Multi-Agent Based Food Processing Supply Chain Management

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ABSTRACT

Supply Chain Management (SCM) is a management paradigm to understand and analyze the flow of goods, services and the accompanying values reaching to the consumers followed by the processes of purchasing, production and distribution with combining and connecting the whole system. SCM is regarded as an essential strategic factor which has a great deal of influence on earning competitiveness in the abruptly changing global business environment. In this project, a Multi-Agent System to support Supply Chain Management is developed. Multi-agent technology becomes the best candidate for problem solver under these circumstances. Five Agents will be developed namely Interface Agent, Sales Agent, Inventory Agent, Factory Agent and Supplier Agent. The agents are created with the help of the Java Agent Development Framework (JADE) and are implemented in an Intranet framework by considering Five Agents.

1. INTRODUCTION

The way of doing business has significantly changed over the last decades. Tremendous amounts of information, continuously emerging new technologies, increase in customer expectations regarding cost and service, as well as global competition are just a few factors which have made enterprise leaders search for new approaches for running their companies. They can no longer rely on static business strategies. They have to be able to cope in rapidly changing and uncertain trading environments: bank rates change overnight, political situations change, materials do not arrive on time, power supplies break down, production facilities fail, workers are absent, new orders arrive and existing orders are changed or canceled. Companies have to govern a number of activities, such as supply, demand, production, sales, deliveries, and customer services, as a single dynamic process in order to keep a balance across them.

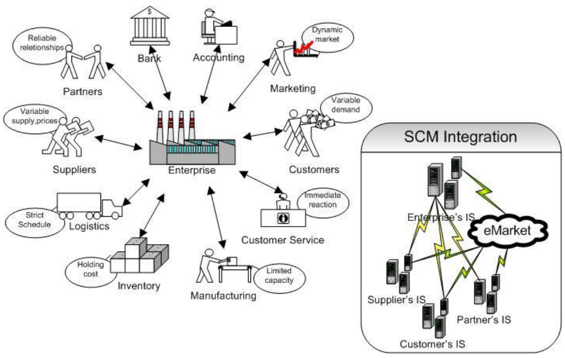


Fig1: SCM Entities

This is the main task for Supply Chain Management (SCM) which is concerned with negotiating with suppliers for raw materials, competing for customer orders, managing inventory, scheduling production, and delivering goods to customers.Taking into consideration market globalization, companies often run distributed businesses, having suppliers and customers all over the world. Development of information technology has enabled organizations to use the Internet to participate in electronic commerce (e-Commerce) in order to reduce their transaction and administrative costs, speed up their turnover, and interact with a larger number of trading partners in different geographical locations. The Internet enables the shift from individual business processes toward a more distributed, collaborative business model. To manage this model, enterprises need a solution (both on software and hardware levels) that allows them to participate in electronic trading environments (eMarketplace). This solution has to include an adaptive decision support system (DSS) that can collect and process information from a large number of sources and in different formats, as well as help make reactive and yet precise decisions in ever changing and competitive market conditions. It has to accommodate and support interfaces to the existing business models of other participant entities through cooperative supply chain integration and management. Conceptually, a supply chain manages coordinated information and material flows, production operations, and logistics of the eMarketplace. In the settings of electronic environments, SCM can be viewed as a cooperative distributed problem-solving activity among various business entities that work together to solve a common problem using various Internet technologies. As eMarketplace is a newlyestablished business model, the problem of designing SCM systems to support participation in it has become now more crucial than ever. Supporting the need for designing mechanisms to coordinate and integrate business entities within distributed electronic trading environments, the research presented in this thesis has its aim to develop such a mechanism in the form of DSS for SCM. The work explores issues which companies experience when doing their business online and offers an intelligent solution for managing supply chains in electronic distributed trading environments.

Multi Agent System (MAS):
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 Supply Chain Management (SCM) systems as it provides an adaptable and dynamic way for managing separate links within the chain. Unlike centralized 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

Agent:

A small piece of code which does work on behalf of users and has the following characteristics:

1) Autonomy
2) Pro-activeness
3) Reactivity
4) Mobility
5) Social Ability
6) Interaction
7) Learning
8) Communication/Co-operation

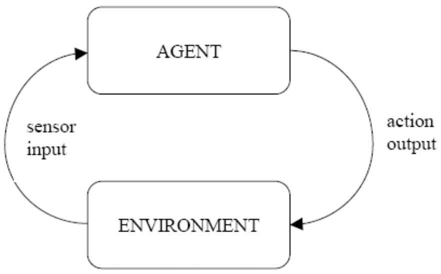


Fig2: Software Agent & its environment

JADE:

JADE (Java Agent DEvelopment Framework) is a software framework to develop agent-based applications in compliance with the FIPA specifications for interoperable intelligent multi-agent systems. The goal is to simplify the development while ensuring standard compliance through a comprehensive set of system services and agents.
JADE can then be considered an agent middleware that implements an Agent Platform and a development framework. It deals with all those aspects that are not peculiar of the agent internals and that are independent of the applications, such as message transport, encoding and parsing, or agent life-cycle.

2. SYSTEM DESIGN:

Use-Case Diagram:

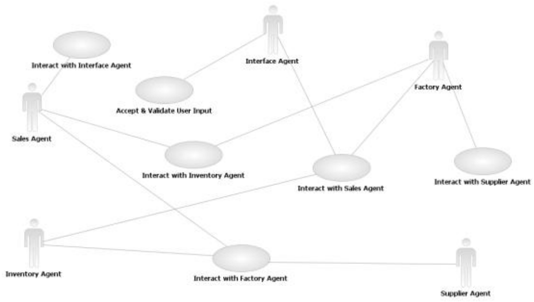


Fig3: Use case Diagram

Activity Diagram for Finished Goods:

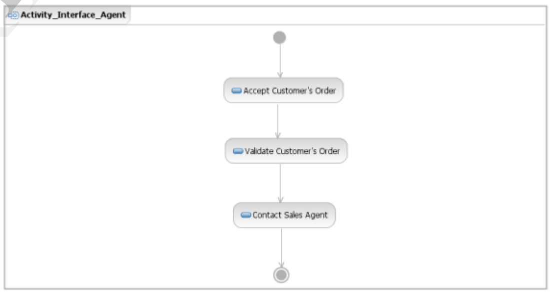


Fig4: Interface Agent Activity Diagram

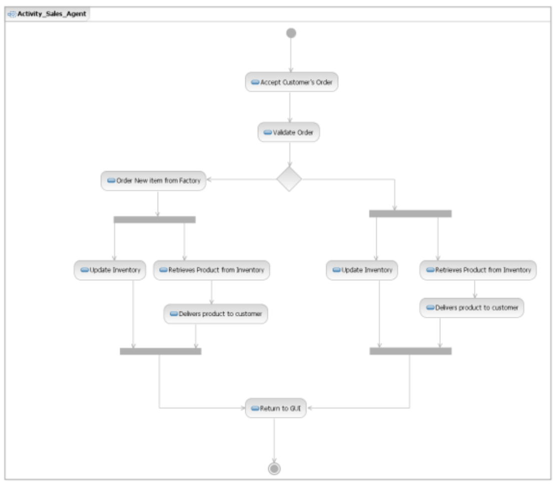


Fig5: Sales Agent Activity Diagram

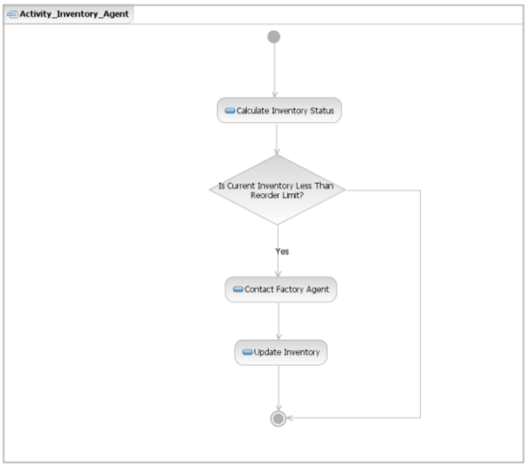


Fig6: Inventory Agent Activity Diagram

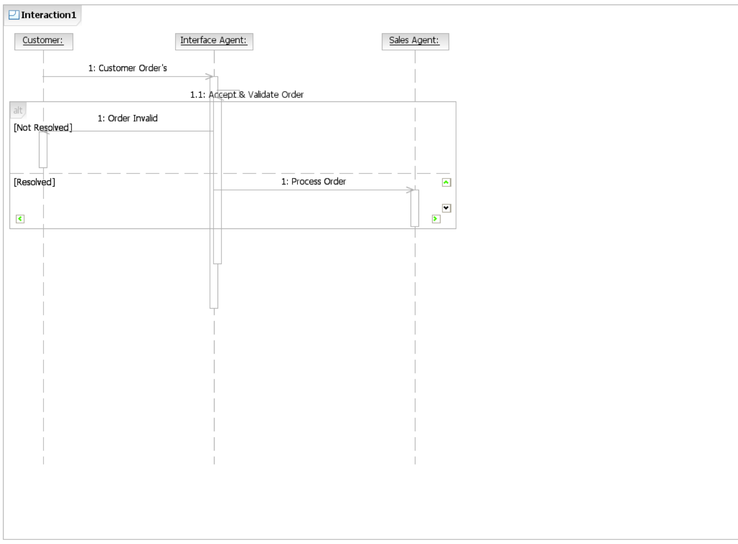


Fig9: Sequence Diagram

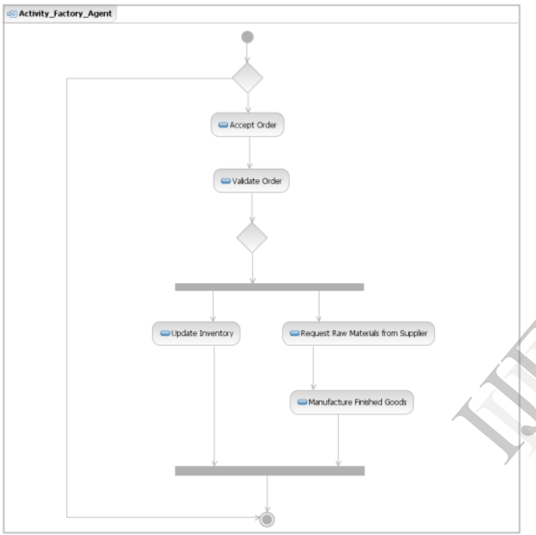


Fig7: Factory Agent Activity Diagram

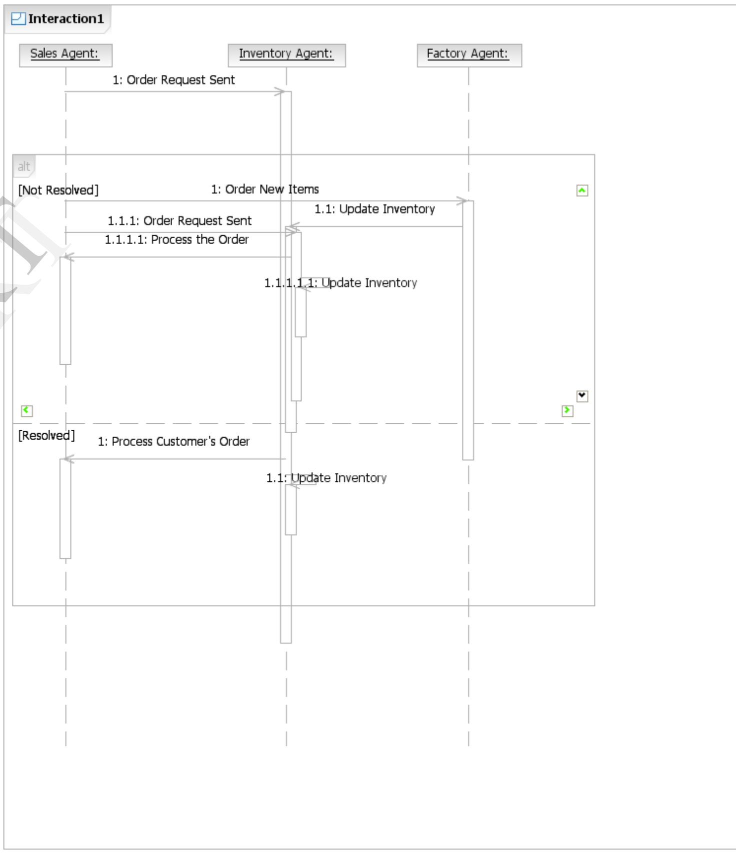


Fig10: Sequence Diagram

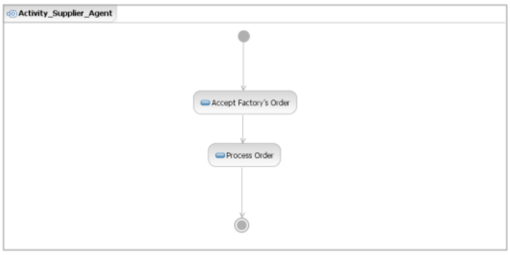


Fig8: Supplier Agent Activity Diagram

Sequence Diagram for Purchase Goods:

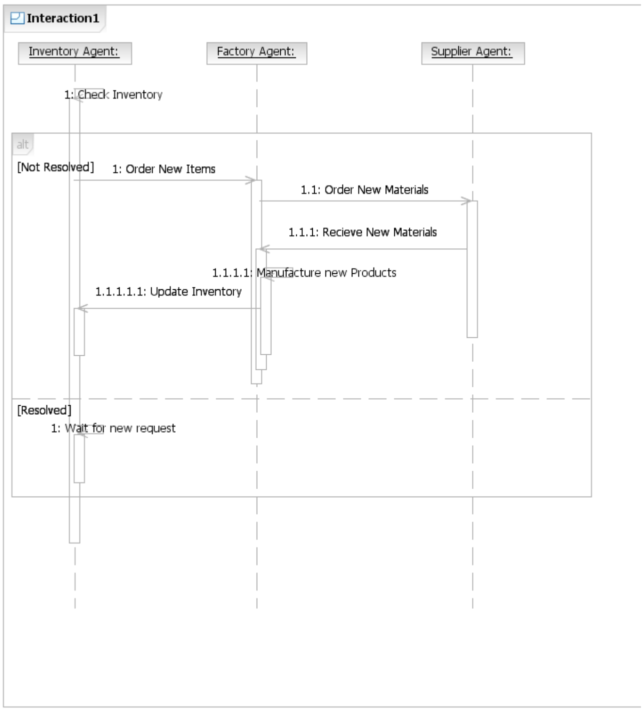


Fig11: Sequence Diagram

Class Diagram:

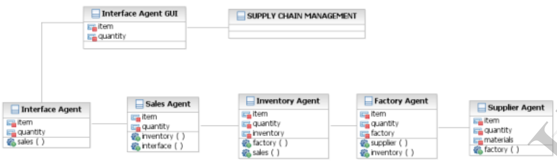


Fig12: Class Diagram

Algorithm:

INTERFACE AGENT

Step 1: Start.

Step 2: Customer requests items along with order quantity on the GUI.

Step 3: The order is forwarded to the Sales Agent.

Step 4: If (confirmation received)

Displays "Order Successful"

Else

Waits for Sales Agent to reply

Step 5: Stop.

SALES AGENT

Step 1: Start.

Step 2: If (Order Received from Interface Agent)

Order Forwarded to Inventory Agent.

If (confirmation received from Inventory Agent)

Sends Confirmation to Sales Agent

Else

Waits for Inventory Agent to reply

Else

Waits for Interface Agent to reply

Step 3: Stops.

INVENTORY AGENT

Step 1: Start.

Step 2: If (Order received from Sales Agent)

Compare the Order the quantity and the Quantity present in the inventory

If (Quantity exists)

Quantity is removed from the inventory.

Sends Confirmation to Sales Agent

Else

Order for additional items is sent to Factory Agent

Waits for order

If (Order is received)

Inventory Agent updates its inventory

Sales Agent Order is processed.

Inventory of the Inventory Agent is updated

Sends Confirmation to Sales Agent

Else

Waits for Factory Agent to reply

Else

Waits for Sales Agent to reply

Step 3: Stops.

FACTORY AGENT

Step 1: Starts.

Step 2: If (Order received from Inventory Agent)

Request for Raw Materials is sent to the Supplier Agent

Waits for order

If (Order is received)

Items are manufactured

Items are sent to Inventory Agent.

Else

Waits for Supplier Agent to reply

Else

Waits for Inventory Agent to reply

Step 3: Stops

SUPPLIER AGENT

Step 1: Starts.

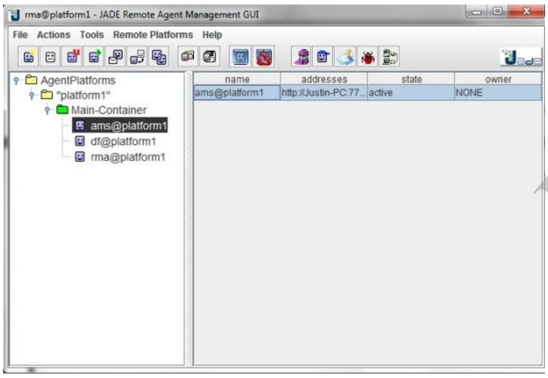
Step 2: If (Order received from Factory Agent)

Sends Raw Materials to the Factory Agent

Else

Waits for Factory Agent to reply

Step 3: Stops



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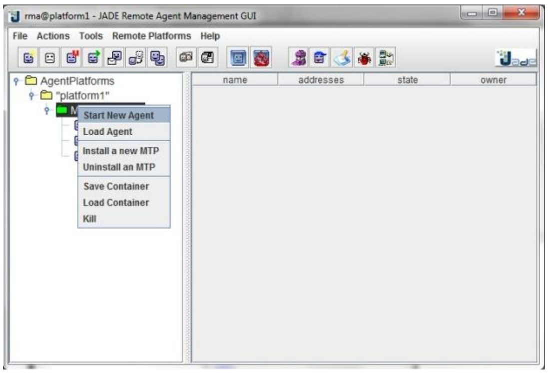
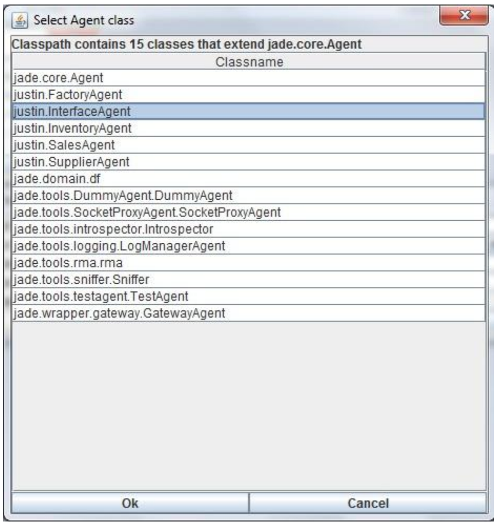


Fig 14:

Fig 15:



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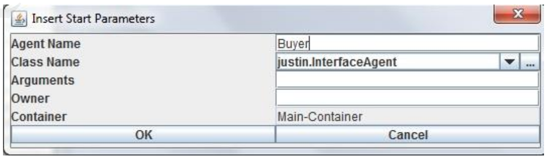
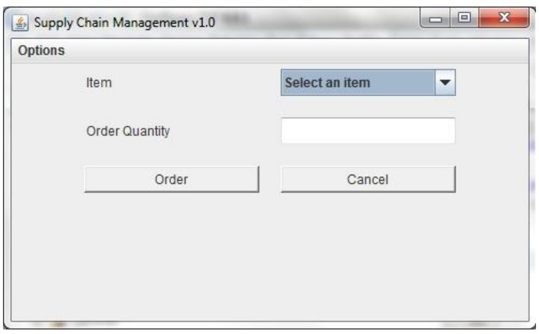


Fig 17:

Fig 18:



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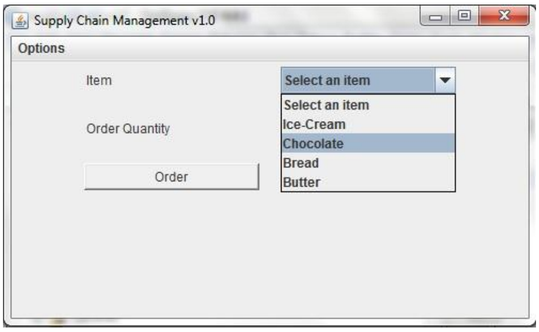

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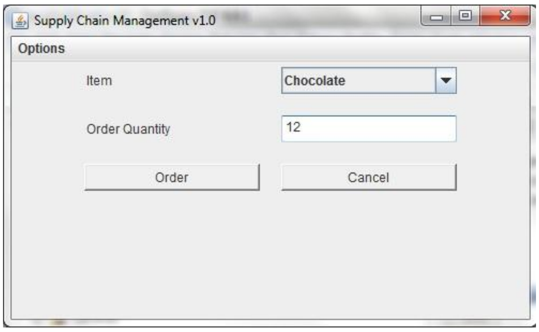

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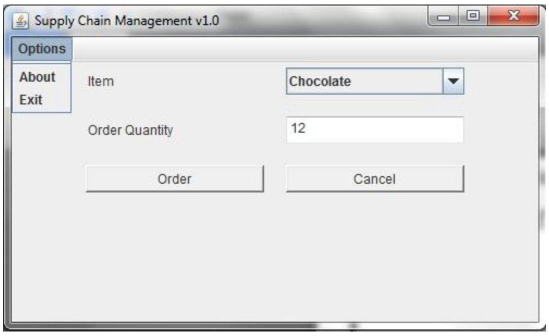
Fig 22:



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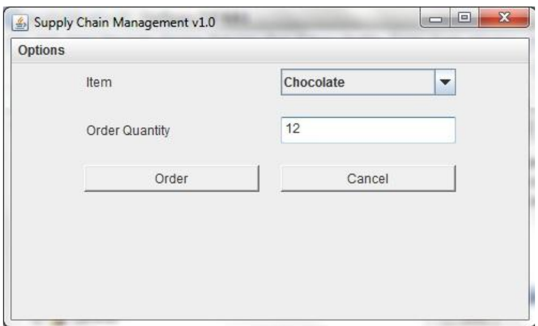

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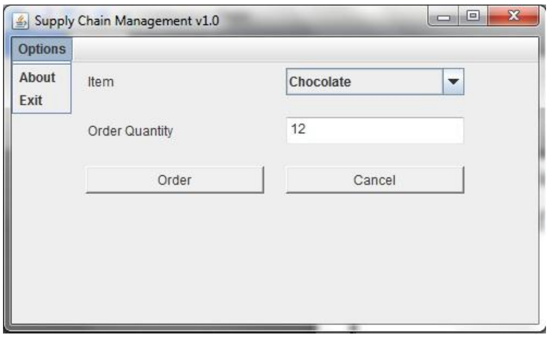
Fig 25



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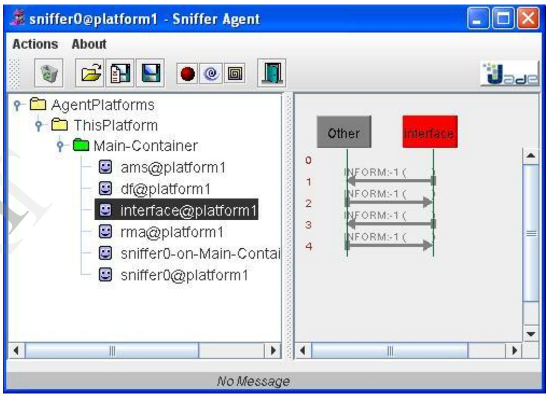

Fig27: Interface Agent

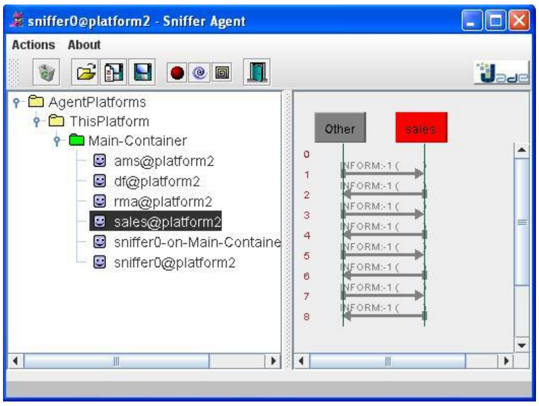

Fig28: Sales Agent

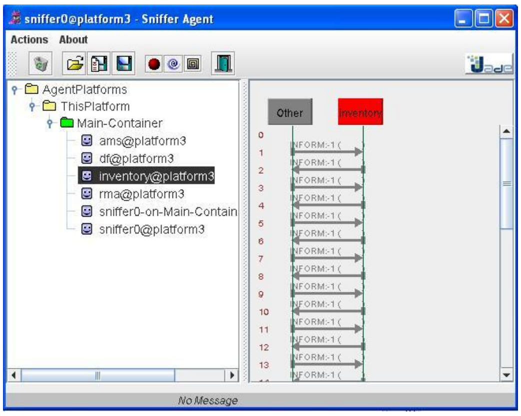

Fig29: Inventory Agent

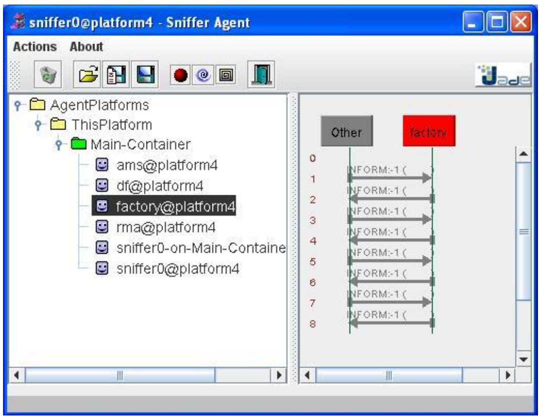

Fig30: Factory Agent

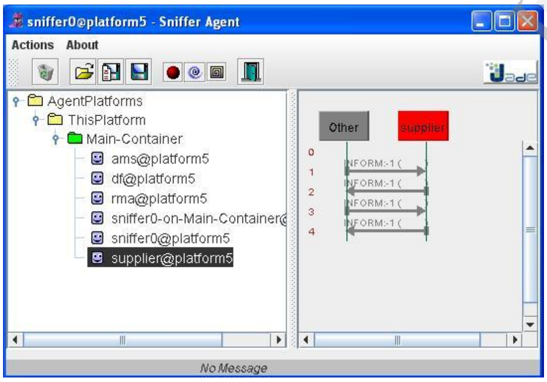

Fig31: Supplier Agent

3. EXPERIMENTAL ENVIRONMENT:

This section describes the experimental environment in which measurements were taken, what inputs were used to drive the system, and what outputs were collected for subsequent analysis and evaluation. Implementation details of the experimental system are illustrated. System operations, like information dissemination, agent migration, and results collection, are also explained.

4. SYSTEM OVERVIEW:

To investigate the coordination in the Supply Chain of Food Processing, a multi-agent system has been implemented to provide a testing platform. The whole system is written in Java using JDK 1.17 using JADE (Java Agent Development) Framework and is 5 Machines running Windows XP Professional Service Pack 3 connected through a Local Area Network The configurations of these 5 machines are listed in Table below.

Table 1.

model	Intel pc
processor	Intel core 2 duo 2.2 GHz
main memory	2 GB
no. of machines	5

These machines reside at the Department of M.C.A, M S Ramaiah Institute of Technology, Bangalore, Karnataka, India. All the machines have separate hard drives.

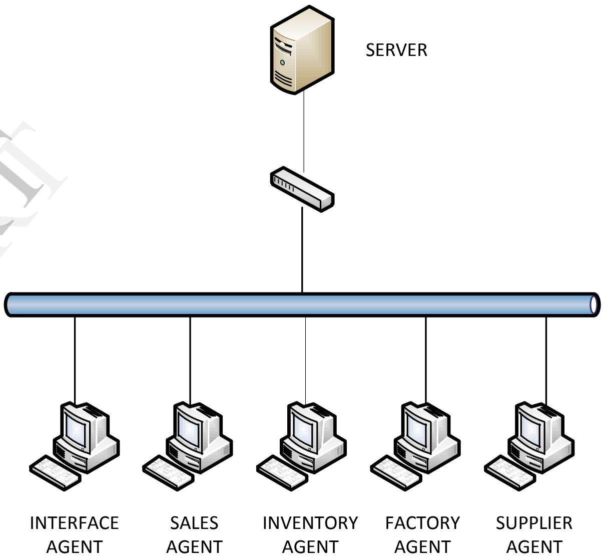

Fig 32:

CLASSIFICATION OF AGENTS:

This system consists of two types of agents. Work Agent is the type which does all the computation and resides on each system. There may be one or more Work Agents. There are three Work Agents implemented. They are Inventory Agent, Factory Agent and Supplier Agent. The second type is the Communication Agent. The Communication Agent, just like the Work Agents resides on each system. There are two Communication Agents implemented. They are Interface Agent and Sales Agent.

SYSTEM HIERARCHY:

Our system is built on top of the JADE Layer as shown in the figure

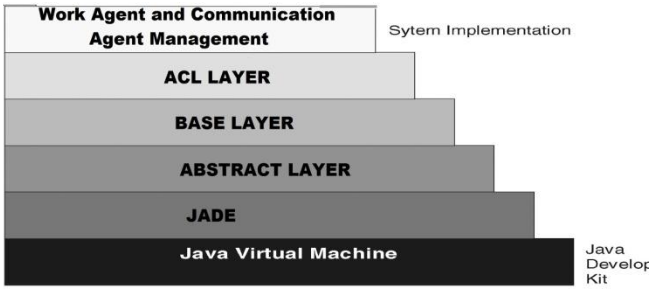

Fig 33:

The lowest layer is the Java virtual machine, which interprets the Java bytecodes. The second lowest layer is the core system of the JADE. It is written in Java. As a result, it is placed on top of the Java virtual machine. The abstract layer provides a collection of abstract classes necessary for JADE implementation. The base layer provides basic communication based on FIPA protocols and the abstract layer. It is independent of the protocol or message language used in the higher layer. The ACL layer provides the encapsulation and parsing of ACL messages. The Agent management layer provides a basis to initiate the Work Agents in the above layer and acts as a coordinator for all agent-related management. The highest layer is where Work Agents do computations and interact. The hierarchies may pose a threat of too much overhead. It should be noted, however, that the most serious overhead lies in the implementation of the Java Virtual Machine, the basis of all Java programs. All the above layers represent one or two function calls and are minimal compared with the JVM layer.

5. RESULTS:

This section describes experimental results obtained from feeding the system with various combinations of parameters and calculating the Response Time.

Query Response Time: Toanalyze the performance, random requests are provided and the Response Time of each of the five Agents is calculated as below.

Table 2.

R	A1	A2	A3	A4	A5
R1	188	187	125	63	15
R2	48	47	31	16	15
R3	48	47	31	15	15
R4	48	47	31	15	15
R5	33	32	31	16	16
R6	48	47	31	15	15
R7	48	47	31	15	15
R8	32	31	15	15	15
R9	47	46	15	15	15
R10	48	47	32	32	15

Where

R- Request

A1- Interface Agent

A2- Sales Agent

A3- Inventory Agent

A4- Factory Agent

A5- Supplier Agent

6. CONCLUCTION:

"**Multi-Agent Based Food Processing Supply Chain Management**" has been developed with the use of JADE (Java Agent Development Framework). It consists of five Agents namely Interface Agent, Sales Agent, Inventory Agent, Factory Agent and Supplier Agent which are deployed in different environments and can interact with each other. With the help of the Interface Agent, the user can get the information of the products available without knowing from where the information is actually fetched. All inputs and outputs are validated and verified. The system can be easily enhanced and expanded.

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