Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 2 (1): 36-42

jeteas.scholarlinkresearch.org

Development of a Prospective Web-Based Inventory System for Management of Lab Facilities

[1]A.N Mustafizul Karim, [1]Mohd Fadli Saad, [2]Mahbubul Haque

[1]Department of Manufacturing and Materials Engineering, Faculty of Engineering,
[2]Faculty of Economics and Management Sciences
International Islamic University Malaysia
Corresponding Author: A.N Mustafizul Karim

Abstract
Inventory management is a prime task for an organization to achieve its goals of maintaining appropriate level of inventory and minimizing waste. A web-based system of managing inventory in a university setting is expected to help various laboratories keep an update on the status of their tools and equipment. In this study, a model is presented for putting a web-based inventory system in place in five different laboratories of an Engineering Department in a large public university in Malaysia. In designing such a system, PHP has been employed as a development language and MySQL as a backend database with CSS implemented for the interface. Two screen-shots have been illustrated to offer a glimpse of the proposed web-based system and its applications. This online system would help the personnel in charge of the laboratories find out the capacity of the labs as well as the relevant information of asset availability, and replace the current practice of extensive manual recording of asset documentation thus holding a key for an organization like university to gaining competitive advantage through efficient operational performance.

Keywords: web-based inventory system, mobile collaboration, inventory, supply chain

INTRODUCTION

Inventory management deals primarily with determining the size and placement of semi-finished and finished items or goods within a facility or within multiple locations of a supply chain network. It is also concerned with the importance of forecasting the required inventory, availability of physical space, and costs in carrying those inventories to maintain the planned course of production against the random fluctuations, or shortage of materials or goods. One way of managing inventory is to have a web-based system in place that can instantly track and update the information about the products, tools or equipment. A report by Yankee Group (2005) reveals that product information management (PIM) improves inventory management by 25%. The study highlights the fact that the retailers and suppliers using web-based product information management system realize an average of 25% improvement in operations related to inventory control. As an organization grows, it is required to deal with a lot of paper-based records for each transaction, necessitating a lot of documentation in hardcopies. As an alternative, a web-based inventory system's records can be digitally archived, thus reducing filing activity at the end of each term's end (Lerdorf et al, 2008). A web application, from the standpoint of software engineering, relates to an application that is accessed via web browser over a network such as the Internet or an Intranet. It is also a computer software application that is coded in a browser-supported language (such as HTML, JavaScript, Java, etc.) and reliant on a common web browser to render the application executable. Also, it can still be accessed by an authorized person anywhere and anytime. According to Tanwari, A. Q (2000) usage of a database or other software can make the inventory management systems much easier by quickly and efficiently cataloguing all the information, including the quantity on hand, cost of the item, and location within the warehouse.

Chaffee, A. (2009) states that the web-based application has been found to be essential in recent years as more organization started to realize the importance of applying new technology to assist current inventory practices. In the last 10 years, a barcode technology has been replaced with an RFID (Radio Frequency Identification) technology, and then evolved rapidly to being able to track any item by using GPS-based device. The importance of implementing a web based inventory system is thus becoming vital as most of the time the information are accessible instantly, thereby making the details of the usage of the equipment available, and improving the movement and anticipation of their demand as well as the productivity of the system as a whole. The implementation of technology-mediated learning can help institutions develop the skills to cope with their operational environments. Because of the transient nature of research personnel and projects in the university environment, academic research laboratories are sources of a large quantity of waste on campuses. As mentioned by Mclean, A., et al

(2006), universities are seeking to establish programs to encourage minimization of waste. The broad purpose of this study is to propose a conceptual web-based inventory control system for tools and equipment in the five main laboratories under the Department of Manufacturing and Materials Engineering in the faculty of Engineering of a public university. It is hoped that the proposed system will lessen the time of the laboratory personnel in the process of borrowing and returning of facilities including equipment and help in keeping an up to date status of the inventories in those laboratories.

OBJECTIVES OF THE STUDY

To pursue the above broad purpose, specific objectives of the study are mentioned as follows:

- to study the current inventory system of lab facilities of Faculty of Engineering by gathering relevant data and information from those laboratories;
- to reveal the pattern of the need of materials consumed in the various laboratories, and identify the vital or critical parts and equipment, and current stock level.
- to develop a web-based inventory management system for the inventory that can be used in determining the current status of raw materials, consumables and machinery available, the quantity to be ordered, and the lead time.

State-of-the-art of Web-based Inventory Management

There is a wealth of information vis-à-vis web-based inventory management found in the existing literature. However, compared to other areas, there exists a relative dearth of information on this aspect from university perspective. The following section sheds light on the earlier studies performed in this regard in different contexts followed by a few in university settings. Chan, F. A. (2005) conducted a study on the design and implementation of MIS using web-based technologies for steel nuts inventory. Integrated into the ERP system for a leading steel nut company in the world, the system simplified process-flow resulting into a faster production and a concomitant reduction by seven days, on average, of the lead time delivery to customers.

Blauth and Ducati (2010) presented a web-based system of open-source coding for monitoring, research and management of grape production in a particular state in Brazil by integrating spatial information from remote sensing images, GPS measurements and inventory data. This system, as argued by the authors, would allow both monitoring of grape production and investigations either on regional land and soil cover, or in other applications derived from image classification. Cakir and Canbolat (2008) has proposed an inventory classification system based on the fuzzy analytic hierarchy process (AHP) by integrating fuzzy concepts with real inventory data. The authors designed a decision support system assisting a sensible multi-criteria inventory classification and validated the design of the proposed multi-criteria inventory classification system and its underlying fuzzy AHP model in a small electrical appliances company.

Siong, S et al (2008) reported about the development and application of a web based, low cost, user friendly inventory analysis tool for stock availability optimization and enhanced delivery performance in the National Heart Center Singapore. The authors contended that by gathering all up-to-date information, the tool could effectively track the level of re-order, replenishment and safety stock of finished goods within minutes, thereby lowering inventory cost and keeping forecasting error under control. Otis, R. J. et al (2004) has described about a web-based performance management and inventory system that includes site evaluation and design tools for onsite wastewater treatment regulation. The code was built on the concept of performance management comprising not only treatment performance of systems themselves, but also that of system owners, practitioners and regulators, each having defined roles, responsibilities and performance expectations.

An exploratory study has been conducted on the potential use of specific CKM (clinical knowledge management) practices Sittiq, D. F. et al (2010). The study emphasized that priority should be given to (i) the clinical content with web-based viewer allowing anyone in the organization to review it; and (ii) an online, interactive tool to facilitate content development. These, the authors argued, would help organizations develop successful computer-based provider order entry systems. A software technology has been used successfully by Mongeau, D. et al (2004) to create, correct and complete records in extracting inventory and configuration data from in-service networks without degrading network performance. The study mentioned that its application for several large wireless service providers and smaller network operators had resulted in their ability to optimize critical network management tasks and in substantial reduction in their operating expenses. Zeng, Y. Et al (2006) presented a web & knowledge-based intelligent decision support system (IDSS) for spare parts inventory control in a nuclear power plant. As the study mentioned, the proposed IDSS was successful in decreasing inventory holding costs significantly by modifying the unreasonable purchase applications while maintaining the target service level. McNeely, M. (2006) highlighted the benefits of EyeTank as a very useful inventory management tool, practiced by Chevron Products Company.. The study reported that

the company's EyeTank was an innovative online fluid monitoring system designed to efficiently and reliably maintain bulk lubricants at optimum levels.

Scope of Web-based System Relevant to Educational Institutions

Chandra, C., & Kumar, S. (2001) made a proposal using a web-based flexible instructional module to disseminate information on research projects for introducing students and industry practitioners to enterprise systems. The study focused on the uses of the module on curricula satisfying cognitive educational goals of an enterprise system and offering live applications through the web site. A hybrid data mining technique to analyze the traditional assessment tools administered on freshmen students at a university has been applied by Shih, C. et al (2009). Such typical pen-and-paper tests would require responses to a multitude of questions, which might lead to student's resistance, fatigue and unwillingness to complete the assessment. The authors observed that the technique helped in dynamically reducing the number of questions while the assessment would proceed.

A study was conducted by Mclean, A. et al (2006) to assess the feasibility of a full-scale chemical inventory and exchange program at the University of Florida to encourage minimization of hazardous wastes in academic research laboratories. The study found that after several months of operation, the user-friendly web-based mechanism for maintenance of on-line chemical inventories and designation of available chemicals had become an effective method in creating awareness for safety, pollution prevention and thoughtful purchasing practices. A study on the student use of personal digital assistant (PDA) technology in fostering a collaborative learning experience in the classroom and laboratory was performed by Avanzato, R. L. (2001). Activities supported by the use of these handheld computers would include electronic team examinations, distribution of notes, collaborative database projects, and access to web-based materials. The study mentioned that the student access to handheld, mobile computers provide opportunities for improvements in both learning effectiveness and in the efficient delivery of instruction.

However, studies vis-à-vis managing lab inventory in a university setting have rather been scarce; though there is a scope of improvement in this context. The undertaken project of the study would address this issue by proposing a conceptual web-based inventory control system for tools, equipment and consumables in various laboratories in the department of engineering of a public university. In doing so, it first presents in the following the current system of managing lab inventories and the various problems being encountered by the system operators.

Current Scenario of Lab Inventory Management

Currently, a recording procedure is in place in the name of managing inventories, which does not cater much to the basic requirement for the implementation of an inventory system. The system lacks in several functions, such as, printing a comprehensive list of available items, physical reference of fixed assets, detailed information on consumable items, etc. It has been observed that there is a problem of keeping an up to date written record of consumables and hand tools purchased throughout the year. It is understood that a technician responsible for each lab has not been trained and equipped to effectively manage the inventory. It has been found that one of the technicians had developed his own record keeping method by using a spreadsheet to organize the labs assets, consumables, and hand tools. However, this method of data collection was incomplete and unverified, and there were loopholes in the monitoring system with no recent procurement record, no update of machine status and no purchase order number. Apart from these, the current system is found to be not user friendly enough to address several categories of users, and less modular to be a standard inventory management tools as most of it only caters for computer parts and peripherals. All these aspects of the current system had to be taken into account to devise a proper system design that would meet the minimum requirement of a web-based inventory management system.

New System Design Consideration

Based on the extensive comparison of the previous systems, it has been concluded that a number of steps is required to design a useful web-based inventory management system in the faculty. These steps are schematically shown as in Figure 1.

Requirements definition: In the first phase, the scope and needs of our web application are defined by investigating a relevant website posted by Fink, R. (2006) in terms of what the application must do, it main features and the technical requirements. This stage consists of the following steps:

- **Scope**: In order to define the scope of the web application, it is necessary to compile a detailed list with a clear description of application features.
- **Need**: Needs analysis is a crucial part of developing process. In this step, one has to estimate the potential users, choose a server-side language (PHP), database (MySQL), and decide where to host it and how to make it live.

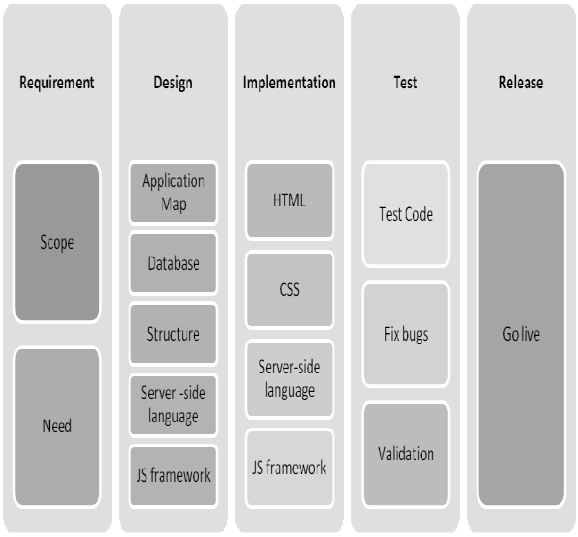

Figure 1: System Design Consideration

Design: After requirements phase, naturally comes the 'design' part of the application. In this phase, the following steps are identified:

- **Application Map**: An application map contains just meaningful and essential information about the structure of the application.
- **Database**: A simple way to do that is to use an entities-relationships (ER) model, which, in general, can follow in the following order: first, define tables, and then attributes and relationships between tables.
- **Page Structure:** Next step is to design an approximate structure of the page, identifying all main sections using a name (for example, *#header*, *#navbar*, #mainContent, *#sidebar*).
- **Server-side Language**: Bearing in mind for taking an object-oriented approach in developing the application, various classes, functions and all server-side features need to be defined. It would act as a 'guide' for the purpose of implementation in the next phase.
- **JS Framework**: In this step, a JavaScript Framework (jQuery, Scriptaculous, MooTools), is chosen with the main features (drag and drop, animation effects, etc.) identified. It requires compiling a simple list, which associates each specific feature to one or more pages identified in the application map.

Implementation

- **Database**: A new database is created and SQL code written, defining tables, attributes and relationships.
- **HTML**: The page structure as defined in Design phase to implement HTML code. This is the moment to add all HTML elements identified during Design phase.
- **CSS (Cascading Style Sheet)**: Once the main structure is ready, CSS code needs to be written to add styles to the application.
- **Server-side language**
  Implementation of application class, application functions, DB interactions and queries requires a server-side interaction.
- **JavaScript**
  Implementation of Ajax features (drag and drop, animation effects, etc.) is done using the framework chosen in the Design phase (jQuery, Scriptaculous, MooTools).

Test: This phase requires 'stressing' the application by executing the code in various conditions (for example using different browser) in an effort is to detect all application bugs and fix them before the final release. Each page and each feature is tested. If a bug is found during test execution, it is to be fixed by modifying the code; the final validation (an ulterior test) of the code is then performed.

Release: A final test is done before the system is ready to be released. If it goes as planned, final release is performed.

SYSTEM DEVELOPMENT METHOD

As prescribed by Gilmore, W. J. (2008) the PHP (Preprocessor Hypertext-Processor) has been used for the development language and MySQL as the backend database for the system main engine. These two sources are chosen based on their capabilities, flexibility and modularity in developing a web-based application as recommended by Lerdorf, R. et al (2008). As this system is going to be a web-based one, PHP rather than client-based application language such as C or Java language has been employed. Based on the data gathered, it is necessary to develop a graphical user interface (GUI) for the system. For this, a CSS for the interface has been implemented leaving a scope of modification to suit user requirement. Also, during the progress of the development period, a few new enhancements has been taken into account so that this system can be used for a very long time, thus mitigating the possibility of an immediate upgrade or patch to the system itself. The system has been developed using a modern programming approach called Model-View-Controller (MVC) approach, with all the logic (model), user interface (view) and engine (controller) being separated so that it can be extended without hassle to adjust to the addition of any new function required.

Proposed Web-based System

The inventory system is designed with the hands-on approach. Prior to the actual field survey, initial visits to the selected laboratories were made and meetings with the technician were conducted. Data regarding

fixed assets, hand tools, and consumables were collected from the respective labs. The data then were analyzed and extrapolated to determine some important aspects of the research, including the forecast of number of students expected to be enrolled in the upcoming semester. A user requirement study was carried out, and the results were used to develop the engine of the system. Since most of the functionality requires flexibility, it was needed to develop the system from the scratch, consequently a top-down system approach has been implemented. The practice of stocking is necessary in the labs since some consumables require a flexible lead time. It is advisable that at the end of each semester, the technician will count the stock, and prepare a proper documentation before it is entered into the system. As a starter, a hardcopy of the available item would be printed and compared to the available stock. Any unusual event will be recorded and necessary action could be taken.

Two screenshots of the developed prospective web-based system – one, regarding the inventory record and the other, listing of assets, are illustrated in the Figure 2 and Figure 3 respectively.

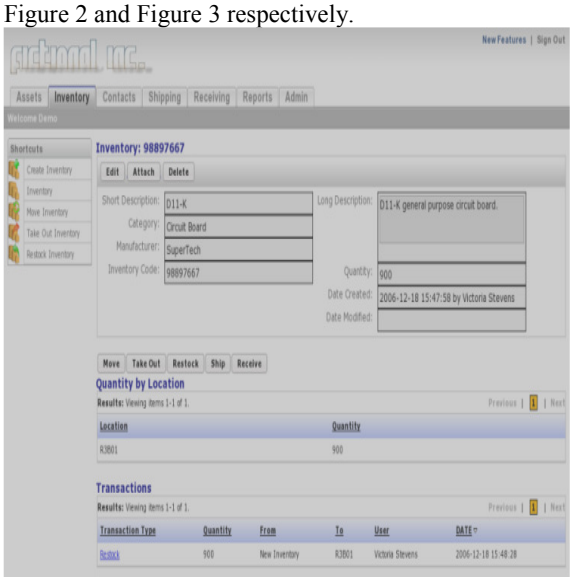

Figure 2: Inventory information with quantity and transfer records

In Figure 2, there is detailed information of an item such as its inventory code, short description, category, manufacturer, location, quantity, date of inventory created, transaction record, such as loan-in and loan-out, and stock indicator if it goes below the required quantity. As for example, the case of an item such as a circuit board with the inventory identification Id 98897667, bought on December 18, 2006 with initial quantity of 900 pieces per batch is illustrated in this Figure.

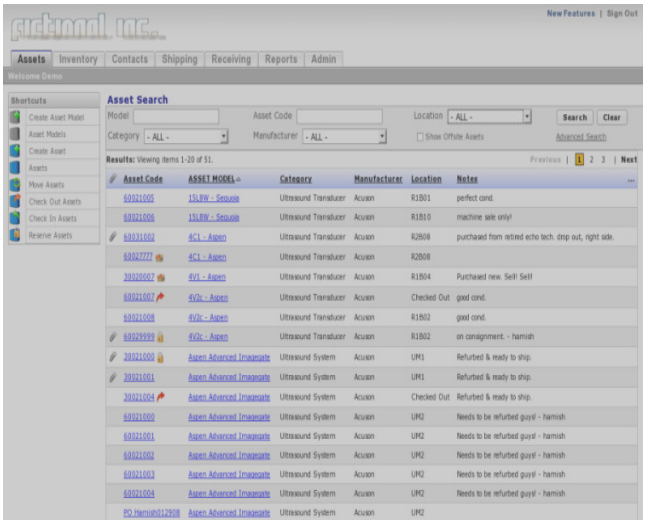

Figure 3: Asset and inventory listing and search

It has also shown all the transaction status (if any), for example, the number of pieces of a particular item taken by a technician from lab a to lab b with the details of location, date, time and the user name. In Figure 3, every detail of the asset and inventory can be monitored through advanced search criteria using Boolean operand (with, not equal, or, including etc.) such as its model, inventory code, location of the item, category, and the manufacturer. The result is displayed so that the query can be viewed by the user immediately, thus reducing the time to search the item record manually using a log book as practiced in the current system.

Advantages of the Proposed System

Each technician involved for this study has been interviewed, and the early feedback is encouraging, as they seem to be eager to use the system that could expedite their works in managing inventory records for their respective labs. It is also felt that they would like to see a similar system in place so that it can be monitored by the supervisors, students and even visitors, as they can maintain the records, generate statistical reports, and provide general information for others to see and know what is available in the labs. Among some of the benefits that can be derived from this system implementation relate to the elimination of the likelihood of purchasing an item already available in the lab, as it will accurately list all the items available. Also, it will promote a part sharing approach as practiced in the industry, as this will minimize holding cost for e.g. spare of machineries. The implementation can significantly upgrade the capability of time-tracking for the machines. Each lab could manage the availability of the machine, so a proper management of the machine can be created. As a result, machine life span can be easily determined based on its usage pattern week in, week out. Procurement procedure also can be made easier and much reliable as it promotes a good supply

chain relationship. It creates a better understanding between the finance and the procurement department thus reducing the long lead time as faced in the current system. The categorization of the item leads to a better accuracy in the database, as the database can be accessed easily and data can be represented in graphical ways as required, especially during audit exercise of inventories.

CONCLUSION AND RECOMMENDATIONS

Inventory management is a prime task for an organization to achieve its goals of maintaining appropriate level of inventory and minimizing waste. In this age, online or a web-based inventory management holds the key for an organization to gaining competitive advantage. In a university setting, a web-based system of managing inventory will help various laboratories keep an update on the status of their tools and equipment. In this study, a model is provided for putting a web-based inventory system in place. For this purpose, system design consideration has been mapped out with a number of steps identified. PHP has been employed as a development language and MySQL as a backend database with CSS implemented for the interface having a scope of modification to suit user requirement. The study would help the personnel in charge of the laboratories find out the capacity of the labs as well as the general information of asset availability, and replace the current practice of extensive manual recording of the documentation.

Future studies should look at the opportunity of implementing a standard procedure for the procurement method as applied in the industry with a view to minimizing waste in the inventory. Other issues that can be further discussed are the ability to integrate the system into faculty website, providing more accessibility to the teachers, students and visitors to acknowledge the inventory status. Also, better strategies are to be devised for the faculty and staff so that a more feasible procedure is followed in the procurement practices.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the financial support provided by Research Management Centre (RMC) of International Islamic University Malaysia (IIUM) through the research grant EDW B 0802-02 to facilitate the project on web-based inventory management system.

REFERENCES

Avanzato, R. L. (2001). Handheld computers in the classroom and laboratory, 2001 ASEE Annual Conference and Exposition: Peppers, Papers, Pueblos and Professors, p. 5323-5328, June 24-27, Albuquerque, NM, United states.

Blauth, D. A., & Ducati, J. R. (2010). A Web-based system for vineyards management, relating inventory data, vectors and images. Computers and Electronics in Agriculture, 71(2), 182-188.

Cakir, O., & Canbolat, M. S. (2008). A web-based decision support system for multi-criteria inventory classification using fuzzy AHP methodology. Expert Systems with Applications, 35(3), 1367-1378.

Chaffee, A. (2009). Web application. Retrieved on August 1, 2009, from: http://en.wikipedia.org/wiki/Web_application

Chan, F. A. (2005). The future trend on system-wide modelling in supply chain studies. International Journal of Advanced Manufacturing Technology , 7(8).

Chandra, C., & Kumar, S. (2001). A web-based instructional module for research and learning in design and analysis of enterprise systems. Journal of Engineering Education, 90(2), 179-185.

Fink, R. (2006). anyInventory. Retrieved on January 2, 2008, from Sourceforge Inc.: http://www.sourceforge.net/anyinventory.php

Gilmore, W. J. (2008). Beginning PHP and MySQL: From Novice to Professional, Third Edition. New York: Apress.

Lerdorf, R., Tatroe, K., & MacIntyre, P. (2008). Programming PHP. New York: O'reilly Press.

Mclean, A., Fleetwood, D., Townsend, T., Ohlsen, M., & Lindner, A. (2006). Development of a university laboratory chemical inventory and exchange program. Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management, 10(1), 46-56.

McNeely, M. (2006). Web-based monitoring for bulk lubricants. Diesel and Gas Turbine Worldwide, 38(1), 52-53.

Mongeau, D., Barshefsky, A., Bass, E., Erman, B., Martin, C., Peterson, R., Rastogi, R., Narayan, P. P. S., Trickey, H., Xie, C., & Wu, M. (2004). Ensuring integrity of network inventory and configuration data. 11th International Telecommunications Network Strategy and Planning Symposium, Networks, p. 267-272, June 13-16, Vienna, Austria.

Otis, R. J., Gilbertson, C. D., McCarthy, B. J., & Barnett, T. B. (2004). Performance management and inventory system for onsite/cluster wastewater treatment facilities. Proceedings of the 10th National Symposium on Individual and Small Community Sewage Systems - On-Site Wastewater Treatment X, p. 140-145, March 21-24, Sacramento, CA, USA.

Shih, C., Chiang, D., Lai, S., & Hu, Y. (2009). Applying hybrid data mining techniques to web-based self-assessment system of Study and Learning Strategies Inventory. Expert Systems with Applications, 36(3), 5523-5532.

Siong, S. C., Edmund, C., & Terence, Y. (2008). Implementation of inventory analysis tool for optimization and policy selection. Proceedings of the 4th IEEE International Conference on Management of Innovation and Technology, ICMIT, p. 1407-1411, September 21-24, Bangkok, Thailand.

Sittiq, D. F., Wright, A., Simonaitis, L., Carpenter, J. D., Allen, G. O., Doebbeling, B. N., Sirajuddin, A. M., Ash, J. S., & Middleton, B. (2010). The state of the art in clinical knowledge management: An inventory of tools and techniques. International Journal of Medical Informatics, 79(1), 44-57.

Tanwari, A. Q. (2000). ABC Analysis as an Inventory Control Technique. Quaid E-Awam University Research Journal of Engineering Science & Technology , 1-16.

Yankee Group (2005). Product Information Management study. E-commerce Technology Report, Feb 11, 2005.

Zeng, Y., Wang, L., Chen, T., & Lu, Y. (2006). A hybird intelligent decision support system for spare parts inventory control using neural network and gene algorithms approach. Proceedings of the IASTED International Conference on Power, Energy, and Applications, PEA 2006: Science and Technology for Development in the 21st Century, p. 32-36, September 11-13, Gaborone, Botswana.