

The Contract Expert System: A Proposal for Long-Term Supplier Evaluation, Selection and Performance Monitoring

Eugene Rex L. Jalao, *Member, IAENG* and Iris Ann G. Martinez, *Member, IAENG*

Abstract— With a major financial crisis troubling the world, managers nowadays are under a lot of pressure to reduce the costs of their day-to-day operational processes. One important business process is purchasing and nowadays, proper selection of suppliers is the primary focus of these purchasing organizations in which the ultimate goal is to select the best supplier with the lowest price, highest quality and on-time delivery. Furthermore, in terms of the philosophy of JIT, long-term partnerships between the buyer and the supplier are preferred. The aim of this study is to systematize the supplier selection process for long-term purchasing with the use of a computer-based expert system that mimics the purchasing decisions of a purchasing professional. The proposed expert system is called Contract Expert System or CES, which is composed of four functional modules: Configuration, Supplier Evaluation, Supplier Selection and Supplier Performance Monitoring. Preliminary validation of the CES was done by comparing the thought process of CES with that of and purchasing managers from two companies that were studied, and results show that the purchasing processes of the two companies are similar to the CES methodology. Further validation of CES will be done by comparing the results of purchasing decisions made by CES and the actual decisions made by purchasing managers.

Index Terms— Expert System, Long-Term Purchasing, Supplier Evaluation, Supplier Selection

I. INTRODUCTION

One of the primary targets for cost cutting is the procurement of raw materials. Managers try to cut costs without sacrificing quality that would give their company a competitive advantage. According to Ding (2003), depending on the industry, 40% to 80% of the cost of a company's product is attributed to the procurement of its raw materials [1]. Therefore, large cost savings would be realized if proper selection of raw material sources could be identified. Proper means sources that can deliver products on time, at the lowest possible cost, and at the highest possible quality.

Evaluating and selecting a supplier for any material is a complex task. In recent years, multiple criteria have been

Manuscript received December 18, 2008. This research is part of ERL Jalao's MS in Industrial Engineering thesis at the University of the Philippines, Diliman, Philippines.

ERL Jalao is an instructor of the Department of Industrial Engineering and Operations Research, University of the Philippines Diliman, Philippines (phone: +63 927 229 7386; e-mail: eugene.rex@gmail.com).

IG Martinez is an associate professor also with the Department of Industrial Engineering and Operations Research, University of the Philippines Diliman, Philippines (e-mail: irisann.martinez@gmail.com).

considered in choosing the best supplier. This has become a strategic decision for many firms due to the pressure of increasingly competitive market conditions [2]. With the advent of the Just-in-Time philosophy, company purchasing departments are under pressure to select suppliers that will eventually lead to partnerships that take in price discounts for bulk orders, increasing buyer-supplier relationships, and forging relations. One-time purchasing is a thing of the past and in order for a company to survive in this competitive world, it must rethink its business scenario to incorporate purchasing contracts. Purchasing contracts or blanket purchase orders are long-term agreements between a supplier and a buyer. Based on this contract, a supplier is to supply the buyer with agreed products at a certain price for a certain period that would last for months, even years, until a certain agreed quantity or value is reached. Deliveries by the supplier can be on a weekly basis or an agreed upon schedule between the two parties.

Most of the previous research works related to purchasing proposed methods in selecting one-time vendors. The previous works considered multiple predefined criteria such as cost, delivery performance, and quality. Nowadays, purchasing organizations consider other important factors aside from these three criteria. This leaves the previous models with room for improvement. Furthermore, for longer term purchasing, this research proposes that the performance of the supplier be monitored. For example, if during the period of the contract, the supplier frequently fails to delivery on time, other sources of supply must be selected and the current contract terminated.

II. THE OBJECTIVE AND PROPOSAL OF THIS RESEARCH

A. The Objective

The objective of this research is to systematize the supplier selection process for long-term purchasing to make it faster, more efficient and highly consistent using a computer-based expert system. This research believes that if a realistic supplier selection procedure can be proposed, that procedure can improve the current purchasing practices of companies. Furthermore, the procedure that should be developed must be reflective of the real thought process of purchasing personnel that considers all selection criteria that may go beyond cost, quality and delivery performance.

B. The Proposed Model: The Contract Expert System (CES)

This research proposes the Contract Expert System or CES. The CES is a VB.NET application which is divided into four functional modules: the Configuration Module, Supplier Evaluation Module, Supplier Selection Module and the Supplier Performance Monitoring Module. The first module maintains the information that is needed by the other three

modules. Suppliers, items for purchase, and decision criteria can be recorded using the Configuration Module. The Supplier Evaluation Module evaluates new suppliers in terms of their capability of supplying items, while the Supplier Selection Module selects the best supplier using the Analytic Hierarchy Process (AHP) proposed by Saaty (1990) and Linear Goal Programming (LGP) when a need for a particular item arises [3]. The Supplier Performance Monitoring Module keeps track of historical delivery performance of a supplier and checks whether the supplier falls below a predefined performance rating during the course of the agreed purchasing agreement.

CES includes an evaluation module in which new suppliers are evaluated first for accreditation. Supplier accreditation, currently part of the best practices in purchasing, minimizes the amount of nuisance suppliers during selection of a final supplier. CES has the capability to accommodate any type of criteria during the evaluation stage, and their weights can be customized using AHP. The expert system proposed by Altunthas (2006) uses predefined decision criteria and predefined weights from a survey during supplier evaluation [4], while Wang (2006) proposed knowledge-based decision support system for government vendor selection and bidding that uses predefined weights based on purchasing expert's judgment and experience. These weights are applied to evaluation factors that include performance, manpower, financial resources, and equipment for the selection of the supplier [5]. All of the reviewed models incorporate one-time purchasing. Voruka (1996) proposed a prototype expert system in which the model classifies purchasing materials as a commodity product (service) or as a quality product (raw material) during the preliminary manual screening process. The expert system is then consulted using predefined criteria for supplier selection [6].

The CES Supplier Selection Module can accommodate different types of criteria that will be used in selecting the best prequalified supplier. The selection module uses a combination of AHP and LGP. AHP is used to generate relative weights for the criteria which will be used for the linear goal programming formulation to select the best supplier. Yao (2007) used AHP to assign weights to predefined decision criteria, namely: cost, quality, project, certification, and delivery performance only [7], while Kumar (2008) used AHP and Fuzzy Linear Programming (FLP) for supplier selection and quota allocation. AHP was used to rate the suppliers, while FLP was used to allocate the purchasing requirements to the suppliers [8]. Ghodsypour (1997) also proposed a decision support system for supplier selection using an integrated analytic hierarchy process and linear programming [9].

Supplier Performance Monitoring takes into account the supplier's delivery performance after the supplier has been selected. Expert system models proposed by Althuntas (2006), Wang (2006), and Voruka (1997) do not incorporate supplier performance monitoring since their focus is one-time purchasing. According to Altuntas (2006), many firms are using computer-based systems for supplier evaluation and selection process only without supplier performance monitoring.

The succeeding sections describe the CES system and its processing logic.

1) The Configuration Module

Important information and data that are needed for supplier evaluation, selection and performance monitoring must first be maintained and configured. All information transacted using the CES are stored in a Microsoft Access database file. Contracts are defined in CES as instances in which an end-user will purchase a given set of items, e.g., purchasing for stock, assets, office suppliers, etc. A user can create as many contracts as he or she wants using the Configuration Module. Each of these contracts has its own set of criteria that has different weights. These criteria will be used when the contract goes to the Supplier Selection Module and in the Supplier Performance Monitoring Module.

Regular purchase items can be maintained using the Configuration Module. Relevant item information like "unit of measurement" can be maintained for reference during actual purchasing. Supplier information can be recorded using the module such as contact information, supplier's address and the list of items that the supplier can provide. The supplier's item list is an important prerequisite in the supplier selection module. An end-user can select all the suppliers that can supply a certain item requirement with ease.

Any type of decision criteria can be configured based on the preferences of the end-user for the different modules using the configuration module. One-time configuration of criteria will be needed for supplier evaluation, while supplier selection and performance monitoring criteria will be based on criteria maintained for each purchasing contract. Pair-wise comparisons of the maintained criteria will be configured, and a consistency index will be computed based on Saaty's consistency index. If the pair-wise comparisons are consistent, normalized weights will be computed for each criterion that will be used for evaluating suppliers.

Delivery dates of individual contracts can be maintained for the performance monitoring module, where each delivery will be evaluated.

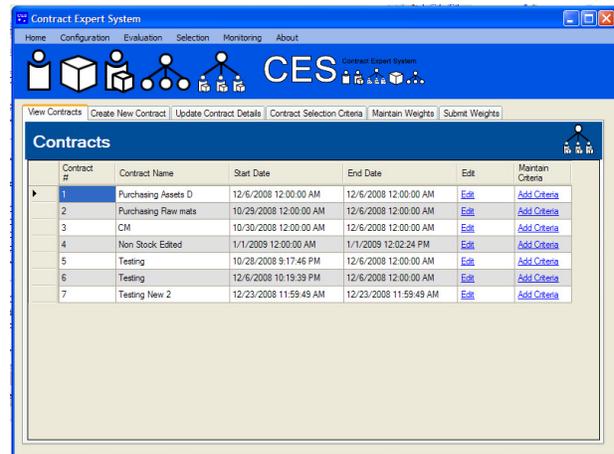


Figure 1: A sample screen of the CES.

Figure 2 shows the functions of the Configuration Module.

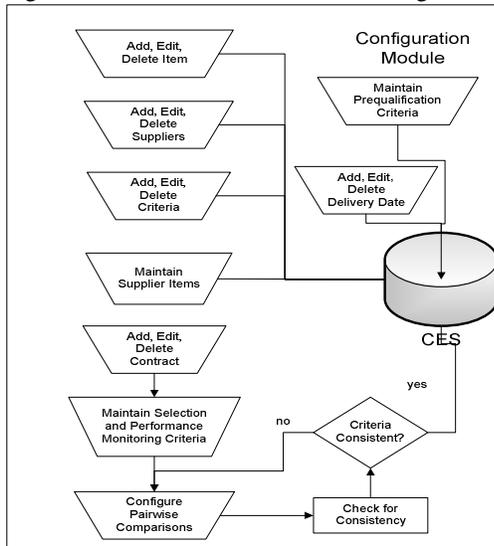


Figure 2: CES Configuration Module

2) Supplier Evaluation Module

Current best practices of purchasing state that any purchasing organization must actively source out new suppliers even before the need for a new item is realized. Keeping records of suppliers in advance would really speed up the purchasing process of a firm. The Supplier Evaluation Module evaluates new suppliers in terms of their capability in supplying items. With this module, a new supplier can be evaluated in terms of the predefined decision criteria using the Configuration Module. The module tells the end-user whether a new supplier can be accredited as a company supplier for long-term purchasing. The following are the contract steps for supplier evaluation using the CES:

a) Identify New Supplier

The module starts with the evaluation of a new supplier for purchasing accreditation. Supplier sources could come from recommendations of other purchasing organizations, production floor requirements, supplier demos, etc.

b) Request Supplier to Submit Requirements for Accreditation

The buyer now requests information from the new supplier based on the predetermined decision criteria. Financial documents, ISO standards, manufacturing capabilities are some of the criteria needed for supplier evaluation.

c) Encode Supplier Information

After receiving information, the end-user encodes the information needed based on the decision criteria selected.

d) Run Expert System

The system is run based on the input information and the system determines if the supplier passes the minimum requirements set by the end-user.

e) Accredite or Reject Supplier

After running the system, the supplier is either placed in the source list as an accredited supplier or a non-accredited

supplier.

Figure 3 represents the functions of the Supplier Evaluation Module.

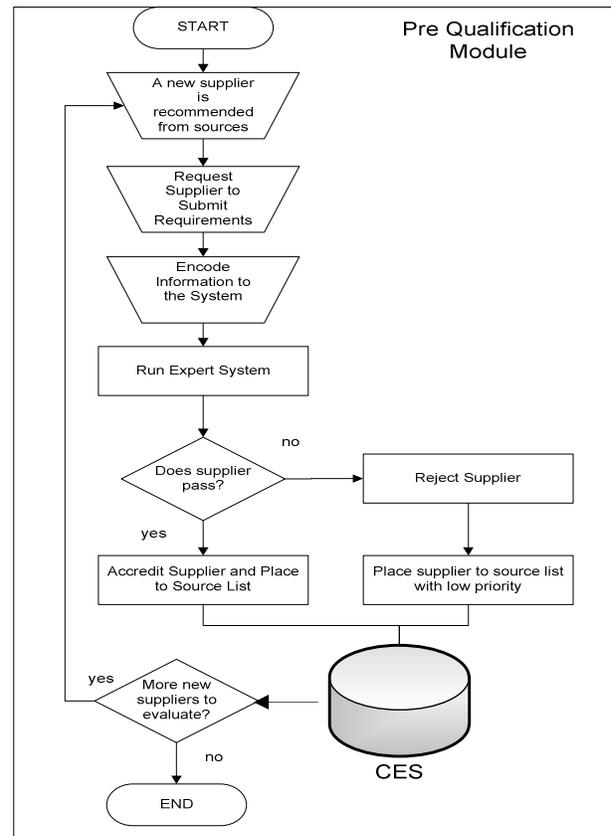


Figure 3: CES Supplier Evaluation Module

3) Supplier Selection Module

After evaluating the suppliers and a need for a new item arises, this module determines the best supplier from the list of prequalified suppliers that can supply the item. The linear goal programming model selects the best supplier based on the predefined decision criteria and weights using AHP. Figure 4 highlights the CES Selection Module.

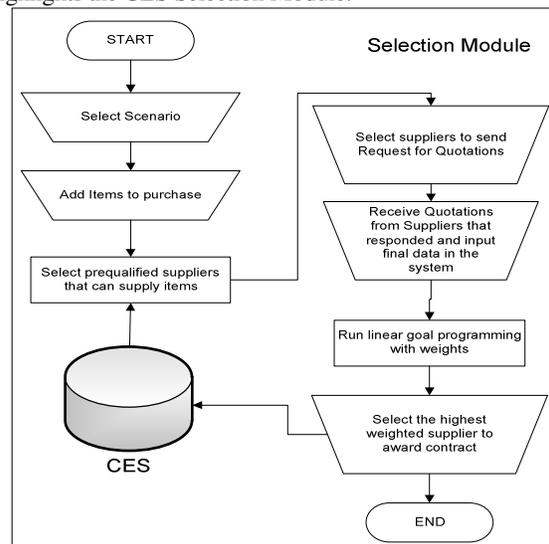


Figure 4: CES Supplier Selection Module

The following are the steps for supplier selection using the CES:

a) *Select Contract*

The user selects the contract, which is representative of the new request for items.

b) *Add Items for Purchasing*

Items are then added in the contract for purchasing.

c) *Select Prequalified Suppliers*

The system is run to select all prequalified suppliers that can supply the needed items for the contract.

d) *Send Request for Quotations*

Request for Quotations can be sent to the prequalified suppliers. After receiving the quotations, relevant data based on the decision criteria can be uploaded in the system and a ranking of suppliers per decision criteria can be established.

e) *Run GP Model and Obtain Best Supplier*

The linear goal programming formulation of obtaining the optimal supplier is defined as follows:

Defining Indices

i = index of the ith item to be purchased, i = 1, 2, ... I
 j = index of the source to get inventory, j = 1, 2, ... J

Defining the Decision Variable

Let
 X_{ij} = quantity to be purchased for item i from source j.

Defining the Objective function

$$\min z = \sum_{i=1}^C W_i V_i$$

Where W_i is the weight obtained from the AHP procedure for criteria i and V_i is the penalty deviation contribution for criteria i

Penalty Coefficients

$$\sum_{i=1}^I \sum_{j=1}^J P_{ij} X_{ij} \leq V_i$$

where P_{ij} is the penalty for purchasing item i from vendor j.

The system will work in such a way that if a vendor has a score of S_i for a given criteria, the vendor will be given a penalty P_i . Example:

For a given price criterion:

Supplier	Price PhP	Penalty
A	95 (Best)	$=(95-95)/95 = 0$
B	100	$=(100-95)/95 = 5/95$
C	120 (Worst)	$=(120-95)/95 = 25/95$

Requirement Constraint

$$\sum_{i=1}^I X_i \geq D$$

Where D_i = is the required quantity of item i to be satisfied

Non-Negativity Constraints

$$\sum_{i=1}^I \sum_{j=1}^J X_{ij} \geq 0$$

The system will automatically recommend the optimal supplier after running the Selection Module. Since the linear goal program is set for minimization, the program will select the least penalized alternative, thus resulting to optimality.

4) *Supplier Performance Monitoring Module*

The Supplier Performance Monitoring Module keeps records of historical deliveries of suppliers and determines if the supplier falls below a minimum rating based on the predefined criteria. A supplier with failing ratings for a review period leads to corrective actions in the next review period so that a supplier can improve its delivery performance.

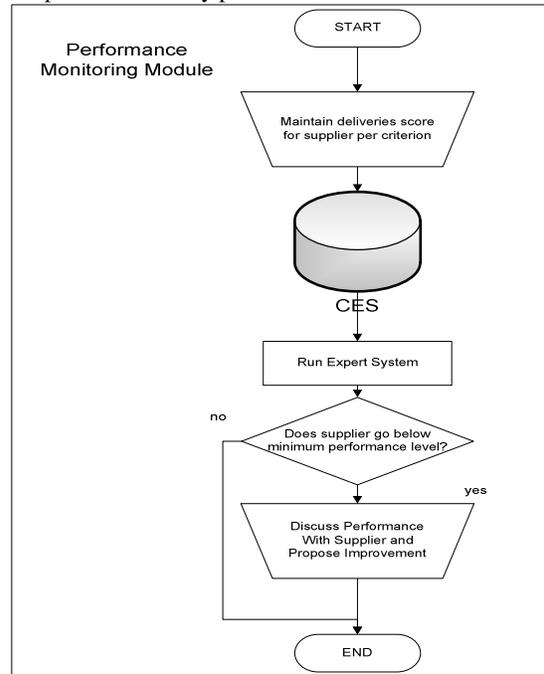


Figure 5: CES Supplier Performance Monitoring Module

a) *Input Delivery Score per Delivery*

The end-user inputs the details of a new delivery. Each predefined criterion is scored based on the actual delivery.

b) *Evaluate Supplier Performance*

A new weighted average score will be determined for the supplier during the review period when the expert system is run.

c) *Check for Supplier Performance*

If, at any point in time, a supplier falls below the minimum performance score, the system prompts the user to perform corrective actions.

C. *Preliminary Validation of the CES*

In order to validate the CES, two companies in the Philippines were investigated. The goal is to compare the CES with the actual thought processes of the purchasing personnel of these companies, and to compare the purchasing processing times of their manual operations to the processing time of CES.

After interviews with Company X's purchasing department, the following diagram summarizes the supplier accreditation process of their purchasing system.

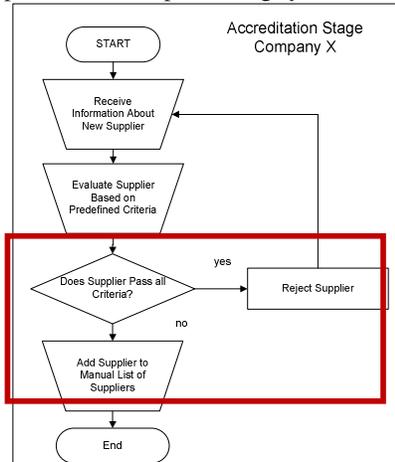


Figure 6: Company X Accreditation Process

It is noted that in Figure 6, the highlighted processes are similar to the CES, with the exception of the predefined criteria. Their system is quite tight in which the supplier must pass all the predefined criteria for accreditation in order to be accepted. Processing time for the manual evaluation of suppliers takes a significant portion of the time as compared to CES, since CES does supplier evaluation automatically.

The following figure shows the accreditation stage thought process for Company Y.

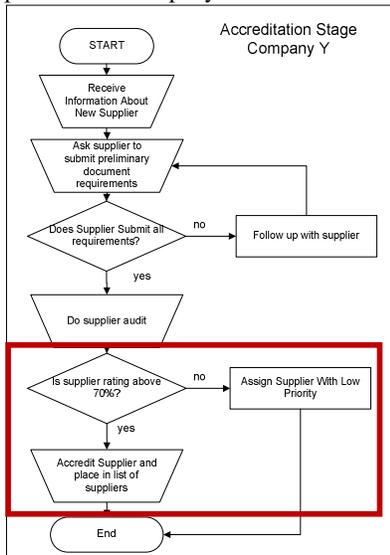


Figure 7: Company Y Accreditation Processes

As shown in Figure 7, Company Y's accreditation procedure also has similarities with the CES's evaluation module. Suppliers are evaluated similarly on predefined decision criteria. Company Y does the accreditation and auditing stage manually, with long processing times.

Figure 8 shows the selection process of Company X in selecting a supplier for satisfying a purchasing request. All preselected suppliers are sent RFQs.

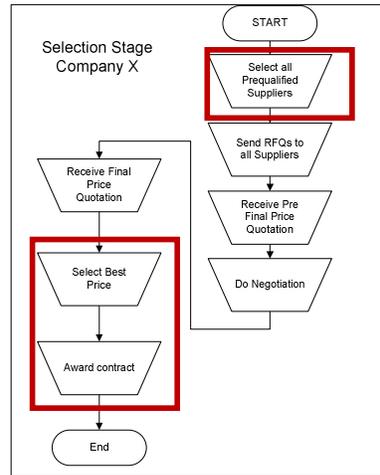


Figure 8: Company X Selection Processes

As highlighted in the diagram, Company X uses only price as the criterion for selecting the supplier to fill the request. This scenario can be accommodated in CES in which the user only chooses price as the decision criterion in the Selection Module with an assigned weight of 1.0. With Linear GP, the lowest penalized supplier is then recommended by CES, which is consistent with the decision of Company X.

The following figure shows the selection thought process of Company Y.

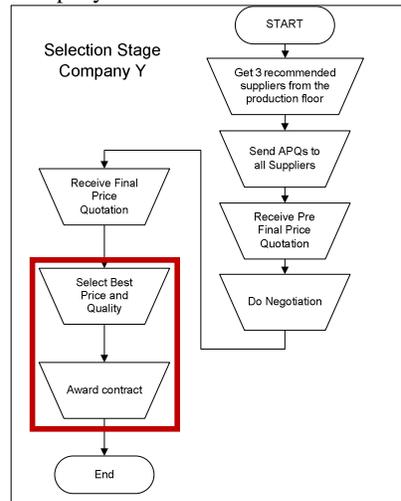


Figure 9: Company Y Selection Processes

Company X and Company Y selection stages are quite similar with the exception of Company Y incorporating quality as a decision criterion in addition to price for selecting suppliers. Both company's selection stages further validate the thought process of the CES since they are similar, and both scenarios obtain similar results.

The following diagram shows the monthly supplier auditing scenario of Company X

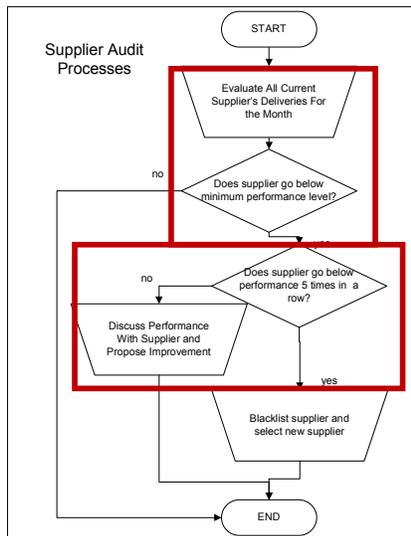


Figure 10: Company X Supplier Auditing Process

Company X's supplier auditing process is composed of predefined criteria, and a scoring mechanism is employed to rate the performance of a supplier each month. This is similar to the performance monitoring module of CES in which predefined criteria are maintained and scores are added for each supplier whenever the performance monitoring module is run. The CES is similar to Company Y's performance auditing scenario as shown in the following figure.

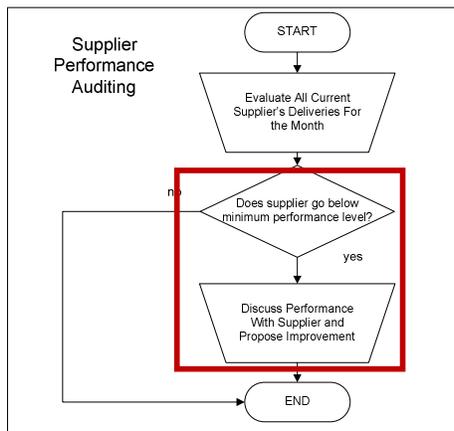


Figure 11: Company Y Supplier Performance Auditing

With this, it is verified that the process steps of CES's are valid. The steps of the interviewed companies are similar to the CES when CES is configured to mimic their purchasing personnel. Processing time for supplier evaluation is significantly faster when CES is used as the Expert System for accreditation.

D. Conclusion

In this study, a computer-based expert system is proposed to support purchasing organizations in pre-selecting or evaluating new suppliers, selection of the best prequalified supplier and monitoring supplier delivery performance for long-term purchasing. The use of the system would hasten the decision making process of the purchasing department since the expert system mimics the decisions of a professional purchasing manager. Aside from price, delivery performance and quality, the expert system can take in any type of criterion upon the

preference of the end-user. Preliminary results show that the workings of CES are similar to the thought processes of the purchasing managers of the companies that were studied and can well be implemented in their current purchasing processes, thus making it valid tool for purchasing decision-making.

E. Future Research Activities

Further validation of the system will be done when the CES will be used to solve real-life purchasing cases from the actual companies. Sample test cases of supplier evaluation, selection and performance monitoring will be requested and solved using the CES. The results of the cases will be presented to these purchasing organizations and will be compared to the actual decisions that they made. Comparisons of the results will be done to compare the processing capability of the CES in terms of supplier evaluation, selection and performance monitoring. Actual processing times will be compared to the processing times using the CES to determine the percentage improvement of the automated process. Consistency in selecting the best supplier with predefined decision criteria will be addressed and researched.

REFERENCES

- [1] Ding, H., et al (2003) A Simulation-Optimization approach using genetic search for supplier selection. *Proceedings of the 2005 Winter Simulation Conference*, p 1260
- [2] Weber, C. A., Current, J. R. and Benton, W. C. (1991), "Vendor selection criteria and methods", *European Journal of Operational Research*, Vol. 50, pp.2-18
- [3] Saaty, T.L. (1990). *The Analytic Hierarchy Process*. RWS Publications.
- [4] Altuntas, et al. (2006) An Application of Expert System Approach for Supplier Evaluation and Selection, *PICMET 2006 Proceedings*
- [5] Wang, et al. (2006) "A Knowledge-Based Decision Support System for Governments", *Advances in Intelligent Systems Research*
- [6] Voruka, et al. (1996) "A prototype expert system for the evaluation and selection of potential suppliers", *International Journal of Operations and Production Management*, pp. 106-127
- [7] Yao, et al. (2005) *Information Systems Outsourcing Vendor Selection Based on the AHP*, Shanghai China
- [8] Kumar, P., et al. (2008) "An integrated approach of Analytic Hierarchy Process and Fuzzy Linear Programming for supplier selection," *International Journal of Operations Research*, 2008
- [9] Ghodsypour (1997) "A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming" *Department of Manufacturing Engineering and Operations Management, University of Nottingham, University Park, Nottingham NG7 2RD, UK*