Order Management for Indirect Materials

Shanu Agrawal

Robert Bosch Engineering and Business Solutions

Bangalore, India

E-mail: [shanu.agrawal@in.bosch.com](mailto:shanu.agrawal@in.bosch.com)

Desika Selvaraj

Robert Bosch Engineering and Business Solutions

Bangalore, India

E-mail: [desika.selvaraj@in.bosch.com](mailto:desika.selvaraj@in.bosch.com)

Sheela Siddappa

Robert Bosch Engineering and Business Solutions

Bangalore, India

E-mail: [sheela.siddappa@in.bosch.com](mailto:sheela.siddappa@in.bosch.com)

ABSTRACT

When a supplier supplies more than one material, multiple purchase orders (PO) may get raised in a short span of time. There by, it becomes difficult for both supplier and buyer to manage PO’s and also increases the processing and transportation cost. Hence, reduces the efficiency of procurement process. In this paper, an efficient approach to reduce the number of purchase orders raised within a short period of time is discussed. It is reduced by bundling the purchase requests (PR) of materials required in near future. Demand forecasting and association between materials helps in bundling. At PO level, buyer combines PO’s, when a single supplier is identified as a right supplier for multiple materials. As a result, number of PO’s that will be raised in short period with unique supplier is reduced.

Keywords: purchase order, forecasting, supplier evaluation, probability

**INTRODUCTION**

Procurement is a key operating component of an organization and an average manufacturing firm spends about 50% of its sales revenue on purchase of goods and services [1]. Corporate procurement can be broadly classified into two types: direct and indirect procurement. Direct procurement refers to purchase of goods that are directly related to the production of a particular good or service being offered. Indirect procurement refers to purchase of goods that a company uses in day-to-day operations, but not in production of goods. Office supplies and equipment, MRO (maintenance, repair and operation), computers, software, etc., are few indirect goods [2].

The Purchase to Pay (P2P) process includes many sub-processes such as sourcing and negotiating terms, ordering, receipting and payment, contract and relationship management [3] [4] [5]. A well-executed P2P process can save costs and increase control, visibility and process efficiency [4] [5].

Indirect procurement is a complex process, with thousands of stock keeping units (SKUs), fluctuating demand and hundreds of individual suppliers, often managed at a local or site level rather than corporate procurement. Indirect procurement has long been ripe for efficiency and cost savings improvements due to various complexities such as large volume of transactions, unpredictable demand, numerous Purchase Requests (PR) that are raised over a period of time and de-centralized management.

This paper aims to improve the indirect procurement process by adapting data mining techniques to

1. Reduce multiple PRs raised by a department within short span of time for different materials required
   * This is achieved by providing details of predicted demand for other materials to the user raising a purchase request for a material
2. Further reduce the number of purchase orders (PO) and also reduce purchase cost by identifying the best supplier for a set of materials and bundling POs of those materials

The paper is organized as follows: Section 1 describes various literatures available on indirect procurement process. Section 2 provides a brief background on the problem at hand. Section 3 describes the approach and methodology with subsection 3.1, 3.2 and 3.3 describing steps 1, 2 and 3 respectively. In Section 4 and 5 details of data used and a case study for implementing our approach along with the analysis and results is provided. The conclusion and future scope of work is discussed in Section 6.

1. Literature review

This section reviews the related literature on the e-procurement and improvements in the area of indirect procurement.

1. E-procurement

E-procurement has become the most significant development in supply management in recent years. A study by Deloitte Consulting of 200 global firms in 2000 indicated that 30% of the organizations started implementing at least a basic e-procurement solution whereas 61% were either planning or considering an implementation [6]. Reduction in labour costs in the purchasing process is one of the major reasons for significant fall in transaction costs with e-procurement.

1. Indirect procurement

All items and services that are not directly part of a finished product fall under indirect materials. Indirect procurement is much more diverse as compared to production-oriented procurement and includes a broad variety of items, ranging from “simple” office products, parts for maintenance, repair, and operations (MRO), such as lubricants or spare parts, to complex construction-related items and to various services. Purchase of indirect materials is often done by non-purchasing experts, as well as by the central purchasing unit. Purchases usually occur on an infrequent basis and hence prediction of demand is very difficult. Also multiple Purchase Requests (PR) are raised by the requester over a period of time due to lack of insight on demand for a material [7].

Researchers developed several techniques to address the challenges of indirect procurement. In recent years, a new generation of purchasing systems has been introduced that support self-service by enabling end user to order supplies directly from a multi-vendor catalogue [8]. While purchasing operations are performed by end users, central purchasing is usually responsible for setting up and maintaining the systems, for incorporating suppliers into the network, and for negotiating blanket order agreements and long-term contracts [9]. A commodity approach is recommended for indirect materials by breaking down the complexity in terms of price volatility, lead time, volume etc. [10].

1. Data mining and machine learning techniques

The emergence of comprehensive data warehouses which integrate operational data with customer, supplier, and market data have resulted in an explosion of information. Enterprises have started using data mining techniques for automated discovery of previously unknown patterns as well as automated prediction of trends and behaviours, thus providing the business analyst and marketing professional with a new way of analysing the business [11].

Many researchers have applied data mining in the field of procurement. Importance of forecasting practises in SCM and demand management has been discussed [12]. Forecasting task for indirect materials is equally important to direct materials. Forecasts of requirements for stationaries, copy paper, laptops, keyboards, software licenses, electrical supplies, pipe, valves and fittings, bearings, safety supplies, and any other indirect material required to support ongoing operations are necessary to assure availability and as a foundation for contract negotiation with suppliers [13].

The analytic hierarchy process (AHP) has found widespread application in decision-making problems, involving multiple criteria in systems of many levels [14]. The AHP method is identified to assist in decision making to resolve the supplier selection problem in choosing the optimal supplier combination [15]. Considering the existing problems in the company initiating from incorrect supplier selection, owing to the human mistakes in judging the raw materials, or paying too much attention to one factor only, such as price, cost and other similar and unexpected problems, the AHP model is highly recommended to handle the supplier selection more accurately in order to alleviate, or better yet, eradicate the mistakes in this line [16].

1. Background

In a buyer-centric procurement process, requester selects the material from multi-vendor catalogue and raises a Purchase Request (PR). This is followed by generation of Purchase Order (PO) by the purchase team. If a requested material is a contracted material, a PR gets directly converted into a PO, else the buyer has to select supplier based on price negotiation and relevant approvals. Once the order is placed, the purchase team monitors the progress of the order through notifications. The supplier generates the invoice for the dispatched material. The finance team makes appropriate payment for the invoice. Figure 1 explains the process flow of indirect procurement.

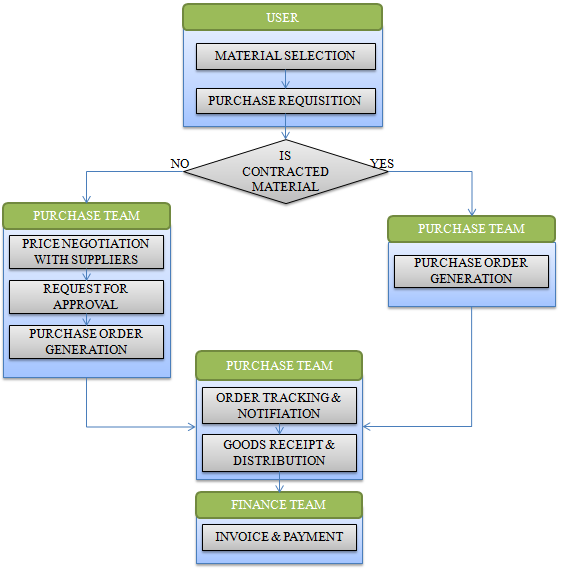


Figure 1. Flowchart for Indirect Procurement Process

By following the general order procedure would be difficult to manage PO’s when supplier supplies more than one material. In this case multiple PO’s may be generated with one supplier in a short span of time. Subsequently, it will also increase the processing cost of PO’s. The above issue can be resolved by providing probable list of materials that may be required in coming days to buyer while ordering for required material. Later a common PO can be raised for all the required materials in that period.

1. Approach and Methodology

The issue of raising multiple PO’s in a short span with the same supplier can be resolved at PR level by providing, the required material with probable list of materials that will be required in the coming days to requestor. As a result, PR’s and subsequently number of PO’s that will be raised in coming days with single supplier is reduced.

There are two ways to identify the probable list of materials that will be required in near future. One way is to forecast the demand for all materials, second is by identifying the list of associated materials with required material. The knowledge on the material requirements helps requestor in raising single PR for multiple materials.

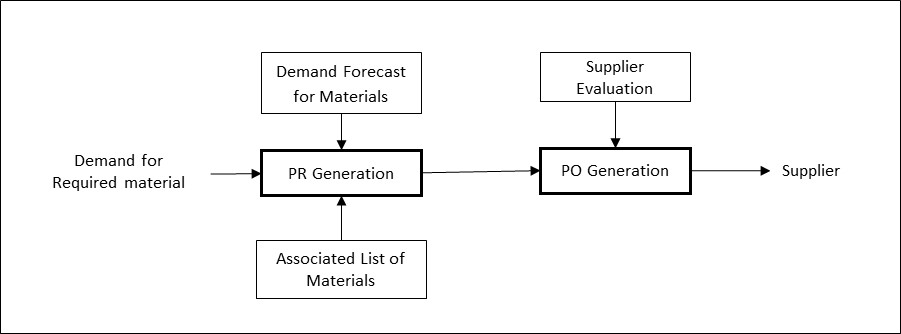


Figure 2. Flow Diagram of Our Approach for Efficient Procurement Process

At PO level, after receiving the PR’s, right supplier will be identified using supplier evaluation technique. If any supplier identified as an acceptable supplier for multiple materials then PO’s will be combined. There by increasing the efficiency of the procurement process. Figure 2 explains the process flow of our approach.

* 1. Demand Forecast for Materials

Typically when demand is based on history, time-series models are most. In this paper, Autoregressive Integrated Moving Average (ARIMA) model is adapted for demand forecasting of next period (e.g. 1 month) for each material. ARIMA is a forecasting technique that projects the future values of a series based entirely on its own inertia. ARIMA methodology describes the movements in a stationary time series as a function of "autoregressive (AR) and moving average (MA)" parameters. These are referred to as AR parameters and MA parameters.

The time series used for ARIMA model is expected to be stationary. In case of non-stationary series, the series is differenced. Suppose *y* denotes the difference of , then:

If: (1)

If (2)

If (3)

In terms of , the general forecasting equation is:

(4)

where are the AR parameters and are MA parameters.

Various measures are available for checking the accuracy of ARIMA model. Most commonly used are mean algebraic error (ME), root mean square error (RMSE), mean absolute error (MAE) and mean absolute scaled error (MASE). Formula for calculating MASE which is used in this paper for checking the accuracy of the model built is given below.

(5)

where is no. of observations, is difference between actual and forecasted value. In naive forecast actual value from previous period is considered as forecast for the current period. If MASE value is less than 1, ARIMA model performs better than naïve forecast method.

While raising the request for required material, demand for other materials which are typically purchased by department are forecasted. From the forecasted list of materials, requestor will be able to identify requirement of other materials. But forecasting is difficult when procurement frequency for a material is very low. In this case associated list of materials with required material will help requestor to identify requirement of other materials.

* 1. Associated List of Materials

Associated list of materials indicates that, if a requestor is raising PR for required material, then what is the probability he may also order other materials in coming days. For example if requestor is raising PR for monitor, what is the probability that CPU and keyboard will be required in coming days.

For identifying the associated list of materials with required material, in this paper conditional probability (CP) is used. For coming days 15 days of window period is used. Suppose we want to know the requirement of M2 in coming days if M1 is already required, then the formula for CP is:

(6)

where *N( )-* Number of times

But, one has to be very careful while interpretation of *CP* because if both materials have been requested only once and together then *CP* will be 1. It will give wrong interpretation of association between materials. Due to this, it is required to observe total number of instances when M1 and M2 have been requested within the relevant time limits (15 days). It is left to the purchaser’s discretion to decide the quantity of material to be ordered, due to insufficient data for demand forecasting. In this paper, to determine the actual requirement last purchase quantity and last purchase date is used.

* 1. Supplier Evaluation and Bundling of PO’s

The Right supplier for a material is identified using supplier evaluation technique. There are two prominent techniques for supplier evaluation:

1. Analytical Hierarchical Process (AHP) which is used when the relative importance of each criterion compared to the others is available.
2. Data Envelopment Analysis (DEA) which is used when the input and output criteria are available.

In this paper, AHP is used for supplier evaluation. AHP generates weight for each criterion according to the decision maker’s pair wise importance matrix A. The matrix A is real matrix, where m is the number of evaluation criteria considered. Each entry of the matrix A represents the importance of the criterion relative to the criterion. If , then the criterion is more important than the criterion, while if < 1, then the criterion is less important than the criterion. If two criteria have the same importance, then the entry is 1. The entries and satisfy the constraint. Obviously, for all. We have measured relative importance between two criteria according to a numerical scale as shown in Table 1,

Table 1.Relative Importance between Criteria for Supplier Evaluation

|  |  |
| --- | --- |
| **Value of** | **Interpretation** |
| 1/5 | is very less important than |
| 1/3 | is less important than |
| 1 | and are equally important |
| 3 | is high important than |
| 5 | is very high important than |

After getting weights for each criteria ( , score for each supplier is calculated by the following equation

(7)

where varies from 1 to Number of suppliers, = criteria value of supplier. The higher the score, the more efficient is the corresponding supplier.

Most common criteria’s used for supplier evaluation are unit price, lead time of delivery, price variance, quality of material, order fulfillment, number of purchase orders, delay in payment days, number of materials supplier supplies etc. One has to be very careful while calculating the score for sign of weights. Because higher value of some variable have negative effect on score like unit price, lead time of delivery, price variance etc. A supplier supplying material at higher price compared to others should get lesser score. Similarly if supplier who takes more time to deliver materials compared to others should get lesser score. Due to this, criteria weights of unit price and lead time of delivery are multiplied by -1.

In AHP, for calculating supplier score single values of criteria are required. But in real time multiple values for single criteria are present when same material has been ordered multiple times with supplier. In this case, for calculating the single values of criteria exponential forecasting is used. The procedure of obtaining single value for criteria can be changed according to requirement.

If any supplier comes out as an acceptable supplier for multiple materials then PO’s will be combined. Hence, multiple PO’s raised within a short period of time are reduced.

1. DatA

Dataset required for the analysis are:

* **PR level dataset**:
  + Information like material name, requested quantity for material, PR generation date, department name etc. are required.
  + It is used for demand forecasting and associated list of materials
* **PO level dataset**
  + Information like Material name, unit price, delivery date, supplier name etc. are required.
  + It is used for supplier evaluation of material.

1. USECASE and results

This section provides an illustration of how the proposed approach is used to improve the procurement process with sample data. The sample data contains information of 11 materials and 6 suppliers.

5.1 Demand Forecast for Materials

To forecast demand, order quantity is aggregated on a monthly basis for each material. If initial purchase was after 15th of the month (or last purchase happened before 15th), starting month (or ending month) is not included in forecasting. It is assumed that data is insufficient for forecasting if the purchase frequency is less than 3 in last 6 months.

Different ARIMA models are developed for different materials. Suppose a requestor wants to raise PR for Material M9, from Table 2, the list of other materials required in coming days will be M1, M2, M3, M4, M6 and M7. It is observed that, forecasting values for materials M5, M8, M10, and M11 are NA, implying data insufficiency. To identify requirement for these materials, associated list of materials is used.

Table 2.Demand Forecasting of Materials using ARIMA

|  |  |  |
| --- | --- | --- |
| Material | Next Month Demand | MASE |
| M1 | 6.86 | 0.72 |
| M2 | 204.83 | 0.66 |
| M3 | 266.37 | 0.42 |
| M4 | 250.76 | 0.66 |
| M5 | NA | NA |
| M6 | 24.6 | 0.53 |
| M7 | 47.06 | 0.67 |
| M8 | NA | NA |
| M9 | 42 | 0.73 |
| M10 | NA | NA |
| M11 | NA | NA |
|  |  |  |

5.2 Associated List of Materials

To identify the requirement of M5, M8, M10 and M11, association with material M9 is computed. Table 3 shows the association of material M9 with M5, M8, M10 and M11 using conditional probability calculation explained in section 3.2.

Table 3 Associated list of Materials for M9

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Material | Last Purchase Date | Last Purchase Quantity | Conditional Prob. | Instances |
| M5 | 5/1/2014 | 132 | 0.41 | 12 |
| M8 | 4/10/2014 | 288 | 0.28 | 8 |
| M10 | 4/28/2014 | 216 | 0.66 | 19 |
| M11 | 4/28/2014 | 216 | 0.83 | 24 |

From Table 3, observe that material M10 and M11, conditional probability value as well as number of instance value are high. There by, PR for Material M10 and M11 can also be raised.

From Table 2 and Table 3, requestor identifies the requirement of other materials. A combined PR for all material except M5 and M8 raised. Thus, it reduces the multiple PRs raised within a short span of time. Subsequently, it will help in reduction of PO’s if suppliers are common for more than one material.

5.3 Supplier Evaluation and Bundling of PO’s

In this paper, the criteria’s considered for supplier evaluation are unit price, lead time of delivery, number of PO’s raised for material and number of materials supplier supplies. Pair wise importance matrix of criteria used for AHP is shown in Table 4.

Table 4.Pair Wise Importance Matrix

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Unit Price | Lead Time | No of PO's | No of Materials |
| Unit Price | 1 | 3 | 3 | 3 |
| Lead Time | 1/3 | 1 | 3 | 3 |
| No of PO's | 1/3 | 1/3 | 1 | 1 |
| No of Materials | 1/3 | 1/3 | 1 | 1 |

Weights obtained from AHP model for each criteria are shown in Table 5.

Table 5. Weights of criteria

|  |  |
| --- | --- |
| Variable | Weight |
| Unit Price | 0.48 |
| Lead Time of Delivery | 0.28 |
| No. of PO’s | 0.12 |
| No. of Materials | 0.12 |

Using these weights score for each supplier is calculated. Supplier with maximum score is considered as a best supplier for material. Suppose we want to know best supplier for material M3 then the score will be as in Table 6. From Table 6, observe that “C Enterprises” is best supplier for Material M3.

Table 6. Supplier evaluation for material M3

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Vendor Name | Unit Price | Lead time (in days) | No of PO's | No of Materials | Score |
| C Enterprises | 1.95 | 5.766122 | 11 | 7 | -0.40714 |
| E Enterprises | 1.96 | 5.418342 | 8 | 6 | -0.44085 |
| D Enterprises | 2.32 | 7.001057 | 13 | 6 | -0.5312 |

Similarly, best supplier for each material is identified and the same is shown in Table 7. From Table 7, it is observed that single supplier turns out to be best for multiple materials. Hence, bundling of orders with single supplier is possible. Overall order bundling with suppliers is shown in Table 8.

From Table 8, it is evident that only 4 PO’s are required in place of 11 PO’s. There by the proposed approach reduces the number of PO’s by 44%. Subsequently, it reduces the processing cost and improves the efficiency of procurement process.

Table 7. Right Supplier for Selected Materials

|  |  |
| --- | --- |
| Material | Best Supplier |
| M1 | C Enterprises |
| M2 | D Enterprises |
| M3 | C Enterprises |
| M4 | F Enterprises |
| M6 | C Enterprises |
| M7 | A Enterprises |
| M9 | D Enterprises |
| M10 | A Enterprises |
| M11 | C Enterprises |

Table 8. Bundling of PO’s

|  |  |
| --- | --- |
| Supplier | Materials |
| A Enterprises | M7, M10 |
| C Enterprises | M1,M6,M11 |
| D Enterprises | M2,M9 |
| F Enterprises | M4 |

1. Conclusion & Future Scope

Multiple PO’s raised in a short span with the same supplier can be resolved at PR level by minimizing the number of PR’s. Probable list of materials helps requestor in identifying the demand for materials in advance and will enable reduction of PR’s that are raised in a short span of time. At PO level, if multiple materials have a common best supplier then PO’s will be combined for those materials. This will lead to reduction of PO’s raised within a short period of time. Subsequently it reduces the processing and transportation cost. There by, improving the efficiency of procurement process.

References

|  |  |  |
| --- | --- | --- |
| [1] | Presutti, William D. Jr. (2003), Supply management and e-procurement: creating value-added in the supply chain, *Industrial Marketing Management,* Vol. 32, pp.219-226. . |  |
| [2] | Kima, J.I, Shunkb, D.L (2004), Matching indirect procurement process with different B2B e-procurement systems, *Computers in Industry Journal*, Vol. 53, pp.153-164. |  |
| [3] | Lysons, K., Farrington, Brian (2006), Purchasing and Supply Chain Management, Pearson Education, New York City, New York |  |
| [4] | Monczka, Robert M. (2009), Purchasing and Supply Chain Management, 4th edition, South-Western Cengage Learning, Mason, Ohio. |  |
| [5] | Marmanis H., Pandit K. (2008), Spend Analysis: The Window into Strategic Sourcing, Fort Lauderdale FL: J. Ross Publishing Inc. |  |
| [6] | Whyte CK. E-procurement: the new competitive weapon. *Purch Today April 2000; 25*(see Ref. [4], pp. 26). |  |
| [7] | Emerging technologies to support indirect procurement: two case studies from the petroleum industry Judith Gebauer and Arie Segev |  |
| [8] | H. Li, & T. Yang, “Research on the Procurement Platform for MRO Materials Based on E-Commerce” in Management and Service Science (MASS), 2011 International Conference on (pp. 1-5). IEEE. |  |
| [9] | A. Segev, J. Gebauer and F. F¨arber, Impact of Emerging Technologies on Indirect Procurement (Fisher Center for IT and Marketplace Transformation, Berkeley, 1999), forthcoming. |  |
| [10] | T. S. Gurjeet, "How Indirect Procurement needs to be focused upon." A white paper, www.infosys.com (2003). |  |
| [11] | Barbara Lauer, “The mission: Elevate indirect spend to the next level of strategy”. A white paper, [www.kellyocg.com](http://www.kellyocg.com) |  |
| [12] | Data mining for the Enterprise, Charly Kleissner. |  |
| [13] | A Study of Forecasting Practices in Supply Chain Management, Abu Raihan. |  |
| [14] | Lee Buddress, Michael E. Smith, Alan Raedels, Getting the most from your indirect purchasing dollar, *91st Annual International Supply Management Conference, May,2006* |  |
| [15] | Liu, F.H. F. & H. L. Hai. (2005), The voting analytic hierarchy process method for selecting supplier. International Journal of Production Economics, Vol 97 No 3, pp.308-317 |  |
| [16] | Yu, X. & S. Jing. (2004),A Decision Model for Supplier Selection Considering Trust, Chinese Business Review, Vol 3 No 6, pp.15-20 |  |
| [17] | Farzad Tahriri, M.Rasid Osman, Aidy Ali, Rosnah Mohd Yusuff, Alireza Esfandiary, AHP approach for supplier evaluation and selection in a steel manufacturing company, Journal of Industrial Engineering and Management, Vol 1 No 2, pp.54-76 |  |