AN INTELLIGENT MODEL FOR SALES AND INVENTORY MANAGEMENT

SYLVANUS O. ANIGBOGU, Ph.D.
Associate Professor of Computer Science
Department of Computer Science,
Nnamdi Azikiwe University, Awka, Anambra State, 420001, Nigeria
dranigbogu@yahoo.com

OLADIPO ONAOLAPO FRANCISCA, Ph.D.
Department of Computer Science,
Nnamdi Azikiwe University, Awka, Anambra State, 420001,Nigeria
onaolamipo@yahoo.com

KARIM USMAN, M.Sc.
System Analyst
Department of Mathematics and Computer Science
Benue State University, Makurdi, Benue State, Nigeria
www.karimkomputing.com, usmank4real@yahoo.co.uk

ABSTRACT
This work involved developing an intelligent model for sales and inventory management aimed at bridging the substantial gap between the theory and the practice of inventory management. The system developed has the capability of providing automatic demand and lead time pattern identification for inventory management. The intelligent inventory model was formulated using the concept of fuzzy logic. The identified patterns and the formulated model were translated into a rule based package developed with Java 2 Enterprise Edition (J2EE). The developed system can work perfectly with any small scale and medium enterprise, but **NOBIS** super market (a reputable super market within Makurdi metropolis, Benue State of Nigeria) was used to test run the working principle of the system. The multi-branching nature of the system and its client server relationship even made it deployable for manufacturing and airline industries around the globe.

Keywords
Inventory control, Rule-based system, Pattern identification, Fuzzy logic, J2EE

1.0 Introduction

Inventory is the stock of some kind of physical commodity while inventory management is the determination of optimal procedures for procuring stocks of commodities to meet future demand.[1] Inventory can also be seen as a firm's totality of stocks of various kinds. Inventory management therefore takes care of anticipated demand, bulk purchase, absorbing wastages and over ordering associated with inventory.[2] Inventory can also be seen as the quantity of product that a merchandising firm has available to sell at any given time. Inventory management system again, monitors the quantity of each product available for sale and help to ensure that proper stock levels are maintained.[3] Inventory does not necessarily refer exclusively to physical merchandise or to goods available for immediate delivery. In airline passenger reservation systems, for instance, inventory corresponds to the number of seats available on flights; in the registration system at a typical university or college; inventory corresponds to the openings available in each class.

This work focused on the mutual impact of trends in inventory management and artificial intelligent technology. It is observed that, on one hand, the need for sales and inventory management is growing, while on the other, the possibilities of artificial intelligence and software development being the integral part of inventory are also growing. The motivating factor behind this work is that sales and inventory management can be enhanced with the help of computer packages modeled with artificial intelligence. A major challenge is to discover the potential synergy between the business trend and artificial intelligence trend.

The problem of the manufacturer and the retailer can be taken as a paradigm. For instance, in order to sell an item, the retailer or manufacturer must maintain a stock of that item to meet the demand for it. As his stock is depleted, the retailer or manufacturer will reorder or produce respectively more quantity so that the demand for the items by the customers can be maintained.

Again, it is also necessary that some quantity should be stored so that the retailer or manufacturer does not get out of stock. And such being the nature of an inventory, it follows that inventory management must deal with the logic which should underline this procedure. Apart from dealing with the logic, it also has to deal with some costs that are associated with inventory which include ordering costs (i.e. cost of replenishment and fresh orders), holding cost and stock out costs.

Hence, this work sought to address the problem of when to order, what quantity to order in order to maximize profit and minimize the risk of getting out of stock.

The key factor here involved developing an intelligent package to compute the optimum stock to order at a particular point in time, and to also monitor the level of stock so that when the level falls below the predetermined level (predetermined level is intelligently automatically determined by the system using fuzzy logic model). In other words, the system automatically gives out signals in the form of flashes or alerts or even short message service (SMS) to notify the stock keeper or manufacturer to order or produce more materials or goods as the need arises.

Inventory management is a complex problem area owing to the diversity of real life situations. Successful inventory management requires sophisticated methods to cope with the continuously changing environment. Literature is rich with works on independent demand inventory modeling.[4] This provides a theoretical foundation for the field of inventory management and makes it one of the most developed fields of operations research. However, it is noted here that the practical implementation of inventory models lags behind the development of inventory modeling.[5]

The discrepancy between theory and practice of inventory is partly caused by the different goals of academics and practitioners.[6] Much of the academic research is aimed at rigorous analysis of underlying equations representing the inventory problems and developing mathematically elegant decision models. This type of theoretical work is most highly valued by the academic community. Therefore, there is often less attention given to providing workable solutions to real problems. Most of the time, the underlying mathematical equations will be made up of numerous mathematical assumptions that make the models practically impossible to provide any workable solution for real life problem.

Furthermore, learning is the process that acquires knowledge for a system.[7] It is hard to say that the machine is intelligent if it has no learning capability.[8] By definition, learning is the activity that enables the system to do the same task more efficiently and more effectively next time.[9] In particular, learning changes the content and organization of a system's knowledge enabling it to improve its performance.[10]

2.0 Design Objectives

The design objectives of this work include;

1) ***Reduction of Mathematical Assumptions:*** Most of the known Inventory Models are mathematical or statistical models and as such they are not voided of assumptions. Most of the time, these mathematical assumptions become so complex for inventory managers to comprehend and this hinders the practical application of inventory models because an understanding of the fundamental structure of complex models is the first step necessary to provide a workable solution of the problem being considered. Moreover, the mathematical techniques and other methods are only aids to management decision making. They cannot replace the judgment of human experts. The developed intelligent system is targeted at reducing these mathematical assumptions to a bearable minimum.
2) ***Multiple Reorder Levels:*** Most inventory models define a single definite reorder level, but the designed intelligent model through the use of fuzzy logic defines five reorder levels. This then gives inventory managers the opportunity to reorder at any of the five distinct points and at any point, the quantity that can be ordered depend on the stock at hand.
3) ***Mobile Enhancement:*** Most of the few inventory models that were implemented are stand alone systems (i.e. they are in fixed locations). This means that inventory managers can only monitor their inventory if and only if they are in their offices and probably load up the inventory package and check stock level from time to time. This great barrier is dealt with in the new system through the ***mobile enhancement module (MEM)*** which delivers real time alerts via SMS to inventory managers and administrators even when they are very far from their offices.

3.0 Materials And Methods

Dynamic System Development Methodology (DSDM) and Object-Oriented Analysis and Design Methodology (OOADM) were used in this work. DSDM assumes that all previous steps may be revisited as part of its iterative approach. Therefore, the current step need be completed only enough to move to the next step, since it can be finished in a later iteration. This premise is that the business requirements may probably change anyway as understanding increases, such that any further work would probably be a waste. According to this approach, the time is taken as a constraint i.e. the time is fixed; resources are fixed while the requirements are allowed to change. This does not follow the fundamental assumption of making a perfect system the first time, but provides a usable and useful 80% of the desired system in 20% of the total development time. This approach has proved to be very useful under time constraints and varying requirements. However, the OOADM methodology is used to identify the objects needed in the system and their interrelationships. Adequate and relevant UML diagrams such as class diagram, use case diagram, activity diagram and entities relationship (E-R) diagram are generated which made the coding process quite easy and straight forward. Most qualities of object oriented programming such as polymorphism, inheritance, encapsulation and code reusability were all employed in the development of the intelligent package which was able to identify, authenticate and assign functionalities to different categories of users based on their login detail.

The Java 2 Enterprise Edition (J2EE) technology used in the development of the system is a very complex technology that interfaces with several development tools. The technology has interface that is compatible with virtually all Database Management System (DBMS). But the DBMS employed in this work is MySql, which is used to design back ends of the system (ie data and knowledge base). Netbean 6.7.1 Integrated Development Environment (IDE) is also employed for the development of the inference engine and business logic. And for the design of the front ends of the work, Adobe CS3 Dreamweaver is used; all the UML diagrams were generated with Poseidon for UML version 7.0.

4.0 Working Principles/Design

The design involved developing an intelligent system that has the ability to learn new things as it is put to use. The longer the system is being used, the more intelligent it becomes.

The learning process is divided into three modules;

1. Reorder Point (ROP) Learning Technique

The new model, unlike the Economic Order Quantity (EOQ) model is a multiple reorder level model; which means that reorder point is not just a single predetermined point as is obtainable with the EOQ model, but orders/reorders can be placed at five distinct points determined intelligently by the system using the equation given below;

$$ROP = [(\bar{d} + \sigma_d), n(\bar{d} + \sigma_d)] \quad (1)$$

Where;

ROP is reorder point;
$\bar{d}$ is average daily demand;
σ_d is standard deviation of daily demand.

The average ($\bar{d}$), and the standard deviation σ_d of daily demand are determined by the set equations given below;

$$\bar{d} = \frac{\sum_{k=1}^{n} d_k}{n} \quad (2)$$

$$\sigma d = \sqrt{\frac{\sum_{k=1}^{n} (d - \bar{d})^2}{n}} \quad (3)$$

Where d_k is the daily demand at day k and n is the number of days the product has been traded upon. By these equations, average daily demand and standard deviation of daily demand keep changing on daily bases and this in turn keeps affecting the value of ROP from time to time. The system is not necessarily interested in the actual value of ROP because whatever the value of ROP is at a particular point in time will always be calibrated into five equidistant points to correspond to the five linguistic values used in the system. The five linguistic values used for ROP are; *very small, small, average, big, and very big.*

It is obvious from the equations and fuzzy learning technique that the longer this system is put to use, the more accurate, more efficient and more effective its decision making scheme becomes.

2. Lead-Time Learning Technique

Lead-time is the time between; when an order is placed and when the physical good is actually delivered. This has been a problem for EOQ model as the model always assumes a fixed lead-time which is often not accurate.

The new model also addressed the issue of uncertainty associated with lead-time by using fuzzy learning logic. Instead of fixing or assuming a particular value for lead-time, the new system defined five district lead-time values within the open intervals shown below;

$$L = [0, n, t]; n = L_{Max}/t; \qquad (4)$$

Where;

L_{max} is the maximum lead-time observed in the previous replenishment;

t is time unit (number of days);

n is a real number.

Just like ROP, the actual value of lead-time at a particular point in time is always calibrated into five equidistant values corresponding to the five fuzzy linguistic values associated to lead-time in this work. These linguistic values are; *very short, short, average, long and very long.*

3. Quantity Order Learning Technique

Quantity order is the number of product ordered for at a particular point in time. Some inventory models defined a fixed value of product to order whenever the predefined reorder point is reached. But with this new model, the size of order to initiate at a particular point in time is always determined by the system using the formula given below;

$$Qapp_t = S_{max} - S_t \qquad (5)$$

$$S_{max} = (\bar{d} + \sigma_d)n \qquad (6)$$

Where $Qapp_t$ is the size of order initiated at day t, S_{max} is maximum stack level, and S_t is the on hand inventory at day t.

Rule base of the system

The system developed is a single antecedent inventory fuzzy model with five rules; fuzzy input is the replenishment lead-time while fuzzy output is the reorder point (ROP). The rules used are in the form of: IF…THEN to relate the input space and the output space.

R1 : IF(Lead_Time is "very short") THEN (ROP is "very small");

R2 : IF(Lead_Time is "short") THEN (ROP is "small");

R3 : IF(Lead_Time is "average") THEN (ROP is "average");

R4 : IF(Lead_Time is "long") THEN (ROP is "big");

R5 : IF(Lead_Time is "very long") THEN (ROP is "very big");

5.0 Implementation

The minimum software requirement of the client system is any graphical user interface (GUI) operating system and any web browser. The system is compatible with virtually all operating systems that support network and any good web browser. However, for the server system, in addition to GUI operating system and good browser, the following software are required;

- ✓ JBOSS Application Server
- ✓ MySql Database Management System
- ✓ Java Development Kit (JDK)

The minimum hardware requirements for the client systems to run effectively are as follow;

- ✓ 750MHZ processor speed
- ✓ 128MB RAM size
- ✓ 20GB Hard Disk Drive
- ✓ Network Adapter
- ✓ Scanner or Digital camera for capturing images

The minimum hardware requirements for the server to run effectively are as follows;

- ✓ 1.77GHZ processor speed
- ✓ 512MB RAM size
- ✓ 80GB Hard Disk Drive
- ✓ Network Adapter
- ✓ Scanner or Digital camera for capturing images

6.0 Results

The system developed has the following features;

i. Can act as an intelligent inventory model with five reorder points
ii. Is a database that fully employ the concept of table normalization to keep track of sales and reorder records
iii. It is a model that has been translated into a rule based package which employed the flexibility of fuzzy learning logic and the architectural design of J2EE
iv. It is an enriched package with the capability of sending SMS alerts to stock controllers and administrators.

7.0 Discussions

Most popular inventory model such as EOQ and the like always define a fixed reorder point value which may work very well mathematically but always fail in real practice. The discrepancy between theory and practice of inventory is partly caused by the different goals of academics and practitioners.[6] This discrepancy can be reduced to the barest minimum as the new system is an intelligent package that can illustrate the working principle of the model. This then allows practitioners to make very little input and get their desired output.

Furthermore, the system developed is a merger of two different products combining the functionalities of normal inventory system and point of sales (POS) system. It can be considered as an intelligent POS that peeps into the inventory to know what to be sold and at what rate from time to time. This is achieved through the use of a common database which acts as sales and inventory tracker and at the same time a reservoir from which inferences can be drawn for making critical reorder/sales decisions

Again, the new system is also enriched with the capability of sending alerts via SMS to stock controllers and administrators even when they are far away from their offices. This capability makes it possible for the administrator to have information about what happens at various branches of his business outfits without visiting the branches.

Finally, the system gives real-time information concerning stock level without manually counting the items on stock, unlike the other inventory models that allow some critical transactions to be done off line, only to be reconciled on a later day. As an online line system, it is possible to have accurate and reliable information at all times for more effective stock management.

8.0 Conclusion

The significance of this system cannot be overemphasized. It has been tested and found to be reliable. This system can be used by any small scale and medium enterprises around the globe. Its multi-branching feature makes it suitable for even big organizations and manufacturing industries. The client server relationship of the system (an inherent property of J2EE) even makes it possible to be hosted on the internet thereby making it useful around the globe.

References

[1] Martin K. Star and David W. Miller (1986); “Inventory Control Theory and Practice”. Prentice- Hall New Jersey, India.
[2] Francis (1998:526); “Business Mathematics and Statistics”. Prentice- Hall New York, USA. Pp. 526
[3] Horngren T. Charles and Forster George (1987); “Cost Accounting: a Managerial Emphasis” 6th Edition, Prentice- Hall New York, USA.
[4] Fleming, I. (1992); “Stock control, OR Insight”, Vol. 5 No 4, pp. 9-11
[5] Silver, E.A. (1981); “Operations research in inventory management”, perations Research, Vol. 29 No. 4, pp. 628-45.
[6] Zanakis, S.H., Austine, M. L, Nowading D. C. and Silver E. A. (1980) “From teaching to implement inventory management: problems of translation, Interfaces”, Vol. 10, pp. 103-110.
[7] Rich, E. and K. Knight (1991); “Artificial Intelligence”, 2nd Edition, the United States of America: McGraw-Hill, Inc.
[8] Ginsberg, M.L. (1993); “Essentials of Artificial Intelligence”, the United States of America: Morgan Kaufmann Publishers, Inc.
[9] Simon, H.A. (1981); “The Sciences of the Artificial”, 2nd Edition,
[10] Cambridge, MA: MIT Press
[11] Simon, H.A. (1983); “Why should machines learn? Machine
[12] Learning: An Artificial Intelligence Approach”, CA: Tioga Press.