Simulation Of The Manufacturing E-Procurement Process

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Abstract

Procurement is migrating from paper-based to electronic-based processes, thus the term e-procurement. E-procurement can shortened the time between receipt and fulfillment of orders, thus reducing inventory and improve company cash flow. Successful e-procurement process design and improvement efforts require the understanding of the behaviour of work flowing through the system. Changes at one station can effect the performance at other station in the system. Correct decision on any changes can maximize the throughput and minimize the flow time.

This paper discusses a study on how simulation was used in modeling and simulating the internal e-procurement process of a multinational company in Penang, Malaysia. The study analysed the performance of the company internal e-procurement process and proposed some area of improvement within the e-procurement process. Statistical analysis method was used to measure the input and output of the model. The model is built using Arena, a package for discrete event simulation. Results obtained were reliable and credible compared to real time data. Recommendations were presented for the improvement of the company internal e-procurement process.

1. Introduction

Emerging Internet technologies are raising high hopes of changing the picture of costly, time-consuming and inefficient procurement processes by enabling major improvements in terms of lower administrative overhead, better service quality, more timely location and receiving of products and increased flexibility.

Procurement as defined by [1] is the purchasing of materials and services from outside organizations to support the firm's operations from production to marketing, sales and logistics. This includes obtaining manufacturing supplies for an assembly line as well as obtaining paper and pencils for a bank [2], [3]. With most organizations spending at least one third of their overall budget on purchasing goods and services, procurement holds significant business value [4]. An example of an e-procurement process spanning multiple boundaries is depicted in Fig. 1.

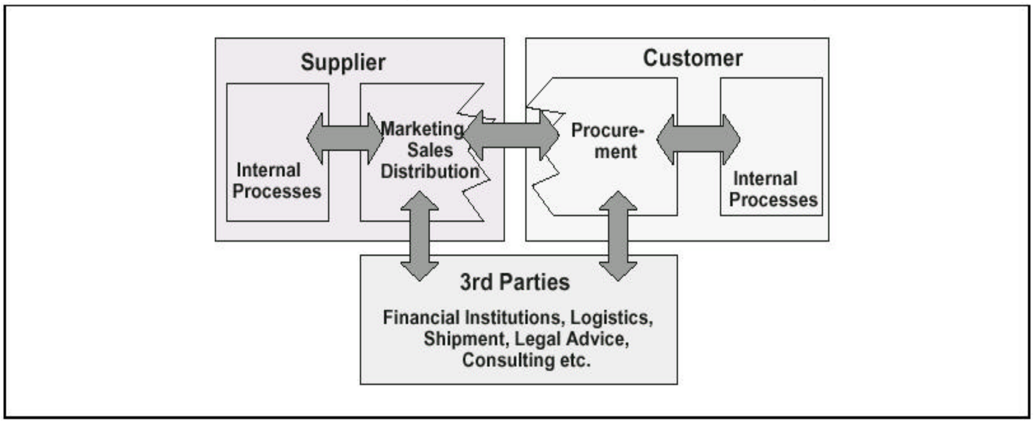

Fig. 1 E-Procurement Spanning Multiple Boundaries

A large amount of research has been devoted to the performance analysis manufacturing systems [5], [6]. Simulation study by [7] provides answers to capacity planning and simulation model for preventive maintenance. However to the authors' knowledge, no study has yet been done on the simulation of the factory e-procurement process.

This paper evaluates the performance of the internal e-Procurement process of a factory using simulation. The factory is a multinational company located at Penang Free Trade Zone, Malaysia. However, due to the policy and regulation of the company, the factory personnel do not wish to publish the company name, in order to minimize any implication after the data and information of the factory e-Procurement system being disclosed. The word "factory" will be used in replacing this company's name in this research. It is important that the internal procurement process is optimized and efficient, as most of the factories have purchasing department to buy the goods or services on behalf of the internal customers. The performance of the internal procurement process will be measured in terms of its delay time, utilization and throughput.

Purchasing which is the act of buying goods and services can be divided into 3 basic steps: information, negotiation, and settlement (Zenz and Thompson 1994). The scope of this research will focus on the activities around the factory buyers, which includes the first two steps in purchasing i.e. information and negotiation. Settlement is normally handle by account payable transaction processor instead of a buyer.

2. The Internal E-Procurement System

The whole process of the internal e-Procurement operation in the Factory starts from the submission of purchase requisition or shopping basket by the factory employee or called requester through the web browser. Figure 1 shows the e-Procurement flow diagram of the factory's internal operation. In the diagram, the activities flow from the submission of shopping baskets to the PO being printed for the supplier.

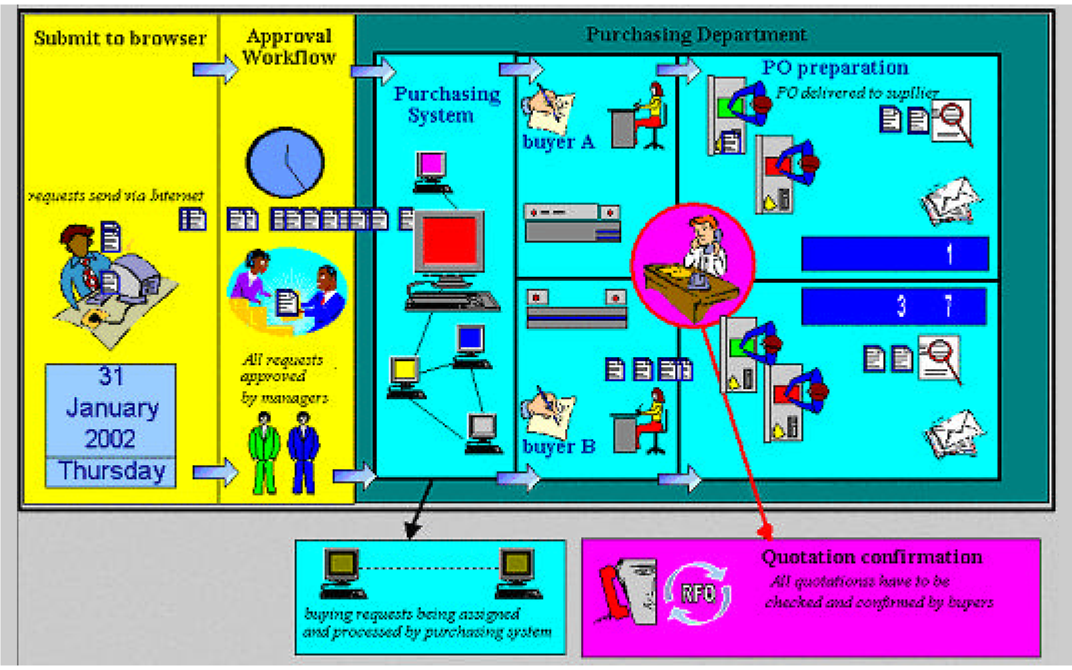

Fig 2 The Internal E-Procurement System

The purchase requisition or shopping basket is divided into two types, i.e. for capital requisition and for expense requisition. The study does not cover any depreciation incurred. In expense requisition, it could be tangible expense item like paper and stationary or intangible service like repairing machine or fixing the light.

The approval workflow involves two levels of management approval and one level of finance approval after the requester submitted the purchase requisition. Once the purchase requisition has been approved in the system, the system will automatically distribute it to either capital buyer or expense buyer based on the request. The segregation of capital PR and expense PR process is automated in the system.

After receiving the approved shopping basket or purchase requisition, the buyers will determine if the item is requested for the first time, which means non-repeated purchase. If it is a repeated purchase, the buyer will base on the contract that was established previously in preparing the Purchase Order information and print it to the supplier. If it is first time purchase, then, the buyer will trigger the request for quotation (RFQ) process. Here, the buyer will send out RFQ to potential suppliers and specify the quantity and delivery date to the potential suppliers. After the suppliers response, based on their availability to support the demand, the buyer will compare the quotations, based primary on the price. Purchase order will be printed after the buyer has determined the supplier.

3. The Simulation Model

The simulation model was designed and built in Arena as depicted in Fig. 3.

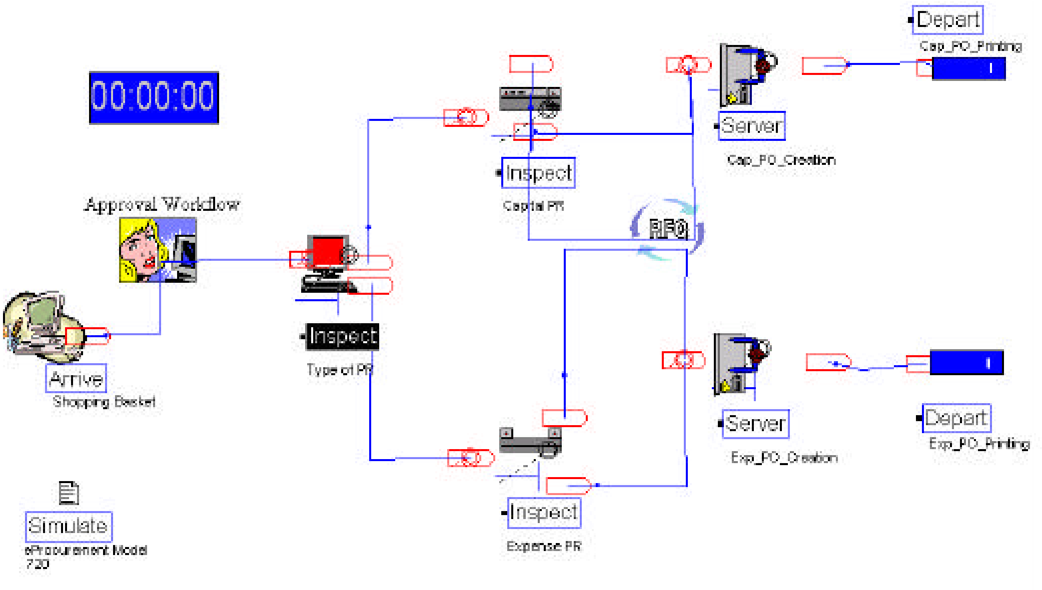

Fig 3 Arena Simulation Model

The data used was from the month of November 2001. This sample size could represent 90% of the data distribution in a year. The data extracted from the system consists of shopping basket (SB) submitted date, SB approved date, purchase order generated date, type of SB (either capital or expense) and if a Request For Quotation (RFQ) from supplier is required.

The factory operates for 24 hours a day. Although there are two rest days or weekend for users who are working in the office area instead of manufacturing area, it does not stop the user from submitting the purchase requisition or shopping basket.

The time taken for approval workflow, throughput time (TPT) from Purchase Requisition (PR) to Purchase Order (PO), delay time for RFQ, and percentage of capital versus expense request over a month can be calculated as follow:

$$\text{Approval Workflow Time} = \text{SB approved date} - \text{SB submitted date}$$

$$\text{Delay Time from PR to PO}_{\text{(without RFQ)}} = \text{PO generated date} - \text{SB submitted date}$$

$$\text{Delay time for RFQ (for those SB that request for quotation from supplier)}$$
$$= \text{Average Delay Time for PR to PO}_{\text{(with RFQ)}} - \text{Average Delay Time PR to PO}_{\text{(without RFQ)}}$$

$$\text{Percentage of Capital PR or expense PR} = \frac{\text{Total Capital PR or Total Expense PR}}{\text{Total PR}}$$

There is a total of 2027 PR generated for a month. The inter-arrival time to the system follows the gamma distribution with parameter -0.001 + GAMM(8.81, 0.651). The time taken for approval workflow for each PR record were extracted from the system where the average processing time is 21.3 minutes. The route time from the approval workflow station to the Type of PR station follows the Gamma distribution with parameter -0.001 + GAMM(8.81, 0.651).

The processing time at the Type of PR station is estimated based on the understanding from the system analyst of the e-Procurement system of the factory. The batch run was observed to be completed in 5 sec. There are 126 capital PR and 1901 expense PR generated from this station. The expense PR will then proceeds to the Expense PR station while the capital PR will proceed to the Capital PR station. The route time for both PR is estimated to be 30 minutes i.e. the time taken for the buyer in next station to pick up the PR in their queue and act on it.

3.1 Capital PR

The Capital PR station receives and processes the capital PR. There are two dedicated buyers in the department. The processing time is estimated to be, on average, 30 minutes for the buyer to determine whether or not the PR would need a quotation. It is observed that out of 126 PR, 69 PR require the RFQ. For the PR without RFQ, the delay time from

Capital PR station to Cap_PR_Creation station follows the beta distribution with parameter 31 * BETA(0.469, 0.866) and the delay time for PR with RFQ follows the lognormal distribution with parameter 1 + LOGN(7.19, 10.5).

The Cap_PO_Creation station will receive and process the PR with a service time that follows the beta distribution with parameter 31 * BETA(0.469, 0.866). There are three dedicated buyers at this station who will prepare and create the purchase order to the supplier. The route time from this station to the Cap_PO_Printing station is observed to be 30 minutes and this is inclusive of the time taken in the print queue and being printed.

3.2 Expense PR

There are eight buyers at the Expense PR station which decide if a PR requires a RFQ or otherwise. There are 1338 PR out of 1901 PR that require the RFQ. The processing time at this station is estimated to be 30 minutes. The route time from this station to Exp_PO_Creation for PR without RFQ follows the weibull distribution with parameter WEIB(2.24, 0.694) and for PR that requires the RFQ follows the lognormal distribution with parameter LOGN(7.78, 15.3).

The Exp_PO_Creation station will receive and process the PR with a service time that follows the weibull distribution with parameter WEIB(2.24, 0.694). There are ten dedicated buyers at this station who will prepare and create the purchase order to the supplier. The route time from this station to the Exp_PO_Printing station is observed to be 30 minutes and this is inclusive of the time taken in the print queue and being printed.

The Exp_PO_Printing station will record the number of expense PR produced during the simulation run. The length of replication for the simulation run was set to 720 which simulates the system for 30 days.

4. Output Analysis

The simulated model has generated a total of 1984 PO, which includes 119 capital PO and 1865 expense PO (refer to Table 1). The accuracy of the simulation result as compared to the actual data is very high. The overall error for throughput is less than 3%. For the expense PO, the accuracy is more than 98% while the accuracy for capital PO is about 94.5%. Simulation results for the utilisation are also comparable to the actual figures.

Table 1 Comparison of Actual and Simulated Results

	Actual	Simulation	Error %
Number of expense PO	1901	1865	1.894
Number of capital PO	126	119	5.556
Total PO	2027	1984	2.121
Utilisation			
Capital PR	0.00167	0.00180	7.222
Cap_PO_Creation	0.60372	0.59027	2.228
Exoense PR	0.00691	0.00681	1.447
Exp_PO_Creation	0.73454	0.75626	2.872

The delay times in producing the PO for both type of PR are as shown in Table 2. The simulation results obtained are within the observed time in the real situation. In conclusion, the model can be used to represent the real situation in the factory.

Table 2 Comparison of Purchase Order Delay Time

PO Type	Delay Time (day)	
	Simulation	Actual
Expense	1.6	1 – 2
Capital	2.4	2 – 3

5. Model Testing

Two what-if model were tested to find out if certain changes in the model will help to improve the performance of the e-Procurement system. Both what-if model will maintain the same number of buyers as in the original model.

5.1 What-If Model

There are two what-if models that have been considered. The existing total number of buyers are maintained but reallocation of buyers at the stations has been done (refer Table 3). Extra buyers are put at the most utilised stations such as the Cap_PO_Creation and Exp_PO_Creation in the model.

Table 3 Buyer Relocation

Station	Number of buyer		
	Original Model	What-if Model 1	What-if Model 2
Capital PR	2	1	1
Cap_PO_ Creation	3	4	4
Expense PR	8	6	2
Exp_PO_Creation	10	12	16
Total	23	23	23

In the original model, Capital PR station is available most of the time and Expense PR station is busy once in a while as depicted in Table 4. The Cap_PO_Creation station is busy half of the time while the Exp_PO_Creation is busy three quarter of the time. This can be expected based on the huge number of expense PO being processed.

Table 4 Comparison of Performance

	Original Model	What-if Model 1	What-if Model 2
Number of PO			
Expense	1865	1861	1871
Capital	119	134	118
Total	1984	1995	1989
Delay Time			
Expense PO	12.803	12.048	12.400
Capital PO	19.166	19.308	20.255
Station Utilisation			
Capital PR	0.00180	0.00391	0.00350
Cap_PO_Creation	0.59027	0.47095	0.41818
Expense PR	0.00681	0.00905	0.02730
Exp_PO_Creation	0.75626	0.57993	0.46984
Cost (RM)	261, 583.49	250,086.00	255,904.90

Both what-if models produced better results than the original model. However the first what-if model is considered better. The highest total number of PO being produced is from what-if model 1 with 1861 number of expense PO and 134 number of capital PO. This is an increase of 0.5% of the amount of PO produced by the original model. The average delay time is 45.3 minutes less than in the original model for expense PO but 8.52 minutes more the time in the original model for capital PO. Utilization of the two most busy stations has been reduced considerably.

The cost that involved in processing the POs in what-if model 1, confirmed that this model will maximize the current resources in the organization. The cost is reduced by RM11,497.49. The cost is calculated by multiplying the number of PO being processed with average delay time for each PO and cost for each hour. The factory estimates that the cost of a buyer is RM 10 per hour by assuming that a buyer's monthly salary is RM 1920 and works eight hours a day for 24 days a month. The configuration in the first what-if model is recommended if the factory wants to maintain the business in a more cost effective way.

5. Conclusion

The simulation model produced is correctly developed where its accuracy is more than 97%. Two what-if models have been used to test new configurations and compare the results with the actual value. In conclusion, it can be said that the factory does not have a significant problem. The factory can still support 2000 ± 50 PO in a month with its current force. However, the factory can use the configuration of the first what-if model if the factory wants to reduce its operating cost and producing the same level of output. The factory is recommended to automate four of its manual stations i.e. Expense PR, Capital PR, Exp_PO_Creation and Cap_PO_Creation in order to increase its productivity and be more competitive. Future work would be to model and simulate the three parties in the e-Business arena.

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