# Intelligent System for Customer Oriented Design and Supply Chain Management

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***Abstract*—Due to the intensely increasing individualized and rapidly changing demand in global market, customer oriented design has been the top priority for modern enterprises to quickly respond to the volatile personalized requirements. This leads to the great change of mass customization in supply chain management, in which the agility, efficiency and cost have become the main impediment to improve supply chain's performance. In this paper, we first propose a new method of adaptive clustering for the orientation and analysis of target customers that is originally inspired from the swarm intelligence of ant colony, then the recommendation system for the design of LCD-TV is illustrated that applied by this method to test the validity of the algorithm. After that, we present a supply chain management based on mobile agents to satisfy the customization, especially, detailed description of the agent-based supply chain process is also expounded. Finally, an integrated intelligent system to support the customer oriented design as well as its supply chain management is discussed.**

***Index Terms*—Supply Chain Management (SCM), Consumer Oriented Design, Adaptive Clustering, Swarm Intelligence**

## I. INTRODUCTION

Customer oriented product design has become the top priority for modern enterprises to quickly meet the personalized and diversified requirements in the increasingly fierce competition environment. For better conduct customer oriented product design, the analysis of target customers' behavioral patterns and characteristics is particularly important. The rapid increase in customer data leads to the urgent demand for an effective analysis method, thus the continuously developing and improving technology of clustering appears, which provides the powerful solution in data processing to mine valuable information for decision support, such as data mining, knowledge discovery, and customer analysis[1]-[3]. From the technical point of view, customer classification can be divided into qualitative and quantitative method. Qualitative classification method is from the empirical survey or existed experience, through logical analysis to classify customers. However, the demands, experience and interests of customers may be dynamically changing, which bring the difficulties in describing their consistent behaviors [4][5]. While quantitative classification analysis is based on data mining technology with data collecting, processing, and analyzing by statistic information to classify the customers. The main currently used methods are decision tree, Bayesian method, cluster analysis, neural network classification method and association rule based classifier, etc. Among these methods, clustering analysis can effectively classify user groups by different features and attributes, and it is a kind of typical combinatorial optimization problems by using mathematical method to study the given object. So, it is necessary to seek dynamically adaptive technology of current cluster analysis in customer oriented product design system.

Theoretical studies have proposed a variety of clustering algorithm. For the cluster analysis algorithm will directly affect the clustering results, swarm intelligence has been introduced to the algorithm of clustering problem in recent years [6]-[8]. Swarm intelligence concept originates from observed sociality of nature insect, ants, and fishes groups, where those simple and unintelligent gregarious creatures demonstrate macroscopic intelligent behavior through negotiation [9]. The algorithm has successfully applied to a standard machine learning database clustering analysis [10]. Swarm intelligence shows the characteristics such as flexibility, robustness, decentralization and self-organization [11].

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Many tests show that ant colony clustering algorithm can provide fast, accurate and effective solution for current problems in clustering algorithm [12]. Ant colony algorithm is actually a kind of intelligent multi-agent system, the self-organization mechanism enable the ant colony algorithm does not need to have detailed understanding of all the issues that are involved. Self-organization is essentially the dynamic process that the system entropy increase by ant colony algorithm mechanism without external effect, reflects the dynamic evolution from disorder to order. Many researchers have made a series of improvement and extension on this algorithm [13]. For example, some use mixed algorithm by performing ant colony clustering algorithm and K algorithm alternately [14]. Some applied ant colony clustering algorithm in image segment [15]. In this paper, we present a new method for the orientation and analysis of target customers. By using this method, the distribution of customer clusters and the related characteristics of each cluster as well as its included customers can be extracted dynamically and adaptively. Consequently, the proper strategy for customer oriented product design is easily established.

This paper is organized as follows: Section 2 presents adaptive clustering algorithm for customer oriented design. Section 3 describes intelligent system for supply chain management by using the clustering algorithm. Section 4 is the conclusion of this paper.

## II. Adaptive Clustering Algorithm For Customer Oriented Design

### A. Adaptive Clustering Algorithm

The inspiration of ant clustering algorithm was from the famous observation that 1500 dead ant bodies were carried and accumulated into some heaps by the ant colony alive [16].

After deep analysis of the ant behaviors in the clustering process, we had presented an improved algorithm with better performance than other algorithms in shrinkage rate and accuracy [13].

The algorithm pseudocode of our improved algorithm is designed as following [6]:

For every item $O_i$ do
Place $O_i$ randomly on grid
End For
For all ants do
Place ant at randomly selected site
End For
/* main loop */
For t=1 to $t_{\max}$ do
For all ants do
If ((ant unladed) and (site $S_j$ occupied by item $O_i$)) then
Compute the similarity $f(O_i)$ of $O_i$ in R×R area
Calculate the $p_p$ and generate a random number Q
If $p_p$ > Q then /*pick-up rule*/
Pick up item $O_i$
Remember the $f(O_i)$ and current position
Move the ant with the item $O_i$ to a random site
Else
Move the empty ant to a random site
End If
Else If ((agent carrying item $O_i$) and (site empty)) then
Compute the similarity $f(O_i)$ of $O_i$ in this place
Calculate the $p_d$ and generate a random number Q
If $p_d$ > Q then /* put-down rule*/
Drop item
End If
Move to a randomly selected neighboring site
End If
End For
If ((t > $0.5t_{\max}$) and (t meet the radius change condition)) then
Reduce the radius
Generate the clusters iteratively and calculate the cluster center
Unite the clusters with the same cluster center
Relocate the items with poor similarity
End If
End For
Print location of items /* export cluster result*/

This algorithm doesn't need to set the number of destined clusters in advance, so it can be automatic and adaptive in clustering analysis.

### B. Experiment Analysis

In this section LCD (Liquid Crystal Display)-TV has been widely used in families and public areas for various purposes, such as cable TV, advertising, and the extended screen of computer [17]. With the rapid development of electronic technology and design arts, the size, function, structure and shape of LCD-TV are diversified to meet with the changing requirements of different customers. By clustering analysis, we can find the different clusters of LCD-TV customer classified by their common preferences. From feedback data of LCD-TV customers processed by the clustering analysis based on swarm intelligence, we get the cluster result data. According to the characteristics and preferences of that cluster, the recommendation solution, including function design, shape design, and component selection, etc., are all provided to proper customer.

First, the collected customer behavior attribute data (may have several attributes) will be projected onto a two-dimensional plane, then the ants measure the group similarity of current object in local environment, and get picked up or down probability through conversion function, with which to get the final number of cluster centers after interaction. We obtained 68 valid samples and customer behavior parameter through the 150 questionnaire survey (the subjects are all existing customers), and Fig.1 is the attribute data of 68 customers, which are distributed in a two-dimension plane before cluster.

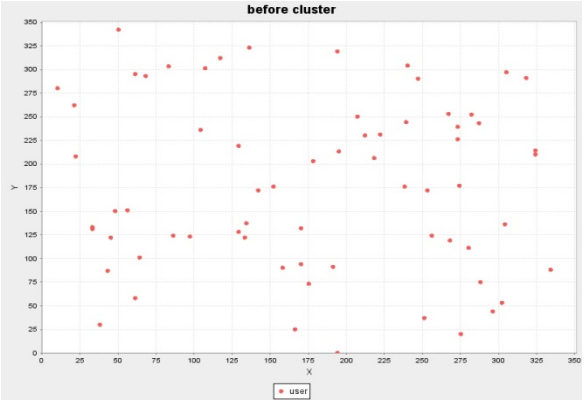


Figure1. Customer data.

Fig.2 is the clustered results of the above attribute data. In Fig.2, the ant number is 80, Parameters for the two-dimensional plane is 350 ×350, the iteration number is 100000, and the observation radius is in [2, 10] variable observation. We see that our algorithm can basically divide the customer aggregations, and classify the entire customer into 6 clusters [17].

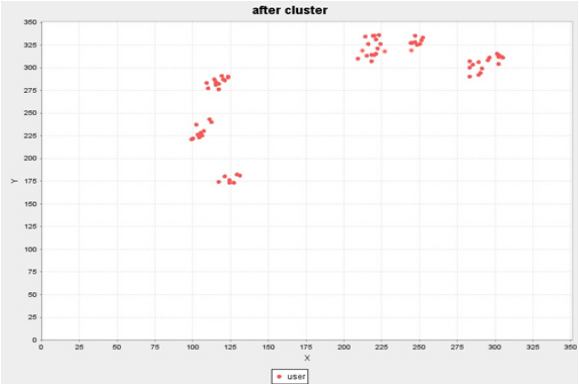


Figure2. Clustered results

The 6 cluster information is shown in table I. From those 6 clusters, we choose Cluster 6 as the example to analyze their preferences. Cluster 6 is the maximal cluster which contains 16 customers.

Cluster 1 contains 10 samples, with age between 31-40 years old, education level is under-graduate or above, a monthly income is between 6000-10000 yuan, most of them are department supervisor in the company. They pay more attention to product brand, design, quality, and process technology. These people are willing to accept manufacturers' regular service and products promotion through media, so that to timely obtain information.

Cluster 2 contains 7 samples, with age between 31-40 years old, a monthly income is between 6000-10000 yuan, and most of them are private owners and the civil servants. They care more about the product brand and quality to show their style and taste. The service and professional image of the manufacture are important to them.

TABLE I.
CLUSTERED RESULT LISTS

| Clusters | Size | Adjacent field X | Adjacent field Y |
|---|---|---|---|
| Cluster1 | 10 | (98,111) | (223,245) |
| Cluster2 | 7 | (116,130) | (175,184) |
| Cluster3 | 8 | (243,251) | (327,337) |
| Cluster4 | 13 | (108,122) | (278,293) |
| Cluster5 | 14 | (208,223) | (309,338) |
| Cluster6 | 16 | (282,304) | (292,317) |

Table I. shows the detailed information. Adjacent field X and adjacent field Y indicate the distributing section of the object on horizontal coordinate and vertical coordinate.

Cluster 3 contains 8 samples, with age between 31-40 years old, and a monthly income is between 3500-6000 yuan office workers. They care more about the quality images, product price and shape. They prefer to choose cost - effective product.

Cluster 4 contains 13 samples, with age below 20 years old, and most of them are female students. They prefer to choose product that cause little damage to the eyes and have good after-sale service.

Cluster 4 contains 13 samples, with age below 20 years old, and most of them are female students. They prefer to choose product that cause little damage to the eyes and have good after-sale service. Those in promotion products are their favorite.

Cluster 5 contains 14 samples, with age about 30 years old, and a monthly income is between 1500-3500 yuan office female workers. They care more about the quality images, product price .They prefer to choose discounted products.

Cluster 6 contains 16 samples, with age about 40 years old, and a monthly income is above 6000 yuan. Most of them are department heads in the company. They care more about the quality images and after sale service. They would like to choose the product that not very harmful to eyes. They will not change the product until it can't work.

From the above six cluster analysis, we find that the customer is very similar in many aspects of the same cluster, from which can take corresponding measures to each cluster after group behavior analysis. One of the distinct characteristics of LCD-TV customer is that their clusters may be dynamically changing, and their demand and interest are diversified. The above process has to be repeated after a certain period, in order to follow the customers' changes in their demand and interest. So the

product design can be adaptive to follow the new distribution of changed clusters.

Competition in today's market is no longer of company versus company but rather supply chain versus supply chain [19].With the development of information technology, single enterprise no longer have the ability to deal with the dynamical changing and customized demands in global market, so customer oriented Supply Chain Management (SCM) and its SCM-based alliance are becoming the main trend in business organization. After analyzing the customer behavior by adaptive clustering algorithm, we can establish an intelligent system of supply chain management for customer oriented design.

## III. Intelligent System For Supply Chain Management

### *A. System Requirements*

With the increasingly strict and changing demands of customers, the organization of SCM is usually required to be differential according to different orders in customer oriented supply chain management. So, the performance of SCM has become the determining factor to satisfy various demands with lowest cost. The primary objective of SCM is to provide suitable and efficient strategy to accomplish customers' needs through existed resources, including distribution capacity, inventory and labors. Fortunately, information technology, such as database, application software, server and communication network (include 3G network and internet), has been widely applied in SCM to improve its performance and efficiency, which has brought much convenience in information sharing and management. But there are still a lot of intelligent functions to be completed, for example, whether the system can actively negotiate and negotiate with each part, once it gets final decision whether can send feedback to hub automatically? The performance of SCM depends on the efficiency of complicated negotiation and integrated management in the whole of supply chain [20][21].

The requirement for the participation of manual intervention often influences directly supply chain cost and efficiency in the face of personal issues and changing situation brought about by the information interaction, negotiation and instant decisions. How to solve optimum utilization of resource under changing environment is worth studying problem in supply chain management. For this reason, we introduce the intelligent system for SCM.

### *B. System Design*

In this system, we will combine the workflow technology with Agent technology, and propose the supply chain workflow integration technology architecture based on Agent technology, which contains inter- enterprise package for the Web service workflow mechanism and Agent system workflow mechanism in enterprise.

The principle of Agent task scheduling is taking related parts (or functional parts) that provide different services as encapsulated Agent, then using Multi - agent negotiation approach to processing resources scheduling. We will employ Intelligent Agent technology and mobile Agent technology to explore novel autonomous information interaction mechanism and intelligent negotiation model.

Intelligent Agent will store previous information and knowledge that need manual intervention through machine learning in the Agent database or knowledge base, and design rules and constraints for the Agent, so that each intelligent Agent can be adaptive to take information interaction and intelligent negotiation independently.

In addition, mobile Agent will transmit problem to information system of each partner actively, and then feedback to the host system when it received relevant information or consultation results, and realize collecting, organizing, communicating and consulting process. Very little laborer required only when the existing information, knowledge and rules cannot solve the problem, only need a small amount of artificial activity. When the class after the settlement of the problem, once the problem solved, new rules will be set for the Agent in order to solve similar problems independently and automatically in the future.

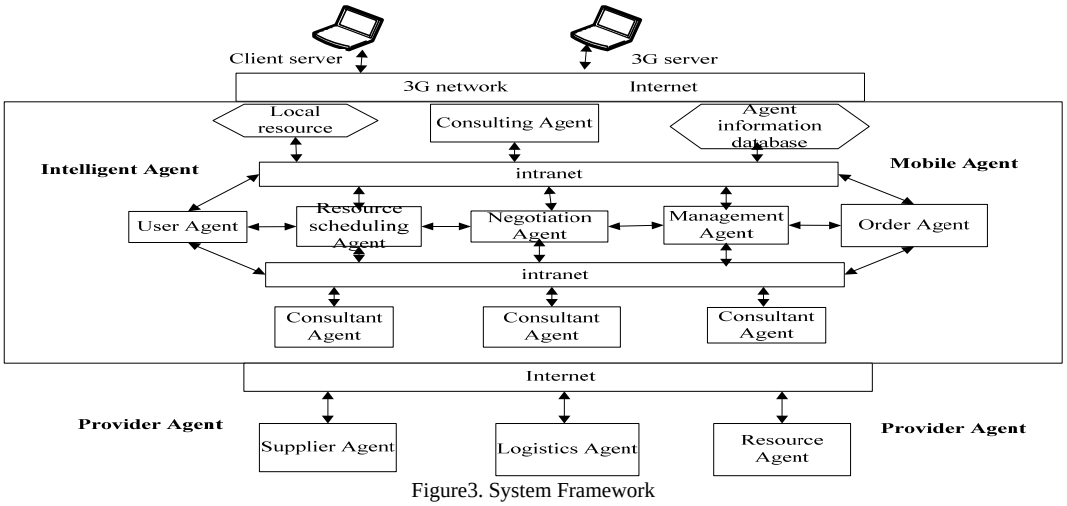


Figure3. System Framework

Fig.3 presents Agent-based supply chain process. At enterprise workflow integration level, as business services offered through the Agent proxy gateway package that registered as Web services, so the workflow use Web service to integrate.

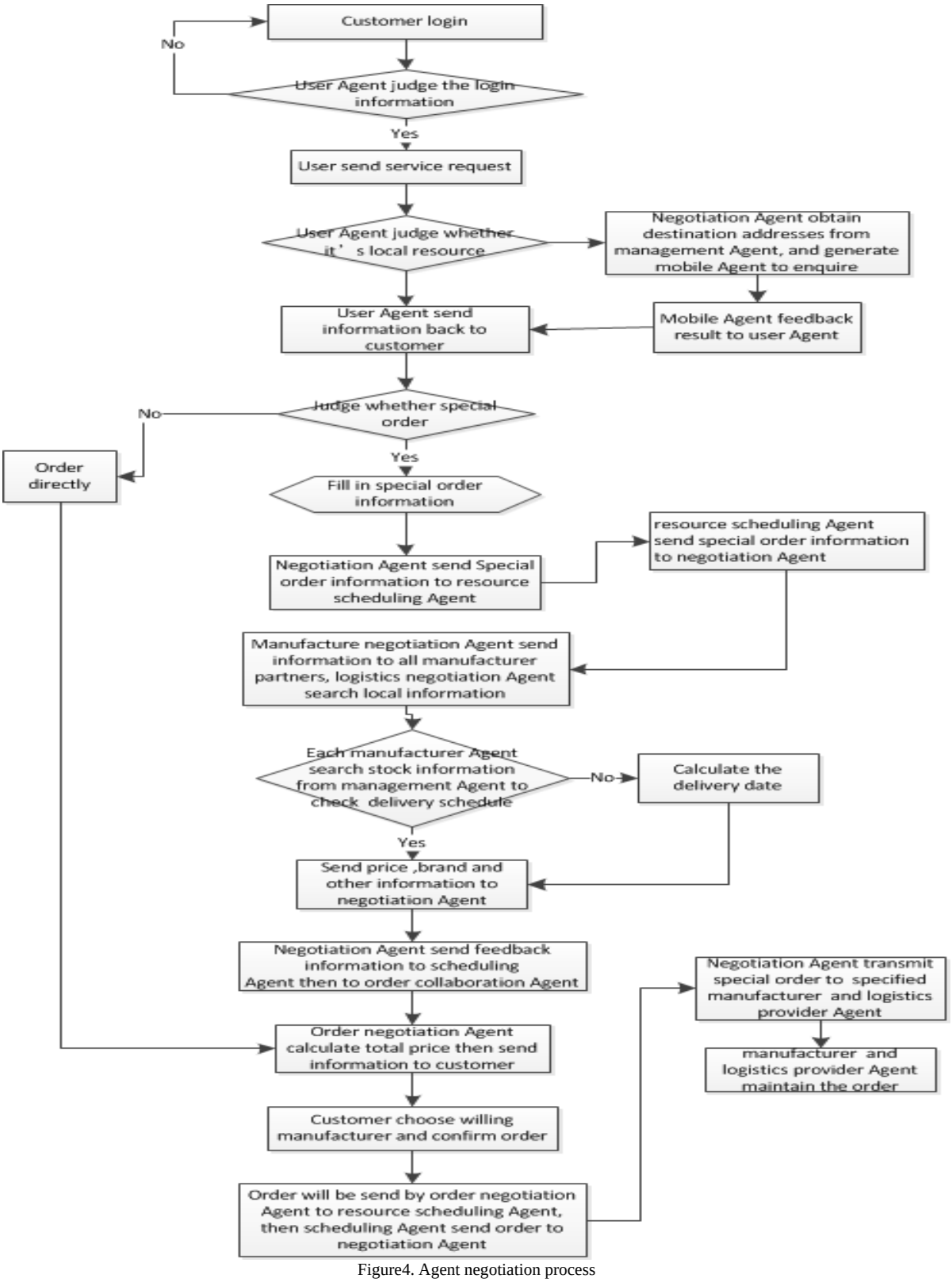


Figure4. Agent negotiation process

In the interior of core enterprise builds a workflow engine, which is mainly composed of information library and Agent. The business process template library keeps supply chain processes of products, services information

library holds information of partners in the supply chain of core business and the services and information and corresponding service interface they provide. Agent mainly includes the service Agent, resource scheduling Agent and negotiation Agent.

Service Agent responsible for regular search for registration in the Web service and Agent platform newly registered Agent services, and obtain these partner enterprise public information through a specific interface, and then store the information in the service information database; resource scheduling Agent responsible for the work of two aspects, one is to receive the service available after negotiation Agent consulting with the collaboration enterprise, the other is to set standard dynamic workflow modeling file after receiving and screening the service information based on rules according to business process template library strategy and service evaluation in service information database; negotiation Agent confirm the workflow and generate workflow cases after interaction with the enterprise Agent system according to the information provided by service resource Agent and workflow modeling file produced by resource scheduling Agent.

*C. System Operation*

Fig.4 is the information flow chart of order. There are some function agents in this system: Customer Agent, Supplier Agent, Logistics Agent, Negotiation Agent, Resource Agent, Order Agent, Management Agent and so on. Customer Agent receives user request and obtain user information from the local database, and prepare the information needed for transmitting orders. Order Agent is a mobile agent, which interactive with client provider Agent in different process phases and for different partners, and complete information and orders. Provider Agent is responsible for processing request from order Agent. The system operation is described as following:

The Agent involved in the computation can be divided into two categories: mobile Agent and service Agent. The main part in the system is order Agent, it is object oriented, can actively communicate with other Agent, and can be movable in different host. Each order Agent is responsible for an order process. Order Agent can interactive with static Agent or other mobile Agent. Every interaction and migration of Mobile Agent is able to achieve three goals: communicate information of previous order to the current enterprise system; receive order information of current location, and add to information storage, then feedback after exchanging results to the previous enterprise.

When the user places orders, order Agent carry information of order, transfer to the enterprises selected in supply chain by resource scheduling Agent, and consult to respective Agent system, to understand whether the enterprise can achieve requirements of the order, if the enterprise cannot meet the requirements, then find a new alternative one. Then feedback enterprise Agent information and consultation results of the supply chain to order consultative Agent.

When the order is changed, the order Agent can timely change message to each enterprise in the supply chain, and then feedback the after adjustment of production, distribution and other information to the starting point to determine whether changes occur.

The realization code of key parts of Provider Agent is as follow:

```
public class ProviderAgent extends Agent {
   private static Configure conf = null;
   private static ConnectionPool pool = null;
private static DocumentBuilderFactory domf =
DocumentBuilderFactory.newInstance();
   static DocumentBuilder domb = null;
   public static void initAgent() {
      try {
         try {
            domb = domf.newDocumentBuilder();
         } catch (ParserConfigurationException ex) {

Logger.getLogger(ProviderAgent.class.getName()).log(L
evel.SEVERE, null, ex);
         }
         InputStream inputStream =
ProviderAgent.class.getResourceAsStream("serverconf
ig.xml");
         conf = new Configure(inputStream);
         System.out.println("driver" +
conf.getParamenter("driver"));
         System.out.println("url" +
conf.getParamenter("url"));
         System.out.println("username" +
conf.getParamenter("user"));
         System.out.println("psw" +
conf.getParamenter("psw"));
         System.out.println("size" +
conf.getParamenter("size"));
         System.out.println("timeout" +
conf.getParamenter("timeout"));
         pool = new
ConnectionPool(conf.getParamenter("driver"),
conf.getParamenter("url"), conf.getParamenter("schema"),
conf.getParamenter("user"), conf.getParamenter("psw"),
Integer.parseInt(conf.getParamenter("size")),
Integer.parseInt(conf.getParamenter("timeout")));
      } catch (SQLException ex) {

Logger.getLogger(ProviderAgent.class.getName()).log(L
evel.SEVERE, null, ex);
      }
      try {
         Runtime rt = Runtime.instance();

ProfileImpl pContainer = new ProfileImpl(null,
Integer.parseInt(conf.getParamenter("agentport")), null);
         AgentContainer cont =
rt.createAgentContainer(pContainer);

AgentController act =
cont.createNewAgent(conf.getParamenter("agentname
"), ProviderAgent.class.getName(), null);
         act.start();
```

```
        } catch (StaleProxyException ex) {

Logger.getLogger(ProviderAgent.class.getName()).log(L
evel.SEVERE, null, ex);
        }
      }
      @Override
      protected void setup() {
        this.getContentManager().registerLanguage(new
SLCodec());

this.getContentManager().registerOntology(AgentConfig
ure.getFlowerOntology());
        setEnabledO2ACommunication(true, 0);
        super.setup();
        addBehaviour(new RecieveBehavior(this));
        DFAgentDescription dfd = new
    DFAgentDescription();
        dfd.setName(getAID());
        ServiceDescription sd = new ServiceDescription();
        sd.setType(ServType.provide.toString());
        sd.setName(getLocalName() + "-" +
   ServType.provide.toString());
        dfd.addServices(sd);
        try {
          DFService.register(this, dfd);
        } catch (FIPAException fe) {
          fe.printStackTrace();
        }
          }
      @Override
      protected void takeDown() {
        super.takeDown();
      }
      public static Configure getConf() {
        return conf;
      }
      public static void setConf(Configure conf) {
        ProviderAgent.conf = conf;
      }
      public static ConnectionPool getPool() {
        return pool;
      }
      public static void setPool(ConnectionPool pool) {
        ProviderAgent.pool = pool;
      }
   }
```

## IV. Conclusion

Customer oriented product design has become the top priority for modern enterprises to quickly meet the personalized and dynamic requirements in the increasingly fierce competition environment. How to improve the efficiency and agility of intelligent activities is a major impediment to improve supply chain's performance in today's business environment. In this paper, we present a new method for the orientation and analysis of ant colony inspired from the swarm intelligence, and then the illustration of LCD-TV is applied to test the validity of the algorithm[22]. We also employ the concept of intelligent agent and mobile agents to complete those tasks independently and automatically, and present a mobile agent system for SCM, then give a detail description of the working process in this system[23].

Future researches are designed to strengthen the agent capability and flexibility with the improvement of knowledge base and security of mobile agents. Furthermore, we hope to test it in a completely new application environment, and potentially advance this system.

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