

## Agent based Information Technology model for purchasing process using SCM

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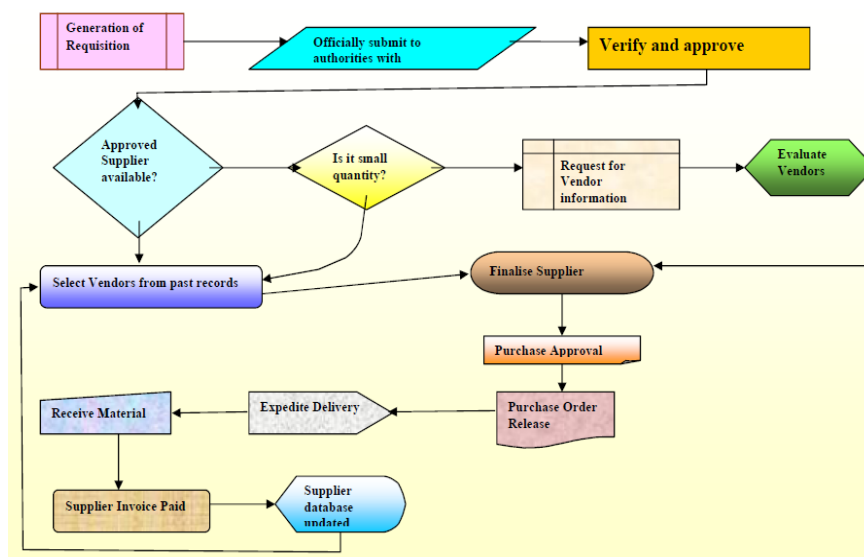
**Abstract:** This paper builds on to the previous work carried on a conceptual model for purchasing process using Agent based approach in Indian Manufacturing firms. The aim of this paper is to provide the necessary information technology support for the supply chains, the basic concepts and features of agent technology has been evaluated in order to determine its suitability for the management of supply chains. A conceptual multi agent model is designed and implemented for the supply chain which exhibits the information sharing. The proposed method shows that how the basic concepts and features of multi agent technology framework has been evaluated using software system that has been developed and presented to demonstrate the information sharing between various units and enhanced capabilities of Supply Chain for a manufacturing organization. The proposed Agent-based systems provides advantages such as, improvements in manufacturing lead time , delayed orders per year, shortage of material, delayed orders to customer after due dates , percentage of f manufacturing activities carried as per the schedule in various industries.

### I. Introduction

To manage the supply chain, companies need to adopt a SCM strategy and implement appropriate SCM practices. However, different SCM strategies and practices require support from appropriate Information Technology applications and their usage. Majority of the earlier reported works have considered only individual supply chain strategy and its effect. On the other hand the current work focused on various supply chain strategies and information system packages, their effect on manufacturing lead time, delayed orders per year, shortage of material, delayed orders to customer after due dates and % of manufacturing activities carried as per the schedule in various industries.

#### 1.2 Proposed Agents for the Automation of Purchasing Process [19]

Purchasing is one of the basic functions of each company and it is essential for a company to work in its business environment. It is often said that the objective for purchasing is "to acquire the right quality of material, at the right time, in the right quantity, from the right source, at the right price". The Purchasing module as proposed in the previous work [19] consists of 10 agents and each AGENT is designed to perform a specific function. Each AGENT uses common database and common form for collection and display of data as shown in Fig.1.1.



**Fig. 1.1** Purchasing Process

The description of various agents that have been developed for performing purchasing activities automatically, a brief discussion about the information contents used for the development of agents are given below. The fig 1.2 describes the various agents that have been used in the

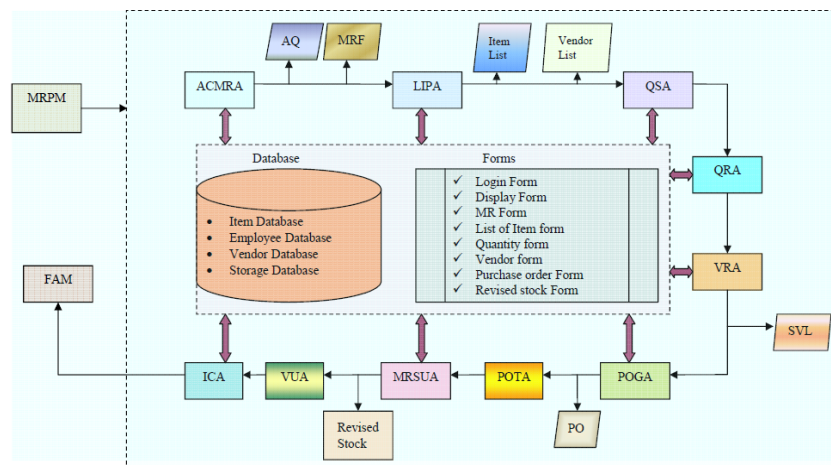


Fig. 1.2 Agents identified for the generation of Purchasing Process

ACMRA-Availability Checking & Material Requisition Agent, LIPA-List of Items to Purchase Agent, QSA-Quotation Sending Agent, QRA-Quotation Receiving &listing Agent ,VRA-Vendor Rating Agent, POGA-Purchase Order Generation Agent, POTA-Purchase Order Tracking Agent, MRSUA-Material Receipt & Stock Updating Agent ,VUA-Vendor data Updating Agent, ICA-Invoice Clearance Agent, AQ-Average Quantity, MRF-Material Requisition Form, SVL-Selected Vendor List, PO-Purchase Order.

## II. Software System For Purchasing Process

Agent based approach for Supply Chain Management has total 10 Agents as proposed in [19]. These agents have been designed and implemented using C#.NET software having SQL server 2008 as back end data base support. C# (pronounced C Sharp) is a multi-paradigm programming language that encompasses functional, imperative, generic, object-oriented (class-based), and component-oriented programming disciplines. It was developed by Microsoft as part of the .NET initiative and later approved as a standard by ECMA (ECMA-334) and ISO (ISO/IEC 23270). C# is one of the programming languages supported by the .NET Framework's Common Language Runtime.

### 2.1 Results and Discussions

For a given master production schedule once, the MRP module performs the time phasing of requirements, then it lead to the generation of information about the inventory needs of individual departments / shops and sections. Each department or section identifies the list of items that are necessary to carry out its expected activities in given period of time and accordingly performs certain activities to ensure that required quality and quality of material are available at right time at its disposal.

In every organization there will be an official who is responsible for ensuring that there is no shortage of any required inventory. He is also referred as the 'authorized user' who can access the storage database to check for availability of inventory, can order the inventory form store or can submit the material requisition as per the requirements of his department / section.

Let a department D1 has the requirement of raw inventory M1 in the nearest time bracket T1. Then the authorized user can check whether sufficient quantity of M1 is available in for the period T1 or not by logging in through login screen shown below in fig.1.4.

For this purpose the authorized user has to execute ACMRA (Availability Checking & Material Requisition Agent) which present to him the log-in screen. The person has to enter the unique number assigned to him periodically.

#### 2.1.1 Execution of agents for performing activities related to purchasing – source code & snap shots

In order to demonstrate the flow of information and execution of supply chain activities, the activities performed by various Agents viz. ACMRA, LIPA, QSA, POGA are presented below. Agent based approach for IT based Supply Chain Management software is designed by making use of the following databases.

Employee Database, Login Data Base, Items Database, Vendors Database, Auto Database, Inbox Database, Sent item Database, Temporary items Database

When user enters into an application the login screen is displayed. This shows title and what ACMRA agent can suppose to do and how to enter into the application. Fig 1.3 is wel-come screen helps a user to enter into the activities of ACMRA agent by clicking on “Enter” button so that user can direct to employee home page. Wel-come screen is common to all the agents.

The following are the some of the process models and snapshots used in implementing the software to automate purchasing activities.

As an example we have presented few lines of code for reference.

**i) Code for Main Program:**

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Windows.Forms;

namespace Inventory
{
    static class Program
    {
        /// <summary>
        /// The main entry point for the application.
        /// </summary>
        [STAThread]
        static void Main()
        {
            Application.EnableVisualStyles();
            Application.SetCompatibleTextRenderingDefault(false);
            Application.Run(new Form1());
        }
    }
}
```



**Fig 1.3** Wel Come Screen – Agent Based Approach for Supply Chain management

**ii) Code for Login Screen:**

```
using System;
using System.Collections.Generic;
using System.ComponentModel;
using System.Data;
using System.Drawing;
using System.Linq;
using System.Text;
using System.Windows.Forms;
using System.Data.SqlClient;
namespace Inventory
{
```

```
public partial class Form1 : Form
{
    int cnt = 0;
    SqlConnection cn = new SqlConnection("Data source=localhost;Initial catalog=inventory;Integrated
security=true");
    public Form1()
    {
        InitializeComponent();
    }
    private void button1_Click(object sender, EventArgs e)
    {
        try
        {
            cn.Open();
            int a = 0;
            SqlCommand cmd = cn.CreateCommand();
            cmd.CommandText = "select * from empinfo where empid=" + textBox1.Text + " and dept=" + textBox2.Text
+ "and uniqueno=" + textBox3.Text + ";";

            SqlDataReader dr = cmd.ExecuteReader();

            while (dr.Read())
            {
                //textBox2.Text = dr["password"].ToString();
                a = 1;
            }
            if (a == 1)
            {
                MessageBox.Show("You are authorized user...", "Alert", MessageBoxButtons.OK,
                MessageBoxIcon.Information);
                this.Hide();
                Form2 ak = new Form2();
                //ak.label1.Text = ap.ToString();
                ak.Show();
            }
            else
            {
                if (cnt >= 2)
                {
                    MessageBox.Show("Login Denied. Application closing....", "Alert", MessageBoxButtons.OK,
                    MessageBoxIcon.Exclamation);
                    Application.Exit();
                }
                else
                {
                    MessageBox.Show("Login Denied.", "Alert", MessageBoxButtons.OK, MessageBoxIcon.Error);
                    cnt = cnt + 1;
                }
            }
            dr.Close();
            cn.Close();
        }
        catch (Exception ex)
        {
            MessageBox.Show(ex.ToString());
        }
    }
    private void button2_Click(object sender, EventArgs e)
    {
```

```
Application.Exit();  
    }  
}  
}
```



Fig 1.4 Employee logging into the ACMRA agent

For the purpose of acquiring required material and supplies from each department an employee is authorized in each department to use the facility of logging in to view storage database for the verification of the materials available in store.

When the authorized users from any departments logs in as in Fig 1.4 to check availability of any materials in the store, the employee database is scanned to confirm the identity and permit the user to view available quantity.

Once the employee successfully Logs-in then he can choose any of the following three options for interacting with the storage database (refer Fig. 1.5).

- To view the available quantity of a specific material by specifying its material code or the list of available quantities in the storage database,
- To provide certain data about an existing vendor or a new vendor, which may be significant for the future purchasing activities and also to update vendor database
- To submit certain material specific information based on some feedback obtained from shop floor personnel which may be significant for future purchasing activities

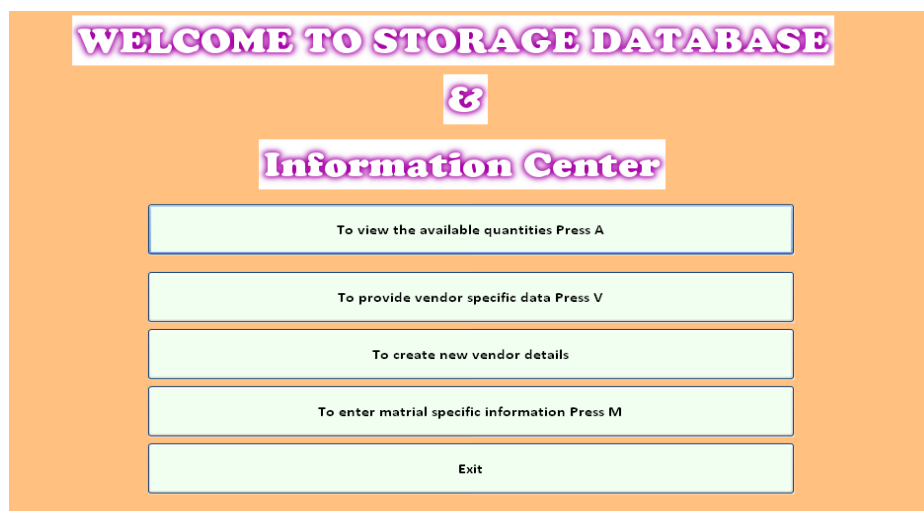


Fig.1.5 Welcome Form for Storage Database

Once, the authorized user selects the first option by clicking on it, and then a new form is presented to the user with the following two choices

- To view exhaustive list available raw inventory,
- To view the available quantity for a specific material.

The form allow the user confirms with the required data for a specific material and for the list of all the available items with quantities. If user selects choice for checking the availability of a specific raw material, then the corresponding form will be displayed and the user is prompted to mention his request by entering the Material name and Material code. If needed form provides a link to get the details about the coding scheme of all the material available in the store. The form also has a provision to invite the user to verify the available quantity of another specific raw material. The user can avail this facility in order to obtain the information about the available quantity for a group of specific items one after another.

Once the user confirms with the required data, the ACMRA verifies with the part of existing stored database, it displays the detailed availability of the material under consideration. It should be noted that if the user makes improper entries for material name and code then, ACMRA guides the user to use the link for obtaining the information about list of materials and their codes and reselect the form.

In the above form the quantity in store indicates the actual quantity available in store at this moment. There can be some pending orders which are submitted by other authorized users through the current procedure. It means the authorized users from other departments / sections which are in need of this material M1 have already verified and confirmed the availability of this material and requested for supply of the same. However, these requested quantities are yet to be supplied to the respective departments / sections. On priority basis as these quantities are requested earlier, first the delivery of material is carried out for these orders. Hence, for the current authorized user the available quantity will be the quantity that may remain in storage after satisfying the pending requisitions. This quantity will be shown as the 'net quantity'.

In order to get a complete list of all the available material in the store, if the user chooses the option then the form shown in Fig. 1.6 will be displayed to present the required information.

MatCode	MatName	AvQty	PendReq	NetQty
K101	Keyboard	110	35	75
M101	Monitor	255	15	240
M102	Scanner	102	47	55
M103	Printer	102	12	90
M104	DVD	105	05	100
M105	Web Camera	105	05	100
M106	CD	105	05	100
*				

**Fig 1.6** Form for checking all available material list

The above form not only shows the details of all the material available in stock but also provides with options for getting details of specific material by clicking on the code of that material on the form or the details of a selected group of materials by continuously pressing on the necessary codes

The form shown in fig.1.6 provide an insight into the storage database and sufficient information about the Material Available in the stock for and further give the clue to the authorized user in order to take appropriate action to ensure the supply of required quantity of material for smooth production activities in the respective department or section. If the net quantity displayed is sufficient for fulfilling the expected demand of the user then ACMRA permits the user to choose the order form

Choosing this form now the user can enter the name of code of the material required for his /her department / section and also specifies the quantity and due date of requirements along with the name of the department. Once the user submits this form with all details ACMRA converts this request into pending requisition and add it to the storage data base. It also assures the user about the supply of required material at right time as per the due date requirement.

If the user finds that net quantity in the store is insufficient to meet his requirements, then he / she can request the ACMRA to present the materiel requisition form (refer Fig.1.6) in order to submit his demand for the material and requesting for procurement of the required material by the purchasing department.

ACMRA displays the material requisition form and prompt the user to enter the following data for processing his request (Fig 1.7)

- Name of the department, Name and code of the material, Specifications of the material, Required quantity, Date on which items are required,

- The user is also permitted to enter the details of preferred vendor and any other significant information as 'remarks' which may support the purchasing of material under consideration.
- Once, the user makes all entries in the material requisition form and submits it for consideration, and then ACMRA makes estimation of budgeting requirements for the requested requisition and obtains confirmation and approval for official in charge for the purpose. Finally, it enters all the details of budget requirements in appropriate box and with a formal approval submit the material requisition form to LIPA for further processing.
- As highlighted above the welcome form of the storage database permits the authorized user to have an access to storage data for checking the availability of raw inventory. Apart from this facility the user also enjoys the provisions through which he can send information about a vendor or a material to storage database by selecting the appropriate boxes.

Fig 1.7 Material Requisition form

- If the user selects the required option, then ACMRA permit the user to enter data about a new vendor or any positive or negative remarks about an existing vendor based on shop floor activities. Similarly the user can select option to obtain the form shown on Fig. 1.8 where he can use to send information about either quality or quantity problem of a specific material.

ACMRA groups all the approved material requisition forms submitted in a given time and submit them to LIPA for further action. LIPA compiles the information submitted by the ACMRA (Fig 1.9) and prepares the consolidated list of items for purchasing in the near future. If a material is requested by more than one department than the due date is determined by the earliest required date among the dates specified by different departments/sections.

LIPA arranges the list in a form as shown in Fig.1.10 and submit it to QSA (Quotation Sending Agent) to proceed for the purchasing of materials.

Fig. 1.8 Form for Entering Material Specific data by the Authorized User

**MRF details from various Departments**

Details of MRF received from departments

mrepro	dt	dept	slno	matcode	matname	itempe	pvendor	itemreq
0	16/10/2012	IFE	1	K101	Keyboard	HP	James	100
0	16/10/2012	CIVIL	1	K101	Keyboard	HP	James	50
0	16/10/2012	AUTO	1	M104	DVD	SAMSUNG	Mark	100
0	16/10/2012	EEE	1	M105	Web Camera	SAMSUNG	Mark	200
0	19/10/2012	ECE	1	K101	Keyboard	HP	Chris	100
0	19/10/2012	CSE	1	M102	Scanner	HP	Mark	10
0	19/10/2012	CSE	1	M102	Scanner	HP	Mark	10

GENERATE REPORT

Exit

Fig 1.9 Form displaying List of Material requested from various departments to be purchased

The major function of QSA is to send the invitation to the eligible vendors to send their quotation for the set of materials required for various departments. Before performing this function it also performs the function of identifying the set of eligible vendors based on their effectiveness in supplying previous orders. The vendor database provides information about each existing vendor

**CONSOLIDATED LIST OF ITEMS**

Consolidated List of Items to be Purchased

matcode	matname	qty	duedate
K101	Keyboard	100	19/10/2012
K101	Keyboard	150	16/10/2012
M102	Scanner	20	19/10/2012
M104	DVD	100	16/10/2012
M105	Web Camera	200	16/10/2012

Fig 1.10 Form displaying List of Material to be purchased

If sufficient number of eligible vendors is not identified in the existing database then QSA follow certain well defined activities to obtain information about new vendors who satisfy the minimum requirements as per the norms of the organization. After ensuring that sufficient vendors list is prepared then QSA prepares the list of materials along with vendors identified in the form as shown in Fig 1.11. To each vendor who has been identified in the above form, QSA sends a request letter inviting the vendor to send the quotation for all those materials which are specified against this vendor.

**MRF details from various Departments**

Details of MRF received from departments

matcode	matname	qty	duedate
K101	Keyboard	100	19/10/2012
K101	Keyboard	150	16/10/2012
M102	Scanner	20	19/10/2012
M104	DVD	100	16/10/2012
M105	Web Camera	200	16/10/2012

GENERATE REPORT

Exit



	matcode	matname	vend
▶	K101	Keyboard	Chris
	K101	Keyboard	James
	M102	Scanner	Mark
	M104	DVD	Mark
	M105	Web Camera	Mark
*			

Fig.1.11 Screen for Material with Vendors and Due Date

The login is used individually with each vendor and once they login they can check the invitation for the quotation from the organization. Each vendor is requested to use the form shown in Fig.1.12 for submitting the quotation. The vendors are specifically informed to specify the following information precisely for each material i.e Price of the item, Lead time for supply of items, Quality in terms expected % of defectives in a lot, Mode of transportation and Cost of transportation

After sending the invitation letters to various vendors identified as eligible vendors, QSA transfer this information about the vendors to QRA, which in turn accepts the quotations submitted by the eligible vendors and checks for minimum terms and conditions which are necessary to perform Vendor rating. All those vendors who are found to be satisfying minimum required conditions for vendor rating are called as qualified vendors. For a particular material if sufficient numbers of qualified vendors are not available then, QRA pass a message to QSA requesting it to make arrangements for the quotations of few more vendors.

Once, sufficient numbers of qualified vendors list is prepared QRA arranges this information in a standard format in which for each material a set of qualified vendors are specified. QRA sends this list to VRA for performing vendor rating.

**QUOTATION FOR MATERIAL**

Name of Organization: PDACE      Mark

Address: GULBARGA

Reference No: 0      Date: 19/10/2012

SI.No	Material Name	Code	Description	Qty	Price	Total	Lead Time
1	Scanner	M102	HP	20	1000	20000	2 weeks

refno	sho	matname	code	descr	qty	price	tot	leadtime
*								

Save      Exit

Fig 1.12 Quotation for the Material from vendor

After receiving material wise vendors list VRA perform the vendor rating based on the following factors like Quality of the material, Cost of the materials, Transportation cost, Delivery aspects. For delivery aspects either the delivery time specified by the vendors in their quotation or the information about number of delayed deliveries forms the vendor database (if all the qualified vendors are existing vendors). Each of these factors may be treated with equal or different degrees of importance. The importance of each factor is specified through certain weightage assigned to that factor such that total weightage will be 100

VRA determines and assigns the weightages to different factors considered for vendor rating, depending upon the purchasing policies of the organization. Further, it considers materials one after other and for each, material calculates Total score / Performance Rating for each qualified vendor.

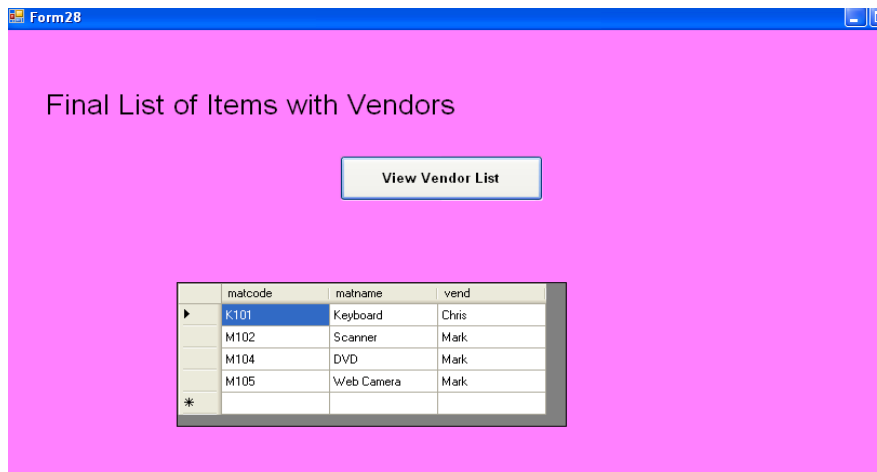


Fig 1.13 Screen for Material with vendors

Once after performing vendor rating for each material, VRA prepares a list of selected vendors and presents it through the list SLV as shown in Fig.1.13. Hence, SLV becomes the prime output of VRA, which will be submitted to POGA to carry out the further steps for purchasing of materials under consideration. SLV will be submitted to POGA by VRA with recommendations to place the purchase order for this selected vendor.

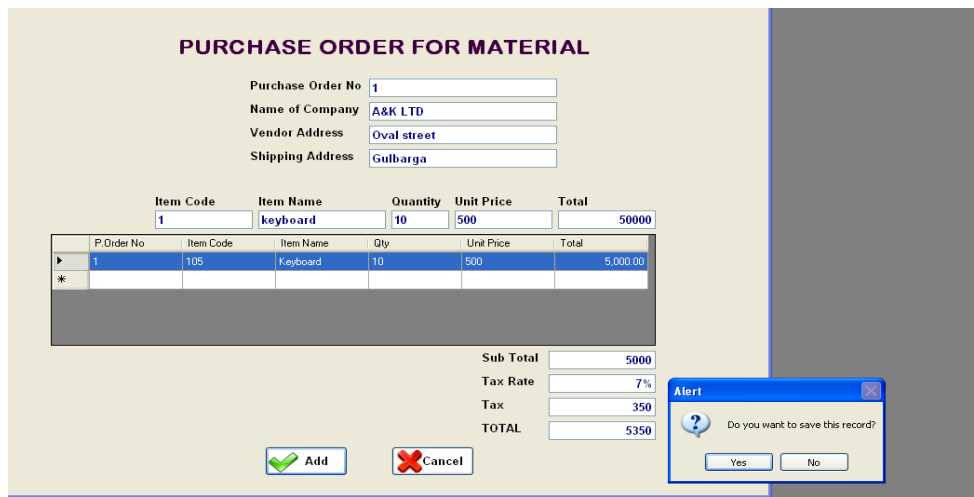


Fig 1.14 Purchase Order

With SLV as its major input, POGA generates purchase order for every selected vendor in the format shown in Fig.1.14, highlighting clearly characteristics of materials, their quantity and due date requirements, mode of transportation, price aspects and also other terms and conditions of purchasing.

POGA is not only responsible for preparing the purchase orders in the format shown above but also to dispatch the purchasing orders to respective vendors. After that it sends the detailed information about all the purchase orders to POTA which is capable of performing pre defined activities to maintain the status of all the purchase orders.

POTA contacts the supplier for either for updating the delivery schedule or to reassess that schedule of delivery of items is maintained and ensures the securing of the quality and timely delivery of goods and components. When a purchased order is executed successfully the quantity supplied by the respective vendor will be received in the storage and the concerned people make use of MRSUA. The MRSUA allow them to use the form shown in Fig. 1.15 to prepare the report about the acceptance / rejection of the lot received. The official personnel for inspection make a complete inspection of the lot by applying the quality control methods to decide about the acceptability of the lot. The result of the inspection of lot is expressed though the following form along with suitable recommendations for further action.

**Form for Clearance Report / Rejection Note**

**Reminder for status of Purchase Order**

Report / Note No  Date

SINo	Order No	Material Name	Item Code	Supplier	Remarks
1	15	M101	Keyboard	Mark	Good

The above mentioned Materials have been Accepted  / Rejected  through Inspection

Signature \_\_\_\_\_

**Fig 1.15** Form for Acceptance or Rejection of Materials received

If the lot is recommended for acceptance then it is officially received by the stores personnel and submits the relevant information by making entries in the form shown in Fig.1.16.

**FORM FOR THE MATERIAL RECEIVED**

Purchase Order No   
 Delivery Point   
 From: Vendor  Vendor's Address

Qty Received	Description of Material	Condition of Goods	Grade
10	Keyboard	Good	A

Pur.Order.No	Qty Recv.	Description of Material	Conditions of Goods	Grade
*				

Counted and Inspected By  Approved By  Remarks for Vendor

**Fig 1.16** Form for Materials Received

Once this form is submitted by stores personnel, MRSUA automatically updates the storage database by enhancing the available quantities suitably. In addition MRSUA sends message to the VUA to update the vendor database by reassigning the new ranks to the vendor under consideration. MRSUA also sends message to ICA to perform a set of well defined activities in order to communicate the agents of financial aspect module with recommendations for timely payments to the vendors who have executed the current purchase orders satisfactorily

### III. Conclusion

In order to provide the necessary information technology support for the supply chains, the basic concepts and features of agent technology has been evaluated in order to determine its suitability for the management of supply chains. A multi agent model proposed for the supply chain is developed using software system that demonstrates the information sharing.

The overall framework describes how the basic concepts and features of multi agent technology framework has been evaluated using software system that has been developed and presented to demonstrate the effective Information sharing between various units and enhanced capabilities of Supply Chain for a manufacturing organization.

The proposed Agent-based systems provides advantages such as, improvements in manufacturing lead time , delayed orders per year, shortage of material, delayed orders to customer after due dates , percentage of f manufacturing activities carried as per the schedule in various industries.

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