Agent Based Solution for Retail Supply Chain Management

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***Abstract*: The entities engaged in the supply chains have become more complex with the expansion of the businesses. Therefore people have used various processes to make the business processes efficient, cost effective and real time. Thus Supply chains have become a main channel of business processes. Supply chain management involves in planning and management of those parties engaged in the chain. Therefore as an intermediary, the retailers' involvement in the supply chains increases the efficiency of the chain. However many problems have been identified in the retail supply chain scenarios such as distribution, distribution strategy, negotiation, communication etc. Due to these problems managing retail supply chains has become a complex problem.**

As a solution, the project implements INSITH, a multi agent system (MAS) which assists in the customer order placing process by choosing the most suitable offer for a particular user. The system uses dynamic intelligent agents; namely, Message Agent, Retailer Agent, Supplier Agent and User Profiler Agent to handle customer requests and provide the best offer by going through various agent negotiation processes. Hence INSITH would be sensitive to the user preferences and will provide solutions based on user experiences and the cost.

1. INTRODUCTION

The retail supply chains consist of suppliers, customers, warehouses, transportation and logistics [7]. The item flow from supplier to customer and information flow from customer to supplier happen through the retailers. Therefore the retailers play a major role in retail supply chains. Further the behavior of a retailer in the business scenario is unpredictable and real time. Therefore in the today's context meeting customer requirements at the given time is a great problem faced by many suppliers. Once the items are ordered the process of delivering the items to the customer involves many complex steps [16]. This process of delivering items to the customer, after sales services, reverse flows such as returning damaged items back to the supplier and handling customer complaints altogether makes the retail supply chain more complex [4]. In each and every step the collaboration of all the components in this chain is highly important to efficiently manage the retail supply process [15, 3].

Nevertheless this process happens in the batch mode. Thus it takes a long time to fulfill the customers' requirements and the supplier fails to deliver items on time. Therefore the supply chain processes have to be highly efficient and need to provide the necessary flexibility to be able to react to short-term changes of the customer demand and unforeseen events during fulfillment [2]. Even though the existing manufacturing software is being used to achieve the expected goals of Supply chains, they have a serious limitation due to the cost of initial investment and resistance to change to new technologies [12]. At the same time they have a serious limitation when it comes to real time processing and forecasting [6]. The reduced negotiation between relevant entities make this process more complicated with the existing supply chain systems. Furthermore they have become inherently complex as each and every component in the chain behaves separately yet try to achieve a common gall [17]. Due to that complexity, the cost incurred in the supply chains has increased a lot. On the other hand the failure in one process has a huge impact on the other processes as they are happening in batch mode [13]. At the same time the customer dissatisfaction could increase a lot due to the supplier failing to meet customer requirements on time with the expected quality. Therefore an agent based approach is suitable for handling this kind of situation [4, 8, 14, 1]. Further it was identified that through proper communication among entities engaged in the retail supply chain the retailers and suppliers can behave more efficiently and meaningfully.

The aim of the proposed solution;INSITH, was to develop a centralized interactive and adaptable system for real time processing of supply chains using the multi-agent technology [9]. INSITH has four agents; namely, Customer agent, Retailer agent, Message agent and Supplier agent who emerge when the request occurs and die when the work finishes. INSITH identifies different scenarios based on the complexity of the transaction and come up with a priority order accordingly.

The rest of the paper is organized as follows. Section two depicts others' work and section three describes the usage of agent technology in effective retail supply chain management (SCM). Section four deals with the design and section five describes implementation approach of the system.

The following section deals with the way INSITH works and section seven describes the implementation approach of INSITH. The conclusion and further work are described in the final section.

2. CURRENT APPROACHES TO EFFICIENT RETAIL SUPPLY CHAIN MANAEMENT

Over the last decade, researchers have introduced various approaches to Retail supply chain management. Cluster approach, hybrid agent based model, trading agents and multi-agent decision support systems are some of them.

2.1. Cluster approach

This research builds an agent-based model to examine retailers' location choice. Here retailers' aim is to maximize profits by changing locations. Two categories of factors impact retailers' decision-making. One is the distance to suppliers, and the other is the distance to markets [5]. This model reveals that clusters emerge, and retailers double up on supplier locations as the number of retailers ascends to a certain number. When more partake in this game, the size of each cluster increases, and cluster density decreases. In this model, retailers directly purchase goods from suppliers and sell them to consumers. It is assumed that players locate in a circular city comprised of discrete locations. The retailers' revenues come from selling products to consumers. Retailers' costs include purchasing cost and shipping cost of products. Retailers' location choice depends not only on their distance to the market, but also on their distance to suppliers. This research thus finds that the centripetal force attracts retailers to supplier locations.

2.2. Hybrid agent-based model to model Petrol market

This is another agent framework based model that uses hybrid agent-based model to a model Petrol retail market [4]. This model was constructed and experiments were conducted to determine whether the trends and patterns of the retail petrol market could be replicated.

Individual petrol stations were created as agent-objects and supplied with knowledge of their initial starting price, production costs, and the prices of those stations within their neighborhood. The prices are either set with real data or idealized data depending on whether the systems are being used to examine real or abstract dynamics. Each agent views the prices of neighboring stations and applies a series of rules to adjust its own prices. Thus the model is shown to reproduce the spatial patterns seen in the real market, as well as well known behaviors of the market.

2.3. Using agent negotiation for effective communication

Another approach can be identified as the use of agent negotiation for effective communication in the supply chain. This framework consists of two types of agents called functional agents and information agents. These agents are usually owned by different companies and are therefore assumed to be self-interested and thus free to join, remain in or leave the supply chain system [18]. Information agents are predefined in the system and help functional agents to find potential negotiation partners or provide other common services such as accepting the registration from a functional agent. All of the negotiating agents have some understanding of system ontology and use a certain Agent Communication Language (ACL) to make conversation.

In the framework, There are no centralized super-agents or distributed mediators to handle the agent cooperation. All these activities occur through negotiation processes, regardless of whether two sides are involved in bargaining for some goods intentionally or de-committing a contract caused by the outside events.

2.4. Implementing trading agents

There are many agent based approaches for SCM by considering it as a game between competing entities for resources. For example the purpose of the KrokodilAgent is to explore how to maximize profit, given the conditions that dominate on the PC market [11]. This has six agents and has its own PC manufacturing companies. The agents are competing in two different markets. On the first market agents compete by buying raw materials necessary to produce personal computers. On the second market the agents are trying to sell all the PCs they produced to customers and at the same time earn as much money as possible. The winner is the agent with the highest bank account at the end of the game. It is also important to establish how the changes during the game effect the game outcome. To play in this game an agent has to connect to the game server. The server has multiple functionalities; it simulates customers and suppliers, controls agent's factory and warehouse and runs the bank.

2.5. Multi-Agent Decision Support System

Another approach for efficient SCM is a decision support agent for SCM scenario [10]. The key idea behind the project is to serve the organizations which deal with a number of activities, such as procurement, production, warehouse management, selling, marketing, and customer services among others, while running a business. To help them to manage these activities, organizations try to automate their business processes. Usually, independent software and hardware solutions are used for each of the activities. However in practice,

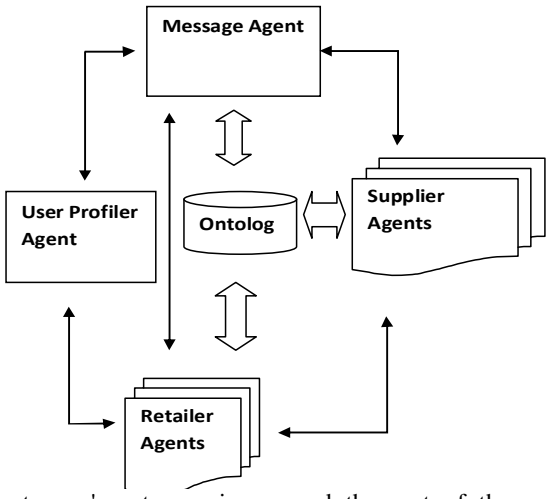
all the activities are highly connected and interdependent.

Since the tasks involved in supply chains are more complex, the aim of the project is mainly focused on the demand part of the supply chain. The expected findings not only can improve a company's performance while running its supply chains, but could also be applied to financial markets and online auctions where the task of predicting winnings and bidding prices is important.

Even though there are various approaches being used, they have failed in efficient modeling of supply chains. Each approach takes the retail supply chain as one scenario and does not take its complexity in to consideration. Therefore it is necessary to identify the various scenarios of the retail supply chains and react to those scenarios in a different manner.

3. APPROACH: MAS FOR TASK BASED MODELING IN SCM

The project implements an agent based retail supply chain to make the processes of the supply chain more effective and efficient. The agent based system makes its processes real time and cost effective. Once the customer places an order, the retailer agents are created. The retailer agents are trying to show their offers and try to compete with the other agents. In this case the most suitable and effective offer will be selected based on the customers' past experiences and the cost of the offer.



Once the customer places an order, the User Profiler identifies him and retailer agents see it through the message space and check whether they can serve the request. If they have enough stocks and they can serve the request, they immediately pop up their agents and send messages to the message space. All the retailer agents can read the message space. Therefore they can compare their offers with others and check the possibility of their survival in the market. If their offers are high compared to others, they can either reduce the prices or move from that market to another. Other agents can analyze the best profit making business and adjust their strategies to acquire the target market. Each and every transaction happens in the market is recorded in to the ontology in a structured manner so that, later the knowledge gained through the past experiences can be useful. In any case, if the retailers do not have enough stocks with them, they have to go for suppliers. The supplier choosing procedure is as same as the process mentioned above. Here the crucial factors are the time of delivery, past experiences and the cost. There may be some trade-offs depending on the scenario.

Compared to other approaches, there are many advantages of INSITH,such as low cost, reduced time, collaborative decision making on behalf of the user and just in time solutions.

4. DESIGN

INSITH consists of four types of agents namely; User Profiler agent, Retailer agent, Message agent and Supplier agent. Ontology is used as the knowledge base to store communication details of the agents. The high level communication between the entities is described in the Figure 1.

4.1 Agent Implementation

The four agents were implemented in the best way they can negotiate with other agents effectively. As the whole process operates based on the communication between entities, the message agent is playing a key role in this process.

4.1.1 User Profiler Agent

The User Profiler agent is the agent who keeps details of the customers who place orders to the system. There may be many or few customers depending on the situation. Once they place an order, the message is sent to the message space. The user Profiler agents continuously read the message space to see the offers from the retailers. When they see the offers, if they are satisfied with the prices they will buy the items. If they are not satisfied with the offers they will place the order again.

4.1.2 Retailer Agent

Retailer agent keeps listening to the requests coming from customers and creates agents automatically. When customers ask for items, the retailer agents appear with their offers. For example, if the customer requests 5 televisions of the type SONY, there may be many retailers who are having SONY televisions. But their prices may vary according to the services they provide. Therefore, the best retailer may be selected based on their prices and the customers past experiences.

In that case even though many retailers appear, in order to provide the items, only one retailer would be selected by the retailer agent based on the above criteria. In any case if a customer is not satisfied with the current retailer the retailer agents will again work collaboratively to find a different retailer for the customer. Here the retailers can market their items. They can offer special discounts to customers who are buying many items.

4.1.3 Supplier agent

They work as the suppliers or manufacturers who produce and supply items. Whenever a request comes from retailer agents the supplier agents should immediately react to the situation. Producing the items which match the exact requirements of the customers is a major challenge they undergo. Sometimes the suppliers may not have enough stocks. Then they have to negotiate between suppliers to fulfill the order. If the retailer is asking for 200 televisions and Supplier agent is having only 100 items then he has to negotiate with the other suppliers in order to get the rest. So that there will not be any delays of delivery to the retailer. Thus the negotiation between the suppliers makes this process more efficient

4.1.4 Message Agent

Message agent handles the overall communication among entities. Once the customers place an order, the message agent sends it to the message board. Thus through the message board all the agents can view others' status. So Message agents provide good analytical details for retailers and suppliers. Therefore, they can adjust their offers according to market trends and come up with new offers based on the market situation.

4.2 Agent Communication

There are many possible scenarios that could occur in a Retail supply chain. The main entities involved in the process are retailers, customers and suppliers. Once the customer places an order, the retailers would be activated and if there is a matching offer, the Retailer agent would show it to the customer. But this scenario may be complex in some situations. It is possible for many retailers to offer the same offers and then the retailer agent has to identify the best suitable offer for the customer. Further the items that a customer requests may not be with the retailers. Then the retailers have to request the items from the suppliers and further if many suppliers appear at the same time the retailer would have to decide which supplier to select. Therefore, INSITH provides a priority order for each supplier with comparison to the requests from the retailers. The User profiler Agent is able to identify the behaviors of all the retailers and suppliers. Thus, by going through the information from the User Profiler, Retailer agent is able to provide an appropriate supplier order for each retailer request. The communication process of the agents is depicted in figure 2.

When a user logs into INSITH, the user profiler identifies the user and provides the related information which enables the retailer agents to identify the behavior of a particular user. It identifies the user as a retailer or supplier and provides information accordingly. Then the discussion between the retailers and suppliers occurs through the message space. And once it is successful and the order is satisfied and when it is not satisfied they go for alternatives and other options.

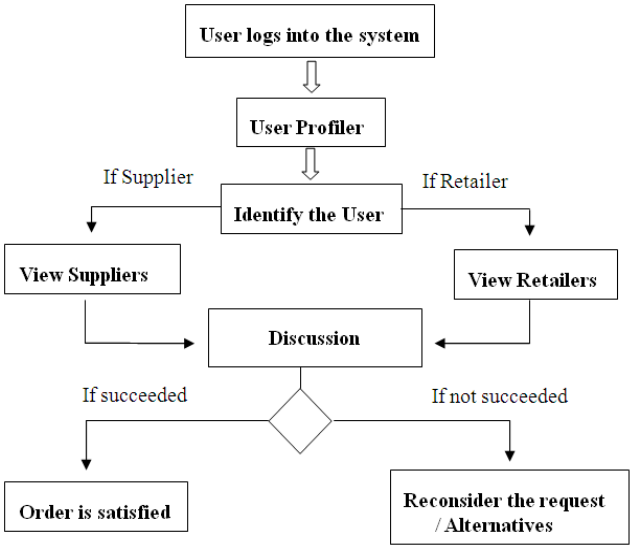


Fig 2: Work flow order of INSITH

Once a customer places an order, the retailer agent will see the order through the message space. Then a retailer would be activated and checks whether he has enough stocks to fulfill the requirement. If many retailers are ready to fulfill the customers' request the retailer agent has to decide which retailer to choose. Here the negotiation among suppliers takes place.

For example, if a retailer places an order asking for 200 computers the supplier agent is activated and checked for the available suppliers. If there is only one supplier for that item and he has enough stocks the retailer can buy from that supplier. In a situation where the supplier does not have enough stocks, the retailer has to look for alternatives. Further complexity increases when the retailer is requesting many types of items at the same time. If the retailer is requesting 200 computers from the supplier and if one supplier fails to deliver the whole amount two suppliers can collaboratively satisfy the offer. Thus when the retailer is requesting many types of items many suppliers can collaborate to fulfill his requirement

4.3 Managing the priority order

The priority order is maintained by providing a relative weight for each supplier for each retailer's requests. INSITH allows users to specify the item information such as lead time, amount, number of items, expected quality and type of item etc. Further, it keeps the relationship between each retailer and supplier. The history information is maintained by tracking how many times a particular supplier has rejected a particular user or item and how many times they have done transactions.

Thus INSITH allocates a relative weight for each parameter and the total weight is measured using the total of all the relative weights. Further, INSITH considers the complexity of the scenario. The selection criterion differs according to the number of retailers and suppliers available.

5. IMPLEMENTATION

The agents have been developed using Java Agent Development Environment (JADE). JADE is implemented according to the FIPA specification and therefore as jade has been used as the programming platform the agents are also implemented according to the FIPA specification. FIPA specifies three major concerns for developing agents. Those are agent communication, agent management and agent message transport. Here each agent has been implemented as a separate java class. Their behaviors are defined within the class scope. The communication methods are implemented in the message agent.

5.1. Agent Negotiation

The whole process happens through the agent negotiation. The agent negotiation is implemented in a way similar to the real world. With relation to real world retail supply chains there are many retailers who are engaged. They have their own prices and they are willing to negotiate and reduce prices and change their offers according to requests. Some retailers are giving discounts when they feel they are having excess stocks or demand decreases. Retailers are interested in regular customers and try their best to keep them satisfied. Sometimes it may be profitable for retailers to interact with the customers who are buying large stocks and in such scenarios they may ignore small requests. Further if others offers are low cost and if one cannot exist in the market they will disappear or change their prices to match the current market conditions. Therefore at the retailer agent negotiation stage, each retailer agent is given a weight according to his preferences to indicate its strength to match a particular request. Parameters like type of request, expected quality, distance to market and user buying history, number of items, item type and cost of items are considered in defining the weight. The weight is defined with a request. Therefore same agent may have different weightings for different requests. The most appropriate agent for each request is given the highest priority while others are given less weights. So the agents who are given the highest weight value will prompt to serve the request. Thus the wight allocation is done according to the best supplier measuring algorithm.

5.2. Best supplier measuring

Quantifiable parameters such as number of items, item type, lead time, cost of items, distance to market and non-quantifiable parameters such as type of request, quality, and user buying history are considered in defining a weight. The non quantifiable parameters are measured with an index value. The weight of a supplier is created with a request. All suppliers are given a specific value for each parameter with comparison to the retailers request and the total of parameter value is considered as the total weight of that particular supplier. Therefore same agent may have different weightings for different requests. The best supplier measuring algorithm is depicted in figure 3. The most appropriate agent for each request is given the priority value 1 while others are given 0. So the agents who are given priority value 1 will be given first priority and prompt to serve the request. The priority allocation for the requests is done using the following algorithm (figure 3).

```
int totalMark, supplierQuality, retailerQuality, supplierPrice, retailerPrice, supplierLeadTime, retailerLeadTime, supplierAmount, retailerAmount,numberOfTimesRetailerRejectSupplier,numberOfSuppliers,
numberOfTimesRetailerBuyFromSupplier;
String bestSupplier;
if (retailerLeadTime == supplierLeadTime) then
        totalTotalMark += 100;
else if ((supplierLeadTime - retailerLeadTime)==1) then
        totalMark += 75;
else if ((supplierLeadTime - retailerLeadTime)==2)  then
        totalMark += 25;
else if ((retailerLeadTime - supplierLeadTime)==1) then
        totalMark += 80;
else if ((retailerLeadTime - supplierLeadTime)==2) then
        totalMark += 50;
if (supplierAmount == 0) then   totalMark -= 200;
else if ((supplierAmount - retailerAmount) < 200) then
        totalMark += 100;
else if (((supplierAmount -retailerAmount)<1000)&&
      (supplierAmount - retailerAmount)  > 200) then totalMark += 75;
else if ((supplierAmount - retailerAmount)>1000) then totalMark += 25;
if ((retailerPrice - supplierPrice) < 500) then   totalMark += 100;
else if (((retailerPrice - supplierPrice) > 500) && (RetP-SupP) < 1000) then  totalMark +=25;
else if ((retailerPrice - supplierPrice) > 1000) then totalMark +=75;
else if ((supplierPrice - retailerPrice) > 1000) then totalMark +=0;
else totalMark += 10;
```

```
for numberOfTimesRetailerBuyFromSupplier totalMark += 20;
for numberOfTimesRetailerRejectSupplier totalMark -+= 20;
for numberOfSuppliers bestSupplier = max (numberOfSuppliers)
```

Fig 3: best supplier measuring algorithm

In the algorithm for each scenario, each retailer is given a weight. If the suppliers cost of item exceeds the retailers expected value of the same item, in such scenarios it is unlikely that they will do a transaction. Further if they haven't done transactions before, INSITH provides a low priority for the particular supplier to satisfy that retailer. But the same supplier may give a higher priority when doing transactions with another retailer. The algorithm provides a low priority for the new comers with comparison to the experienced suppliers and retailers. Therefore, with the time, the new comers may also lead in the market. More importantly if a supplier is providing high cost items with low quality and with a delay of supply, no retailers will go for that particular supplier. Then they will be given a low priority and they will vanish from the negotiation process while more reasonable and effective agents will remain there.

6. HOW INSITH WORKS

When a user logs in, the system identifies the user as a retailer, supplier or a customer through their log in information. Then he will be given the available offers, offered by various retailers and suppliers. This information is filtered by the message agent based on the users' preferences and recent activities. For example Retailer A wants to buy 10 SONY Televisions with the cost of Rs. 12,000. So the Retailer A is prompted with the available Suppliers who are offering SONY televisions with the price close to the retailer's request. The Supplier agents are waiting for the requests from the retailers and try to sell goods to them. Here the suppliers are competing with retailers and the retailers are also competing for suppliers. Thus the best solution emerges as an emergent property of the agent negotiation process.

Agent negotiation results depend on the parameters it passes and the content it has absorbed previously. For example, Retailer agents will look for sellers considering factors such as price, quantity, quality level, past transactions and relationships (INSITH will give a weight based on the customer satisfaction), lead time (time taken to deliver goods from the date of ordering), the extent to which the order quantity matches with the Economic Order Quantity, and taxation transportation and other expenses. More importantly, customers can prioritize the above mentioned requirements. Then Retailer agent will look for the sellers who match with the mentioned parameter. For example, one customer may want to purchase the cheapest car irrespective of the quality. In order to execute this request Retail agent will move through all the archives to find the lowest offer. Mean time if the customer requires a quality product, then Retailer agent will take quality as a parameter too.

7. CONCLUSION

At the moment the project has been concentrated on retail market where few customers and retailers are available. But later this study can be expanded to handle huge SCM environments having thousands of customers, retailers, wholesalers and suppliers. Furthermore, features like warehouse management, procurement management, logistics management also can be added.

When the businesses grow the business transactions occur in them would be much complex. There would be thousands of records stored in the ontology. Data processing would be much more complex and as a result knowledge base will expand heavily. But with the use of agent technology users will be able to work in such environments efficiently. As discussed throughout the report, the adapted approach is more users specific and based on agent technology. When compared with other systems this has a unique feature being able to adjusted itself to different scenarios. Further the system can be updated with new diverse agents.

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