BULLWHIP EFFECT REDUCTION THROUGH MULTI-AGENT SYSTEM USING JADE TOOL

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Abstract: *The bullwhip effect is the magnification of demand fluctuations, not the magnification of demand. Whenever demand increases and decreases, the bull whip effect are evident in a supply chain. When the supply chain is large, the issue becomes more complex. Also Bullwhip effect is caused from distortions in information along the supply chain Some of the bull whip effects are excess inventories, problems with quality, increased costs, overtime expenditures, lost customer service, lost sales and more. This leads to poor forecasting of sales, incorrect information along the supply chain. In order to solve bullwhip effect, it is proposed that Multi-agent based Supply chain management which ensures entire supply chain working on real time. Intention of our work is to develop a supply chain management application based on MAS and SOA and build a*

model how it can help in reducing bullwhip effect in a manufacturing unit. The Supply Chain Management application consists of three different services i.e. MAS, SOA and SCM. These services are designed, integrated and architected separately and brought them together using MAS and SOA technologies.

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I. INTRODUCTION

A supply chain consists of all parties involved, directly or indirectly, in fulfilling a customer request, or demand. The supply chain not only includes the manufacture and suppliers, but also transporters, warehouses, retailers, and finally the end consumers themselves The objective of every supply chain is to maximize the overall value generated. The value a supply chain generates is the difference between what the final product is worth to the customer and the effort the supply chain expends in filling the customer's request.

Supply chain management involves the management of flows of information, product, or funds between and among stages in a supply chain to maximize total supply chain profitability An important phenomenon in SCM, known as the bullwhip effect, which suggests that the demand variability increases as one moves up a supply chain. It is 1989 that Sterman first introduced regarding this effect. Since then, worldwide researches have been carried out by various authors to study different aspects of SCM, causing the bullwhip effect and suggested a number of methods to reduce its effect.

The impact of the bullwhip effect is to increase Manufacturing cost , Inventory cost, Replenishment lead time, Transportation cost $ Labor cost for shipping and receiving, for building surplus capacity and holding surplus inventories. The impact of the bullwhip effect is also to decrease 'Level of Product Availability', since More run out of stocks in supply chain, and to decrease 'Relationship Across the Supply Chain', since each stage tends to blame other stages of the supply chain

There are so many minor causes which gives rise to bullwhip effect. But, they can never be quantified through mathematical equations, however, can be controlled through effective managerial levers. Some of these causes can be pointed out as below,

- Lack of supply chain coordination
- Lack of information sharing
- Lack of trust among the members in SC
- Lack of proper incentive scheme
- Lack of proper trained sales forces etc

The major causes which increase in variability are projections of future demand expectations, which result in over-exaggerated responses to changes in demand.

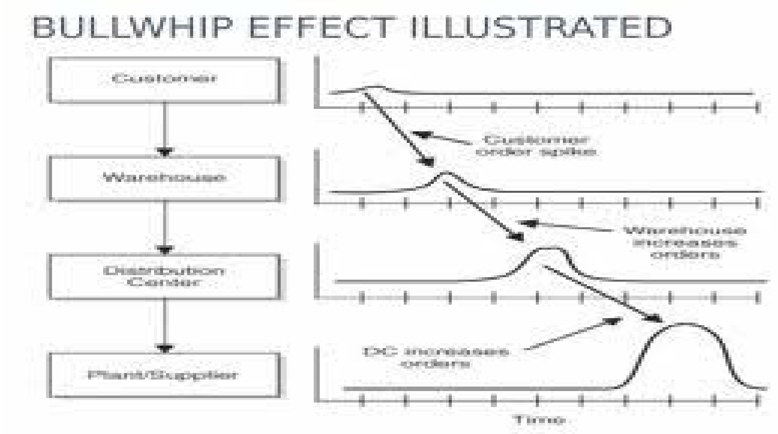

Figure 1: Bullwhip effect

In 1997 Lee et al. identified five major causes of the bullwhip effect which was all the consequence of the rational behavior of the supply chain members:

They are the use of

- Demand Forecasting
- Batch purchasing OR Ordering Lots
- Replenishment lead times
- Rationing & Supply Shortages
- Price Fluctuations and Safety Stock

The loss due to this can be quantified through mathematical equations, and can be controlled effectively, if the factors affecting the bullwhip effect are analyzed properly through proper method.

All previous works were only limited on quantifying the bullwhip effect based on common methods of reducing its impact. However, with all these previous works, it is difficult to obtain graphical illustration of the bullwhip effect

II. RELATED WORK

Lee et.al (1997) stated that the bullwhip effect occurred when the demand order variabilities in the supply chain were amplified as they moved up the supply chain. Distorted information from one end of a supply chain to the other could lead to tremendous inefficiencies. Companies could effectively counteract the bullwhip effect by thoroughly understanding its underlying causes. Industry leaders were implementing innovative strategies that posed new challenges: 1. integrating new information systems, 2. defining new organizational relationships, and 3. implementing new incentive and measurement systems.

Fransoo et.al (2000) stated discussed Increased demand variability in supply chains (the bullwhip effect) in the literature. The practical measurement of this effect, however, entailed some problems that had not received much attention in the literature and that had to do with the aggregation of data, incompleteness of data, the isolation of demand data for defined supply chains that were part of a greater supply web. This paper discussed those conceptual measurement problems and discusses experiences in dealing with some of these problems in an industrial project. Also presented empirical results of measurements of the bullwhip effect in two supply chains.

Merkuryev et.al (2002) described the impact of two different information sharing strategies – decentralized and centralized information – combined with two inventory control policies – min-max and stock-to-demand inventory control – on the bullwhip effect. To investigate and measure this impact, simulation models were developed using the Arena 5.0 software package for a four-stage supply chain, consisting of a single retailer, wholesaler, distributor and manufacturer. The experiments with the developed models were described and the results are analyzed

Warburton et.al (2004) described The Bullwhip Effect as problematic: order variability increases as orders propagate along the supply chain. The fundamental differential delayed equations for a retailer's inventory reacting to a surge in demand were solved exactly. Much of the rich and complex inventory behavior was determined by the replenishment delay. The analytical solutions agreed with numerical integrations and previous control theory results. Managerially useful ordering strategies were proposed. Exact expressions were derived for the retailer's orders to the manufacturer, and the Bullwhip Effect raised naturally. The approach was quite general and applicable to a wide variety of supply chain problems.

Croson et.al (2005) proposed a new behavioral cause of the bullwhip, coordination risk, arising when players deviated from equilibrium to build inventory to protect against the perceived risk that others would not behave optimally. They tested two strategies to mitigate coordination risk: (1) holding additional on-hand inventory, and (2) creating common knowledge by informing participants of the optimal policy. Both strategies reduced, but did not eliminate, the bullwhip effect. Holding excess inventory reduced order amplification by providing a buffer against the ndogenous risk of coordination failure. Such coordination stock differed from traditional safety stock, which buffers against exogenous demand uncertainty. Surprisingly, neither strategy reduced supply-line underweighting. They concluded that the bullwhip could be mitigated but its behavioral caused appeared robust.

Mujaj et.al (2007) addressed the problem of increasing order variances in multi-tier supply chains. The majority of current approaches for reducing this problem, namely the bullwhip effect, relied on information sharing and/or cooperative planning in inter-organizational systems. Due to multiple barriers in implementing these approaches, they maintained the local autonomy of the participants in the supply chain and provided a multiagent-oriented solution to the problem. In particular, they designed an agent-based reverse pricing model for matching supply and demand between independent agents. They adopted reverse pricing for operational procurement decisions and matchmaking that could be automated to a large extent. They evaluated our proposal by conducting a simulation study using a multiagent-based simulation system, and showed that the novel approach results in a significant reduction of the bullwhip effect

Chaharsooghi et.al (2008) stated that two-echelon supply chain, which included two products based on the following considerations, had been studied and the bullwhip effect was quantified. Providing a measure for bullwhip effect that enabled us to analyze and reduce this phenomenon in supply chains with two products was the basic purpose of this paper. Demand of products was presented by the first order vector autoregressive time series and ordering system was established

according to order up to policy. Moreover, lead-time demand forecasting was based on moving average method because this forecasting method is used widely in real world. Based on these assumptions, a general equation for bullwhip effect measure was derived and there was a discussion about nonexistence of an explicit expression for bullwhip effect measure according to the present approach on the bullwhip effect measure. However, bullwhip effect equation was presented for some limited cases. Finally, bullwhip effect in a two-product supply chain was analyzed by a numerical example.

Duc et.al (2010) studied whether a third-party warehouse can help to reduce the bullwhip effect in a supply chain. We compare the bullwhip effect in a three-stage supply chain with one supplier, one third-party warehouse, and two retailers and that in a two-stage supply chain with one supplier and two retailers. As a result, they exactly quantified an upper bound on variance of order lead time when order lead times of the warehouse and the retailers had the same mean value. In addition, they showed that the bullwhip effect pooling exists (i.e., the existence of third-party warehouse is beneficial for mitigating the bullwhip effect in supply chains) regardless market shares of the retailers if the variance of order lead time of the warehouse is less than the upper bound value.

Barlas et.al (2011) discussed that Supply chain inventories were prone to fluctuations and instability. Known as the bullwhip effect, small variations in the end item demand created oscillations that amplified throughout the chain. By using system dynamics simulation, they investigated some of the structural sources of the bullwhip effect, and explored the effectiveness of information sharing to eliminate the undesirable fluctuations. Extensive simulation analysis was carried out on parameters of some standard ordering policies, as well as external demand and lead-time parameters. Simulation results showed that (i) a major structural cause of the bullwhip effect was isolated demand forecasting performed at each echelon of the supply chain, and (ii) demand and forecast sharing strategies could significantly reduce the bullwhip effect, even though they could not completely eliminate it. They specifically showed how each policy is improved by demand and forecast sharing. Future research involves more advanced ordering and forecasting methods, modelling of other well-known sources of bullwhip, and more complex supply network structures.

III. MULTI-AGENT SYSTEM

Computers are not very good at knowing what to do: every action a computer performs must be explicitly anticipated, planned for, and coded by a programmer. If a computer program ever encounters a situation that its designer did not anticipate, then the result is not usually pretty—a system crash at best, multiple loss of life at worst. This mundane fact is at the heart of our relationship with computers. It is so self-evident to the computer literate that it is rarely mentioned.

And yet it comes as a complete surprise to those encountering computers for the first time. For the most part, we are happy to accept computers as obedient, literal, unimaginative servants. For many applications (such as payroll processing), it is entirely acceptable. However, for an increasingly large number of applications, we require systems that can decide for themselves that they need to do in order to satisfy their design objectives. Such computer systems are known as agents.

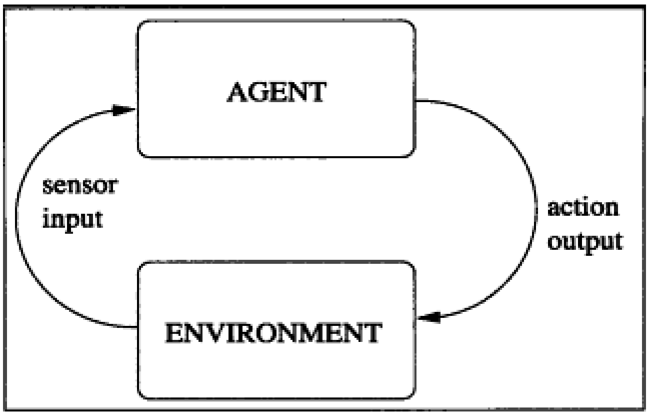

Figure 2: Intelligent Agent

Agents that must operate robustly in rapidly changing, unpredictable, or open environments, where there is a significant possibility that actions can fail are known as intelligent agents, or sometimes autonomous agents. Here are examples of recent application areas for intelligent agents:

- When a space probe makes its long flight from Earth to the outer planets, a ground crew is usually required to continually track its progress, and decide how to deal with unexpected eventualities. This is costly and, if decisions are required quickly, it is simply not practicable. For these reasons, organisations like NASA are seriously investigating the possibility of making probes more autonomous— giving them richer decision making capabilities and responsibilities.
- Searching the Internet for the answer to a specific query can be a long and tedious process. So, why not allow a computer program—an agent—do searches for us? The agent would typically be given a query that would require synthesising pieces of information from various different Internet information sources. Failure would occur when a particular resource was unavailable, (perhaps due to network failure), or where results could not be obtained.

The multi-agent system (M.A.S.) is a computerized system composed of multiple interacting intelligent agents within an environment. Multi-agent systems can be used to solve problems that are difficult or impossible for an individual agent or a monolithic system to solve. Intelligence may include as given below:

- some methodic,
- functional,
- procedural or algorithmic search,
- find and
- processing approach.

Although there is considerable overlap, a multi-agent system is not always the same as an agent-based model (ABM). The goal of an ABM is to search for explanatory insight into the collective behavior of agents (which don't necessarily need to be "intelligent") obeying simple rules, typically in natural systems, rather than in solving specific practical or engineering problems. The terminology of ABM tends to be used more often in the sciences, and MAS in engineering and technology.

Agents communicate in order to achieve better the goals of themselves or of the society/system in which they exist. Note that the goals might or might not be known to the agents explicitly, depending on whether or not the agents are goalbased. Communication can enable the agents to coordinate their actions and behavior, resulting in systems that are more coherent.

Coordination is a property of a system of agents performing some activity in a shared environment. The degree of coordination is the extent to which they avoid extraneous activity by reducing resource contention, avoiding livelock and deadlock, and maintaining applicable safety conditions. Cooperation is coordination among nonantagonistic agents, while negotiation is coordination among competitive or simply self-interested agents. Typically, to cooperate successfully, each agent must maintain a model of the other agents, and also develop a model of future interactions. This presupposes sociability.

IV. MULTI-AGENT SYSTEM BASED SUPPLY CHAIN SYSTEM

A multi-agent approach is applied for designing the system in order to deal with the complexity of the domain and to provide flexibility regarding the system architecture. Indeed, agent technology has become the most popular tool for designing distributed SCM systems as it provides an adaptable and dynamic way for managing separate links within the chain.

Unlike centralised approaches, agent-based SCM systems can respond quickly to changes and disturbances (either internal or external) through local decision making. Another advantage of designing the SCM solution as a multi-agent system (MAS) is that it allows different tasks within the SCM to be separated and explored both independently and in relation to each other. This feature is particularly important for the project presented in the thesis, as the research is mainly focused on one side of the supply chain, namely, its demand part, which deals with selling products to customers. The main problem which sellers are facing when managing their supply chains is of deciding on the details of offers to be made to customers: which prices to set, how many items, when and to whom to sell in order to increase profit, and when to sell available stocks without being penalized for late deliveries at the same time. The ability to predict market prices is crucial for developing better selling strategies. The task is not easy to solve in the context of e-Commerce, where prices are established dynamically. Using the principles of the MAS, this problem is studied in the thesis: a number of predictive models are deployed in the Demand agents of the MAS, and their effect on the behaviour of other internal agents as well as the whole system is investigated. The principles of the multi-agent approach help to meet the requirements of SCM in the following way:

- **Distributed**: The functions of SCM are divided among a set of separate, asynchronous software agents.
- **Dynamic**: Each agent performs its functions asynchronously as required, as opposed to in a batch or periodic mode.
- **Intelligent**: Each agent is an "expert" in its function; it uses artificial intelligence and operations research problem-solving methods.
- **Integrated**: Each agent is aware of and can access the functional capabilities of other agents.
- **Responsive**: Each agent is able to ask for information and/or a decision from another agent - each agent is both a client and a server.
- **Reactive**: Each agent is able to respond to events as they occur, modifying its behaviour as required, as opposed to responding in a pre-planned, rigid, batch manner.

- **Cooperative**: Each agent can cooperate with other agents in finding a solution to a problem - that is, they do not act independently.
- **Interactive**: Each agent may work with people to solve a problem.
- **Anytime**: No matter how much time is available, an agent is able to respond to a request, but the quality of the response is proportional to the time given to respond.
- **Complete**: The total functionality of the agents must span the range of functions required to manage the supply chain.
- **Reconfigurable**: The SCM system itself must be adaptable and must support the "relevant subset" of software agents.
- **General**: Each agent must be adaptable to as broad a set of domains as possible.
- **Adaptable**: Agents need to quickly adapt to the changing needs of the human organization. For example, adding a resource or changing inventory policy should be quick and easy for the user to do.
- **Backwards Compatible**: Agents need to have a seamless upgrade path so that the release of new or changed features does not compromise existing integration or functionality.

Various type of hybrid agent is used here which describe as below:

- **Demand Agent** used for handling the point-of-sale data and provide the information to central agent.

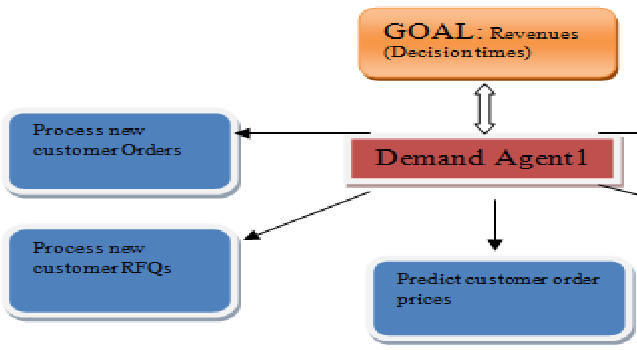

Figure 3: Demand Agent

- **Forecasting Agent** used for analysising the market and upcoming trends and up and down and gives a optimistic forecasting values.

Figure 4: Forecasting Agent

- **Supply Agent** used for sequencing and handling the order data with high managing skills and control supply for the manufacturing process.

Figure 5: Supply Agent

- **Delivery Agent** used for studying everyday price of market and mention the peak high and deliver the product below the price in day and their reasons and provide this information to central agent

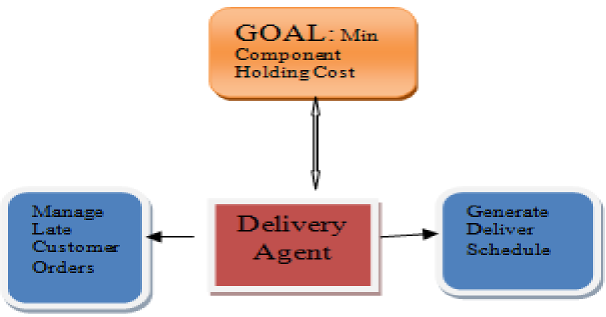

Figure 6: Delivery Agent

- **Stock Control Agent (SCA)** used for handling the stock and control each steps of stocking related to market demand and up- down, and all these work done by sharing the information to central agent.

- **Inventory Agent (IA)** used for handling the inventory control system.

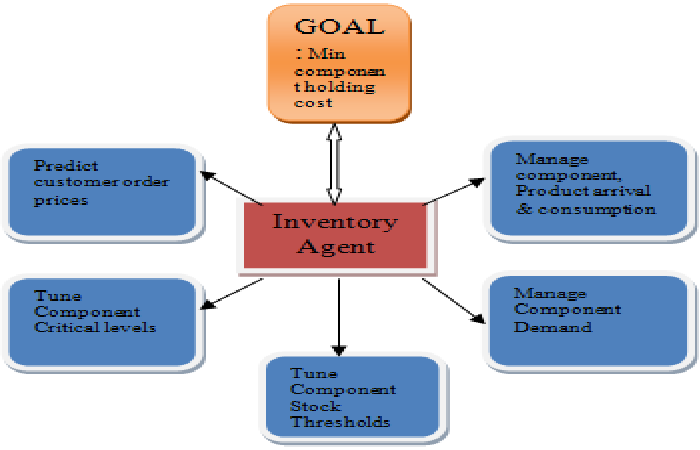

Figure 7: Inventory Agent

- **Central Information Managing Agent (CIMA)** used for sharing the information from all the agent and provide the information which is required for particular agent.
- **Production Agent (PA)** used for handling the production of the product which is related to supply chain agent, because production low and high demand also cause the bullwhip.

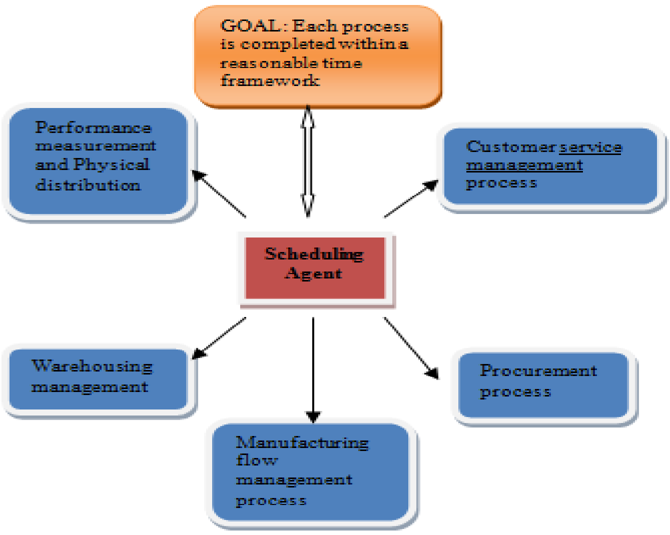

Figure 8: Scheduling Agent

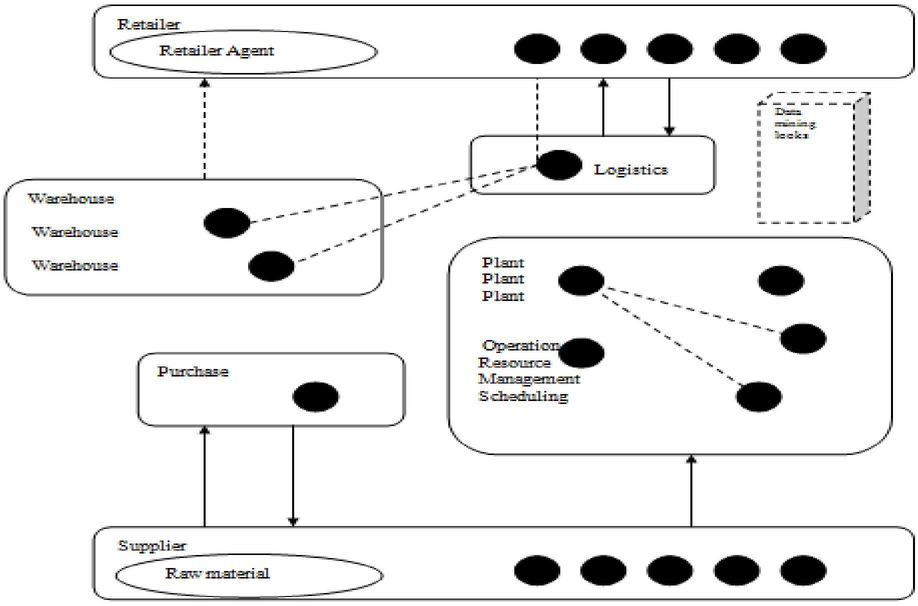

Figure 9: MAS based SCM system

V. BULLWHIP EFFECT REDUCTION

Supply Chain encompasses all those activities needed to design, manufacture and deliver a product or service needs a mechanism or frame work for information sharing. Agent-based manufacturing is a new way of thinking about and applying information. With this idea an effort is made to provide a multi agent system model for the supply chain management in order to reduce the bull whip effect. Basic interface is given below:

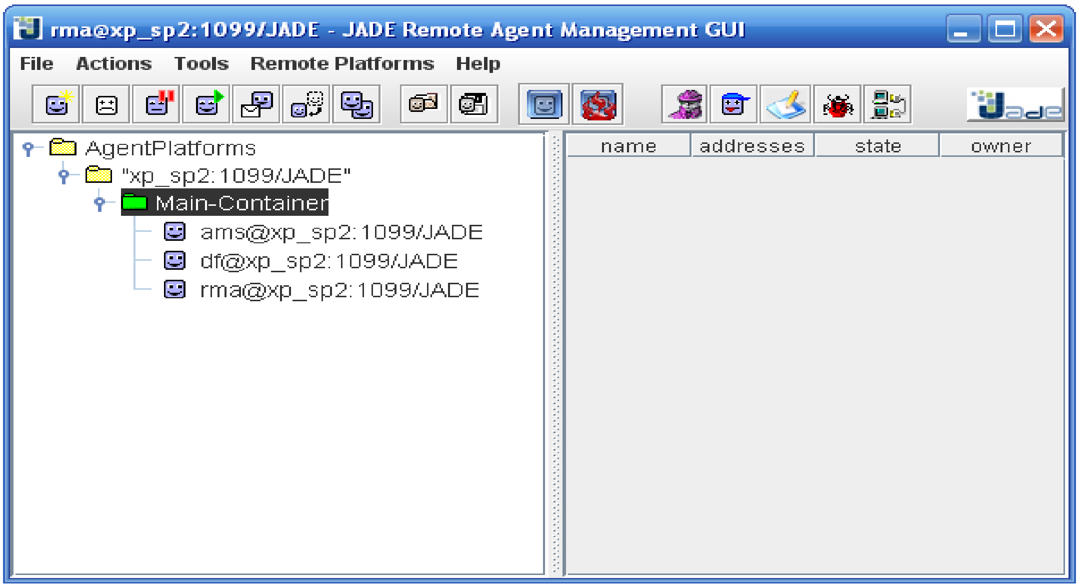

Figure 10 GUI of the JADE RMA

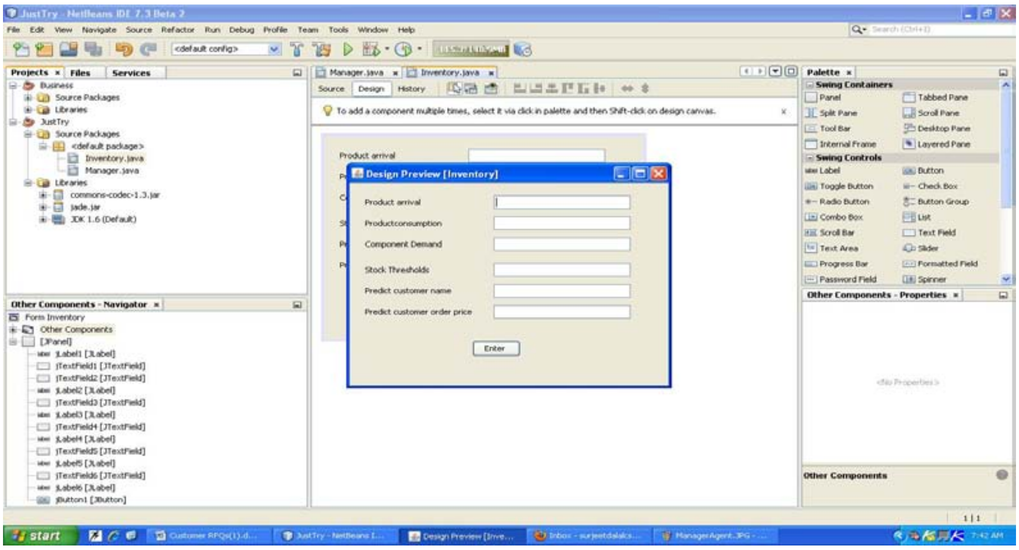

Fig 11:- Manger Agent

In the proposed model (bull whip effect model) each agent performs a specific function of the organization and share the information with information agent. There by the most important requirement of successful supply chain i.e information sharing is achieved besides controlling the demand-supply trouble in the proposed model. In the current work a part of the model related to control agent is designed and it may be the first ever such system to reduce the bull whip effect

VI. CONCLUSION

Supply Chain networks are multi stage complex dynamical systems consist of various involved organizations performing different processes and activities in each and consequent stages which are connected through upstream and downstream linkages to produce value in the form of products and services Demand forecasting and decision making processes are among the key activities which directly affect the performance of this complex systems. The variability of the demand information between the stages of Supply Chain networks and the increase in this variability as the demand data moves upstream from the customer to the consequent stages which cause the bull whip, and there are lot of buff whip calling factor is available in supply chain, so control these factor proposed multi-agents are being designed, and it control very effectively and reduce the bull whip in the supply chain networks

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