dramatically increases inventory costs. The goal of the project is to produce an automated sales and inventory management system which will allow the general manager and the employees of the company to achieve better business workflow. The study attempts to apply a Problem Oriented perspective in creating a system to address the aforementioned issues. The created system was evaluated by the company with satisfactory results. This paper shares the systems implementation process and the results.

KEYWORDS

Restock Point, Inventory Cost, Scrum Framework, Agile Method, ABC Classification System.

1 INTRODUCTION

The company, located in San Pablo, Laguna, specializes in the sale of car accessories and auto supplies. It is a family owned business that has been established for the past 22 years. It offers top quality car accessories from Thailand and China and can be considered a specialty store catering to car enthusiasts. It offers car accessories for car brands which include Toyota, Honda, Kia, and Hyundai among many others. From a simple startup, the company is now a profitable vehicle accessories and auto parts supplier strategically positioned at a prime location with high market traffic in Laguna. The company site is easily accessible to its target market thus providing a competitive advantage to other business competitors.

The researchers were tasked to investigate and develop a system to solve the company's inventory issues. The study applies a Problem Oriented Approach to solving the business issues over the requirements given by the client. A Problem Oriented Approach presents development as the representation and step-wise transformation of real world business problems. It allows for the identification and clarification of system requirements, the understanding of the problem world, the specification of a system that can ensure satisfaction of the requirements in the problem world, and the construction of adequacy arguments, convincing both to developers and to users that the system will provide what is needed [1].

Using this approach, however, does not mean that the researchers have disregarded the initial software specifications agreed upon with the client; in fact, they investigated the structure of the organizational problems with the use of software engineering methods and disciplines. They concluded that a majority of the problems could be solved using the ABC Classification System and with the Agile Methodology as the main development approach.

Basic Economic Order Quantity Model

With the present problem of the business having unreliable inventory control as regards supply and demand, the researchers decided to make use of the Economic Order Quantity model to solve the dilemma. The Basic EOQ Model is a formula for determining the optimal order size that minimizes the sum of carrying costs and ordering costs. Figure 1 describes the continuous inventory order cycle system inherent in the EOQ model. An order quantity, Q, is received and is used up over time at a constant rate. When the inventory level decreases to the reorder point, R, a new order is placed; a period of time, referred to as the lead time, is required for delivery. The order is received all just at the moment when demand depletes the entire stock of inventory—the inventory level reaches 0—so there will be no shortages. This cycle is repeated continuously for the same order quantity, reorder point, and lead time [2].

The ABC Classification System

To solve the problem of the business with regard to inflating inventory cost due to inaccurate inventory listing, the researchers decided to use the ABC system to address this issue. The ABC system is a method for classifying inventory according to several criteria, including its peso value to the firm. Figure 2 shows the approximate ABC classes.

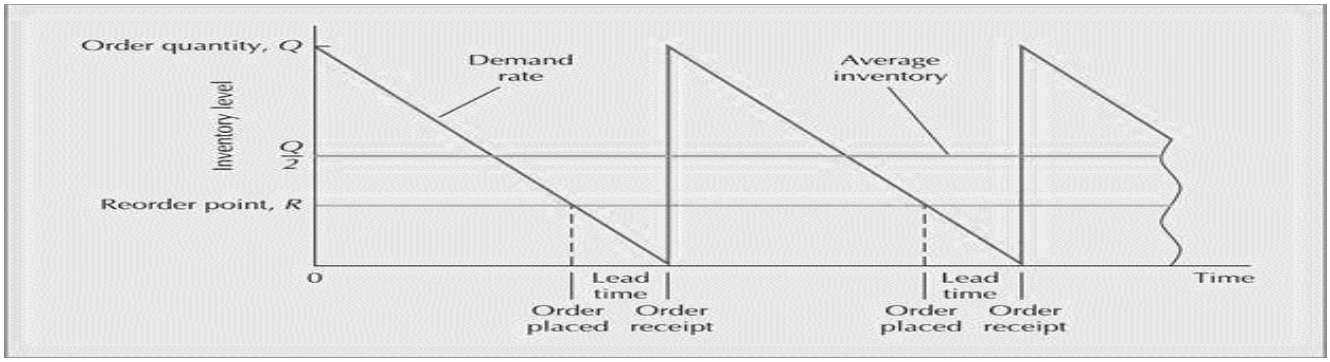

Figure 1. The Inventory Control Cycle [2]

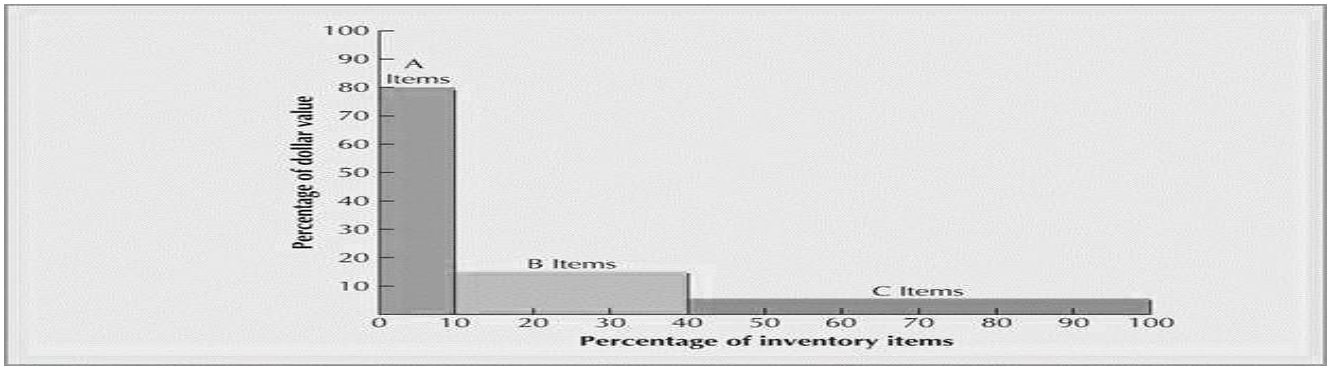

Figure 2. ABC Classifications [2]

In general, about 5 to 15% of all inventory items account for 70% to 80% of the total peso value of inventory. These are classified as A, or Class A, items. B items represent approximately 30% of total inventory units but only about 15% of total inventory peso value. C items generally account for 50 to 60% of all inventory units but represent only 5 to 10% of total peso value. In ABC analysis each class of inventory requires different levels of inventory monitoring and controls—the higher the value of the inventory, the tighter the control. The first step in ABC analysis is to classify all inventory items as either A, B, or C. Each item is assigned a dollar value, which is computed by multiplying the peso cost of one unit by the annual demand for that item. All items are then ranked according to their annual peso value with, for example, the top 10% classified as A items, the next 30% as B items, and the last 60% as C items. These classifications will not be exact, but they have been found to be close to the actual occurrence in organizations with remarkable frequency [2].

The next step is to determine the level of inventory control for each classification. Class A items require tight inventory control because they represent such a large percentage of the total dollar value of inventory. These inventory levels should be as low as possible, and safety stocks minimized. The appropriate inventory control system and inventory modeling procedure to determine order quantity should be applied. In addition, close attention should be given to purchasing policies and procedures if the inventory items are acquired from outside the firm. B and C items require less stringent inventory control. Since carrying costs are usually lower for C items, higher inventory levels can sometimes be maintained with larger safety stocks. It may not be necessary to control C items beyond simple observation. In general, items frequently require a continuous control system, where the inventory level is continuously monitored; a periodic review system with less monitoring will suffice for C items [2].

The Agile Methodology

The customer system requirements changed frequently during the development process, as more problems of the business surfaced after each succeeding meeting with the client. This is the primary reason why the researchers made use of the Agile Methodology. Agile methods are incremental development methods in which the increments are small, and typically new releases of the system are created and made available to the customer every two to three weeks [3]. The versatility of the Agile Methodology makes it the most logical choice as a problem oriented solution because not only is it client focused, it bridges customer feedback as well.

The Agile Methodology relies on a very high level of customer involvement throughout the project. The customer has frequent and early opportunities to see the work being delivered by the team, and to make decisions and changes throughout the development of the project [3]. This methodology is the most logical approach for solving the business' current problem because it focuses on the business value by allowing the client to determine the priority of features such as the use of the ABC system. The researchers also understand which factors are the most important to the client's business, and the team can deliver the features that provide the most business value.

The framework of the Agile Methodology, called Scrum, was implemented for this research. The Scrum framework was centered on a set of sprints, which are fixed time periods when a system increment is developed [4]. A Scrum involves daily stand up meetings, the team, a product and sprint backlog, and an end of sprint evaluation.

The Product Backlog is an ordered list of everything that is known to be needed in the product. It is the single source of requirements for any changes to be made to the product [5]. The Sprint Backlog is the set of Product Backlog items selected for the Sprint, plus a plan for delivering the product Increment [6]. The daily standup meetings are observed to optimize team collaboration and performance by inspecting the work since the last Daily Scrum and forecasting upcoming Sprint work [7].

The three roles in an Agile Scrum are as follows: (1) Product Owner; (2) Scrum Master; and (3) Scrum Team. The Product Owner sets the requirements and makes sure that the tasks are always followed. The Scrum Master is a servant-leader for the Scrum Team. He is responsible for promoting and supporting Scrum by helping the members of the Scrum Team understand Scrum theory, practices, rules, and values [8]. The Scrum Team is composed of individuals responsible for building the product. They are self-organizing and choose how best to accomplish their work [4].

The researchers used the Agile approach because it made it possible to establish constant communications between the system customer and the development team. Furthermore, the team also considered the project size in choosing what approach or methodology to use. Since the project size can be considered average, the Agile approach is the best methodology to use because it works better in small projects where the team can provide small deliverables in very short periods of time in order to gradually build the final product.

Refer to Figure 3 for the Conceptual Framework used for the study. The Problem Oriented Approach starts with the discovery and analysis of the Problems of the business through interviews and observation and selecting the best solutions in the form of the Prototype which is then evaluated in the produced System.

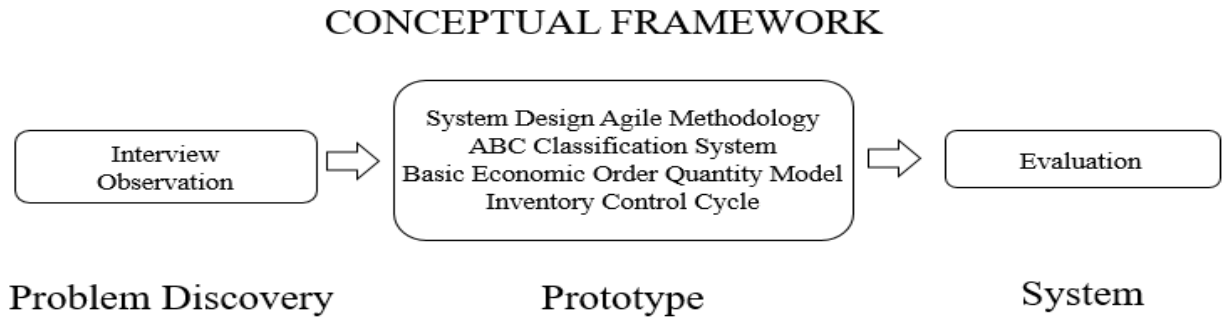

Figure 3. Conceptual Framework

2 Research Objectives

The primary reason why the researchers used the Agile Methodology is because it involved customer representatives directly in the development process. This kind of methodology focuses on reducing process overheads and documentation and on incremental software delivery, which made it easier for them to see the progress of the project without having to worry about heavy documentation [3].

The research objectives of the project are:

1. To identify and describe the evolution of the problems discovered during the Agile development;
2. To identify the changes to the system's functionality to the discovered problems; and
3. To describe the sales and inventory system software design.

3 Methodology

3.1 Research Design

Problem oriented research is utilized in this paper. A problem oriented research method is defined as a study undertaken to know the exact nature of the problem that is required to be solved. A ‘problem’, when used in this context, is a decision making dilemma or a need to tackle a particular business situation. It is appropriate with the

current research because its primary aim is to present a solution that would solve the problems that are affecting the value of the business.

In the interim, the research technique used is a combination of basic research and qualitative interrogation. For the basic research, the researchers reviewed existing studies about current inventory management systems and their rate of effectivity on present businesses. Afterwards, they performed qualitative interrogation with the client to verify if the relationship exists, supplementing the argument on the two variables' interaction.

3.2 Research Participant

The researchers interviewed the stakeholders of the organization: the general manager, the bookkeeper, and the staff. The participants assessed are both male and female, whose ages range from 30 to 40 years old.

3.3 Data-Gathering Procedure

The researchers made use of existing academic materials to discover the best applicable system that would solve the problem of the business regarding its present problems. The researchers also visited the company site to acquire more data about the exact process of the business workflow environment and conducted interviews with the stakeholders of the company.

The researchers conducted a client conference every four weeks wherein they gathered feedback and suggestions from the general manager. A total of 3 Sprints were conducted, with each sprint consisting of 30 working days from Monday to Friday, and each working day with a total of 8 working hours. The team observed stand up meetings daily discussing the issues that every member of the team was facing and what tasks have been finished. Additionally, one day in one working week (every Wednesday) is dedicated to a 15-minute consultation with the Scrum Master. The researchers made use of Trello boards to keep track of the tasks being done. The Trello board served as the Product Backlog of the entire project. From there, the researchers would pick tasks that were designed as User Stories and label them according to an estimate of how many working days it would approximately take to finish the said task. In the event that a task would not meet the deadline of a Sprint, it was moved as another task in the next Sprint.

3.4 Treatment of Data

For the great part of the analysis conducted, the researchers utilized qualitative data analysis. The preliminary observation of the researchers of the business workflow and business environment supplemented the primary functions and design of the system. Every meeting with the client yield feedback that were incorporated in the next iteration of development. Client evaluation scores were submitted under strict confidentiality. The mean scores were calculated to determine the final results of the system.

3.5 Prototyping

The researchers developed a prototype of the system based on the primary software requirements specifications which defined what services were required from the system and identified the constraints on the system's operation and development [3]. For the prototyping phase, the researchers used the Scrum framework of the Agile Methodology. At the end of each Sprint, the researchers met with the client to present the implemented changes to the system from the problems that surfaced from the previous meeting, including suggested changes.

An evaluation and certification form was also used to rate the system for (1) ease of use, (2) pleasant appearance, (3) reliability, (4) security, (5) efficiency, (6) completeness of function, (7) completeness of system, and (8) readiness for deployment. The 8 criteria were subdivided into 4 categories according to good software attributes: Usability, Dependability & Security, Efficiency, and Acceptability. Each criterion was scored using the Likert Scale, with 1(one) being the lowest, and five (5) being the highest.

4 Results and Discussion

Table 1 shows the problems the researchers identified from both observation and interview.

Table 1. Interview and Observation Results

Questions	Answers
What are the positive and negative location factors of your company?	The business is located at prime location with high market traffic, making it a smart choice for other auto-supply companies as well.
What factors influence the acquisition and allocation of resources?	Low retail price of a wide range of products from trusted suppliers.
What kind of inventory control system does your company use?	The Traditional System for inventory control, which is done by manually recording each item in the inventory.
Do you think that your company can further increase the quality of its service to its customers? How?	By avoiding slow order fulfillment, which means not making them wait for a long time when locating the product they requested from the storage room.
Business Process/Environment	**Observation**
Manual inventory listing	Inaccurate, leads to inventory overstock or understock. High inventory costs.
Unorganized storage	Slow order fulfillment.
Manual sale transaction recording	Long hours of sales computation.

Based from the interview results in Table 1, the researchers identified that the traditional system that the company uses is no longer effective in managing their inventory. The standard business process begins once the general manager entertains a customer that enters the business premises, which approximately takes 15 minutes depending

on the number of items he wishes to purchase. The general manager searches for the item in the store which takes up an unnecessary amount of time. Once the item is sold, the cashier records the transaction in a receipt. This process is repeated until the end of working hours. Before the general manager rests, he collects all the receipts of the day and records them by hand one by one in a record journal, a task that approximately takes 4 hours. At the end of each week, he checks the record books and records all the items in the inventory individually to determine which items to purchase from the suppliers. The general manager and cashier of the business reviews the actual inventory by checking each item separately and comparing the total number with the log from the receipts and the record journal. This type of inventory control is difficult to manage as it introduces a number of problems, which include, but are not limited to, the following: incorrect inventory, slow order fulfillment, product overstock, excessive inventory costs, and losing track of items.

4.1 Problems and Resolutions

Table 4 shows the problems the researchers discovered in the business environment and the functionality they devised for the software in order to solve them.

Table 2. Problems and Resolutions

PROBLEM	RESOLUTION
Manual inventory listing.	Created the following functionalities to automate the recording of inventory: Add Category, Add Supplier, and Add Product.
Excessive inventory costs.	Used the principles of the ABC Classification System to develop a functionality which classifies a product according to their total peso value to the business.
Unreliable inventory control with regard to supply and demand **(**Product overstock and product understock**).**	Used the principles of the Basic EOQ Model to calculate the reorder point of each item in the inventory.
Unorganized inventory storage management leading to slow order fulfillment and long waiting times for customers.	Created a function that enables the printing of consistent product labeling. With the advent of the new product labeling method, the arrangement of the physical inventory will have to adjust and arrange the items according to car brand. These labels will be the basis on how to properly locate the item in the storage.
Long hours of calculating the business sales of the day and of the week.	Created a database that records all the sale transactions that occur in one business day. The system dashboard also shows the total amount for the sales of the day. In addition, the system is able to generate sales reports from a specific date.

Losing track of the number of items in the inventory.	Created a database that records the historical data of the items in the inventory, including the exact number of items in stock. In addition, the system has a function that generates an inventory report from a specific date.
Restrictive access of employees to managerial level business information.	Added filters to the system to limit the access of unauthorized employees to confidential business data.

The information the researchers acquired by observing the actual business process and business environment revealed several problems. The inventory costs of the business are unnecessarily huge due to inventory overstock when the general manager orders more items than needed from the suppliers. This is caused by the inaccurate information from the record journals of the business which are managed manually. Aside from overstock, the business also experiences item insufficiency because of inconsistent inventory information caused by human error. Furthermore, the products of the business in the storage room are not organized properly. In the event that a customer requests for a product that is not on display, this leads to long waiting times for them while the employee searches for the product in stock. As a result, this leads to slow order fulfillment. Because the company lacks a formal automated system in its environment, the computation of the daily and weekly sales also takes a very long time.

The system being proposed aims to automate the inventory control of the business which will solve its present business problems and benefit the business and its stakeholders in the long run. The system should be able to determine the total inventory of the business to address the inaccurate inventory control caused by human error. In addition, the proposed system will grant easy access to historical data for the business owner, which is effortless compared to manually sifting through countless record books that could also be lost or damaged. Furthermore, this system will provide consistent product labeling for a more organized physical inventory control. The data for the product labeling feature for each item will include the car brand, item price, supplier, color, and item code. Next, the system will automatically notify the general manager if a certain item in the inventory has reached its restock point so that it can be added to the list of products that the owner needs to get from his weekly meeting with the suppliers. Also, the system should produce a daily and weekly sales and inventory report as demanded by the business owner.

Figure 4 shows the specified actors in the client company's organization who are able to directly interact with the system. Included are the General Manager, Cashier, Bookkeeper, and other Employees. Each actor has different restrictions respective to their role.

4.2 Software Context

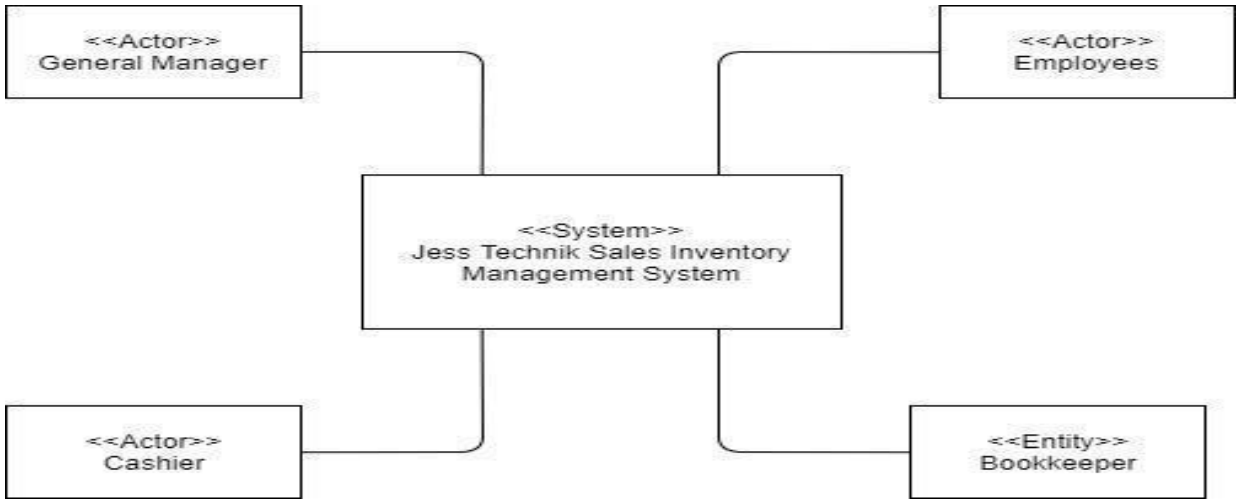

Figure 4: Software Context

4.3 Initial Architectural Diagram

JavaScript Native)
JSP
Servlet (Java)
Database (MySQL)

Figure 5. Initial Architectural Diagram

Figure 5 shows the architectural diagram developed during the initial data gathering procedure based on the interviews with the research participants and the primary observation of the researchers of the business process and environment. The researchers aimed to use the Model-View-Controller (MVC) as the architectural pattern that separates an application into three main logical components: the model, the view, and the controller. Each of these components are built to handle specific development aspects of an application [9].

4.4 Entity Relationship Diagram

Figure 6 shows the different entities that the researchers developed for the data storage and retrieval of information that are essential to the process of the system. These entities are shown as tables with different attributes and keys that pertain to the needed data and information that are connected among each other.

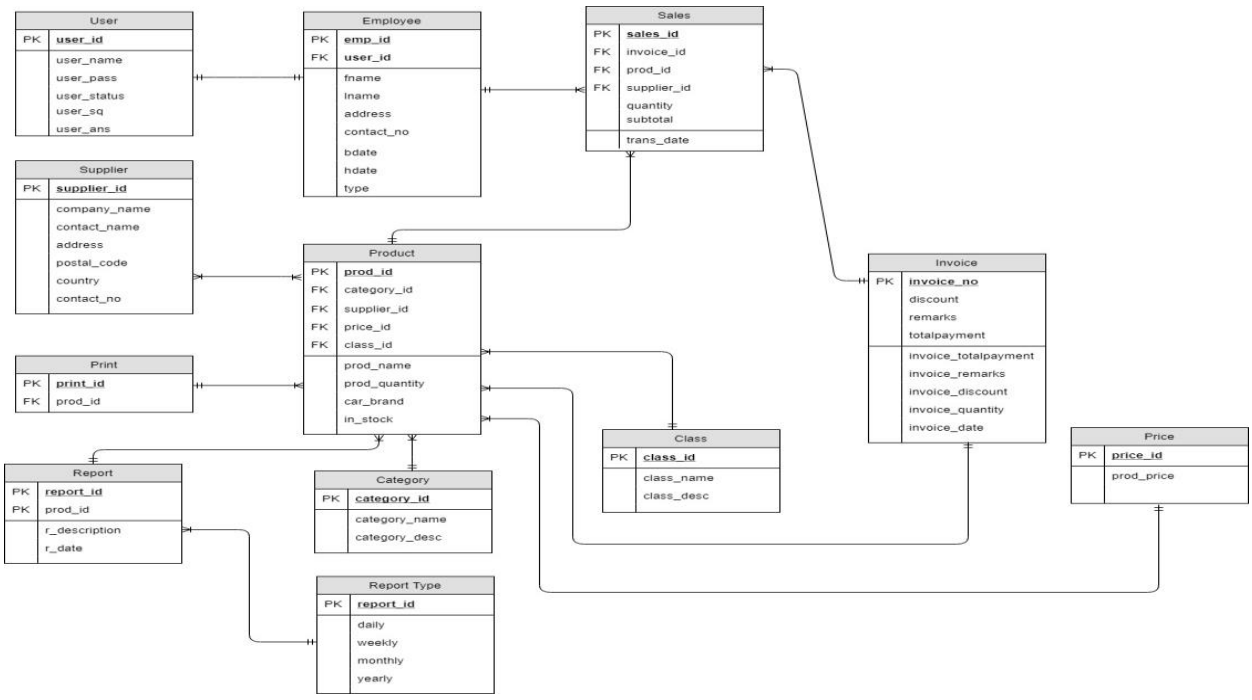

Figure 6: Entity Relationship Diagram

4.5 Client Modifications

Table 2 shows the requested changes of the client per Sprint. At the end of each Sprint, the client gave feedback to the delivered system and suggested changes to the system according to the needs of the business.

The prototype of the system changed according to the problems highlighted in Table 4 during the meetings the researchers had with the client after the end of each Sprint. Using the Agile Methodology, the researchers adjusted the initial development of the system and adapted to the changing specifications and additional custom requests of the client. Since the Agile Methodology involves a very high level of customer participation, the researchers made sure that the client was involved with the progress of the overall project development and comfortable with suggesting additional features for the system. In addition, the changes requested by the client in each Sprint were necessary in using the said approach. These changes served as guidelines in the development of the system for the next Sprint and improving it towards the desired outcome of the client.

4.6 Revised Architectural Diagram

Figure 7 shows the modified architectural diagram after several problems with the initial architectural design of the system arose during the client meetings at the end of each Sprint. Since the Agile Methodology allows changes to the system after small increments, it was not very hard for the researchers to alter the initial design of the system architecture. The updated architectural diagram points to a more maintainable and multi-faceted system. Several demands of the client and different problems that were discovered after the end of Sprint meetings made it clear that the initial system architectural design would not be able to fulfill the new changes. Hence, the researchers used a cross-platform JavaScript library like jQuery to simplify the client-side scripting of HTML [10]. Modals were also used as a fail-safe mechanism when the client needs to update several records in the database; this means that the changes that the system will implement after the user completes the action has the clear consent of the user and thus is not liable for any changes that the rest of the affected records might have. The Google Visualization API + Charts was used to give the user a bird's eye view of the performance of the business in terms of sales. Different

functionalities of the system were also split into different packages with each having its own data repository to maintain data integrity. Lastly, the problem of concurrent users having specific system privileges was solved by adding filters to the system.

Table 2. Requested changes of the client per sprint.

Sprint	Changes
1	1. Include the viewing of the sales of the day.
2	1. A request tab inside the header that contains all the requests such as User Request, Restock Request, and Depletion Request. 2. Scrollable table for employee, category, supplier, and product lists. 3. Approve and Reject button must be beside in the status column.
3	1. Delete button for each item inside the customer's cart. 2. Alter table name into id. 3. Add total amount of sale. 4. Insert the first product depending on the number of products inside the cart. 5. Keep data for when product was entered into the database; rename "date_time" column in Product table to "date_entered". 6. Create new column for reclassification date in Product Table; will periodically update annually depending on the exact date of reclassification of the specific product. 7. Fix New Restock Request from Incomplete Order. 8. Inserting multiple products using one invoice_id in the database. 9. Deduct the number of quantity ordered to the number of stocks. 10. Add "Restock Requests" to admin dashboard. 11. Add "Highest Selling Item" to admin dashboard.

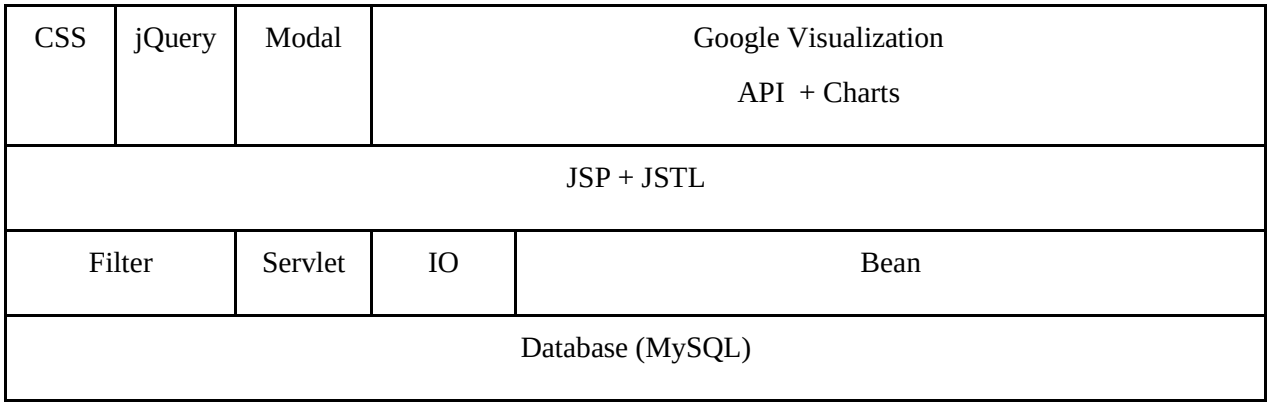

Figure 8. Revised Architectural Diagram

4.7 Client Feedback

Table 3 shows the mean score for the three sprints during the Development Phase of the software engineering process. The general manager evaluate the system at the end of each 30-day sprint. The criteria follow the attributes

of a good piece of software. Ease of use and Pleasantness of Appearance falls under the characteristic of Usability. Reliable, Completeness of Function, and Completeness of System falls under the characteristic of Reliability. Efficient is under the Performance attribute. Readiness for Deployment falls under Availability. And lastly, the criteria of System Security falls under the attribute of the same name.

Based on the scores given by the client, the present software was still incomplete but already serviceable and able to perform the major functionalities that the company requires. Furthermore, the use of the Agile Methodology was helpful in developing the software as it adapted to the problems that arose during the period of the research.

Table 3. Mean Score of 3 Sprints

Criteria	Mean Score
Ease of Use	4.67
Pleasantness of Appearance	4.67
Reliability	2.67
Security	4.33
Efficiency	3.33
Completeness of Function	2.00
Completeness of System	4.33
Readiness for Deployment	3.67

5 Conclusion

The researchers were able to recognize several problems of the company by conducting interviews with the general manager and employees of the company and observing the business process and the business environment firsthand. These problems were a combination of the traditional method of maintaining inventory and the unsystematic way of keeping them in storage. The current method of inventory control of the company was prone to data errors that gave rise to multiple problems down the road. The company would often experience product overstock and excessive inventory costs. The present system of storing inventory also led to slow order fulfillment which resulted in long customer waiting time. Using the Agile Methodology, the researchers were able to adapt to the changing client demands and the problems that surfaced after each client meeting. At the end of the third sprint, the researchers were able to complete a functional prototype of the system. The client evaluation reflected the prototype's success.

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