



Agent Based Software Engineering
Instructed by Dr. Behrouz H. Far

Agent-based Personal Electronic Commerce System
SENG 609.22 Fall 2003

Reported by
Jian Huang
Ming He

Table of Contents

1. Introduction.....	6
2. System Overview.....	7
2.1 System Description	7
2.2 System Requirements.....	7
2.3 Wish list	8
2.4 Assumptions.....	9
2.5 System Hardware Specification.....	9
3. System Architecture.....	10
3.1 PEC Agent.....	11
3.2 Bank Agent	11
3.3 Deliverer Agent.....	12
3.4 Vender Agent	12
3.5 Agent Internal Architecture.....	13
4. Detail Design.....	14
4.1 Use Case Diagram.....	14
4.1.1 PEC Agent use case diagram.....	15
4.1.2 Bank Agent use case diagram.....	17
4.1.3 Deliverer Agent use case diagram.....	19
4.1.4 Vender Agent use case diagram.....	21
4.2 Class and Sequence Diagrams.....	24
4.2.1 Server Daemon.....	24
4.2.2 Bank Agent	27
4.2.3 PEC Agent	28
4.2.4 Deliverer Agent	37
4.2.5 Vender Agent.....	41
5. Data Specification.....	46
5.1 PEC Agent	46
5.1.1 Profile Table	46
5.1.2 Order Table.....	47
5.2 Bank Agent	47
5.2.1 Bank Information	47
5.2.2 Transaction Record	48
5.3 Deliverer Agent	48
5.3.1 Delivery Company Information.....	48
5.3.2 Contract Information.....	49
5.4 Vender Agent	49
5.4.1 Product Information.....	49
5.4.2 Seller Information.....	50
5.4.3 Contract Information	50
6. PEC System Messages.....	51
6.1 Register	51
6.2 Sign in.....	51
6.3 Sign out	52

6.4 Inquire information.....	52
6.5 Make order.....	53
6.6 Update profile	54
6.7 Close profile	55
6.8 Ask Payment.....	55
6.9 Require PayStatement.....	56
6.10 Ask Product Information.....	57
6.11 Ask Vender Information.....	57
6.12 Ask Order Product	58
6.12 Ask Delivery Information.....	59
6.13 Ask Order Delivery Service	59
6.14 Ask Delivery Statement	60
7. Conclusion.....	61
8. References.....	62

Table Index

Table 1 Detail Use Case Definition for PEC Agent.....	17
Table 2 Detailed Use Case Definition for Bank Agent	19
Table 3 Detail Use Case Definition for Deliverer Agent	21
Table 4 Detail Use Case Definition for Vender Agent.....	24
Table 5 Profile Table.....	46
Table 6 Order Table.....	47
Table 7 Bank Information.....	47
Table 8 Transaction Record.....	48
Table 9 Delivery Company Information.....	48
Table 10 Contract Information (Agent and Delivery Company).....	49
Table 11 Product Information.....	49
Table 12 Seller Information.....	50
Table 13 Contract Information (Agent and Seller).....	50

Table of Figures

Figures 1 PEC System Overview.....	7
Figures 2 Hardware System Architecture.....	9
Figures 3 PEC System Architecture.....	10
Figures 4 Agent Internal Architecture.....	13
Figures 5 Use Case Diagram for PEC Agent.....	15
Figures 6 Use Case Diagram for Bank Agent.....	18
Figures 7 Use Case Diagram for Deliverer Agent.....	20
Figures 8 Use Case Diagram for Vender Agent	22
Figures 9 Framework Class Diagram.....	25
Figures 10 Agent Startup and Shutdown Sequence Diagram	26
Figures 11 Bank Agent Class Diagram	27
Figures 12 Bank Agent Payment Process Sequence Diagram	28
Figures 13 PEC Agent Class Diagram.....	29
Figures 14 Register Sequence Diagram.....	30
Figures 15 Sign In Sequence Diagram.....	31
Figures 16 Sign Out Sequence Diagram.....	32
Figures 17 Update Consumer Profile Sequence Diagram	33
Figures 18 Inquire Sequence Diagram.....	34
Figures 19 Making order Sequence Diagram.....	35
Figures 20 Close Account Sequence Diagram	36
Figures 21 Deliverer Agent Class Diagram.....	37
Figures 22 Collect deliverer information Sequence Diagram.....	38
Figures 23 Shipment Order(Contract) Sequence Diagram.....	39
Figures 24 Provide Delivery Company(Services) Sequence Diagram.....	40
Figures 25 Veder Class Diagram.....	41
Figures 26 Collect Product Information Sequence Diagram (Vender).....	42
Figures 27 Making product order Sequence Diagram (Vender).....	43
Figures 28 Collect Product Information Sequence Diagram(Vender).....	44

1. Introduction

Today internet using is popular all over the world. New business patterns are emerged as well as the new technology develops. The wider bandwidth and more security computational environment are provided, the more comfortable and faster shopping methods customers need. When customers access a web site today, they want to be able to browse a product catalog, buy the products online in a secure environment, and have the product delivered to their home. On the other hand, in order to be competitive in the global marketplace, businesses need to offer greater levels of customer service and support than ever before.

The term electronic commerce(e-commerce) implies that goods and services can be purchased on the web. There are two kinds of e-commerce models. One is Business-to-Consumer(B2C), called Personal Electronic Commerce(PEC) in this project. The other is Business-to-Business. In this project only the former is discussed. Lots of approaches can achieve B2C e-commerce models. In this paper, agent-based approach is provided.

PEC system refers to an e-commerce store which offers products and services. It is analogous to a store on the web site, where anyone can “walk in” and make a shopping.

When a new customer called first shopper, walks in the PEC system, he/she can make purchase after providing some general information about himself/herself to fulfill the transaction(name, address, credit card, etc.). The PEC system encourage users to register and become members. In doing so, the business can establish a relationship with the customer, provide better service, and set up customer loyalty.

The total difference between PEC system and B2C system is that PEC system works like a broker which help customers find products and services while B2C system provides what it has. PEC system contains four agents collaborating together to provide the services to customers.

The rest of this report is structured as follows. System overview will be described in Section 2. Section 3 explains the system architecture. Design will be detailed in Section 4. Database schema and inter-agent message will be given in section 5 and 6 respectively. Finally the conclusion will be given.

2. System Overview

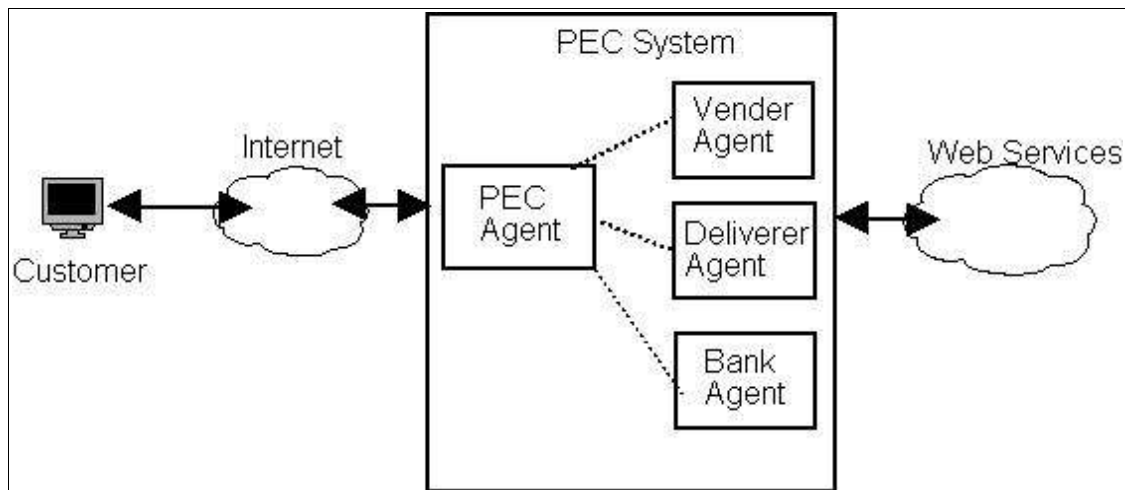
2.1 System Description

The PEC system allows users to sign in system and inquire merchandise information, seller information, and delivery services information. Users can ask the system to provide product, seller, and delivery services comparison information. Sellers(venders) and delivery companies' prestige are ranked by the system based on the transaction history.

PEC system is a multi-agent system. PEC Agent, Vender Agent, Deliverer Agent, and Bank Agent are involved in PEC system. PEC Agent is used to provide the web interface communicating with customer. Vender Agent is used to collect merchandise and vender information automatically, and it feeds these information to PEC Agent. Vender agent also makes contract with vender if PEC Agent informs it that customer has made the new order. Deliverer Agent collects delivery companies and services information automatically. These information will be passed to PEC Agent. The contract with the delivery company is also made according to customer's order. Bank Agent is applied to verify customer credit information and require financial companies transfer fund from customer's account to seller's account and delivery company's account.

The Vender agent and Deliverer agent also provide some intelligence functionalities. That means they will choose the appropriate vender and deliverer according to the strategy specified by the customer. The detail will be described in Section 3.

The PEC system overview is shown in the Figure 1.



Figures 1 PEC System Overview

2.2 System Requirements

The PEC System should implement the following features:

1. It allows users to:

- register
 - sign in
 - inquire merchandise, vender, and delivery company information
 - compare merchandise, vender, and delivery company information
 - make order, select specified merchandise, vender, and delivery company
 - specify intelligence selecting strategy
 - update personal profile
 - close account (profile)
 - download order statement
 - sign out
2. Vender and Deliverer agent could:
- collect relative information automatically
 - dynamic collection fired by PEC agent
 - feed collected information to PEC agent
 - make contract with seller and delivery companies through web services
 - maintain contract records
 - intelligently select vender and delivery company according to customer strategy
 - provide contract statement to PEC agent
3. PEC agent should:
- provide web communication interface between customer and PEC system
 - maintain customer profile and order information
 - search vender and deliverer alternative agent
4. Bank agent should:
- help the system verify customer credit information through web services
 - require financial company transfer money from customer's account to vender and delivery company's account
 - record transaction journals
 - provide transaction statement to PEC agent

2.3 Wish list

The following functionalities are not implemented at this stage. They are supposed to be implemented in the next release.

1. Allow customer cancel order within the grace period.
2. Provide shipping suggestions based on customer's shipping history.
3. Allow customer track order process.
4. Provide services through mobile interface.
5. Provide equal-month payment services.

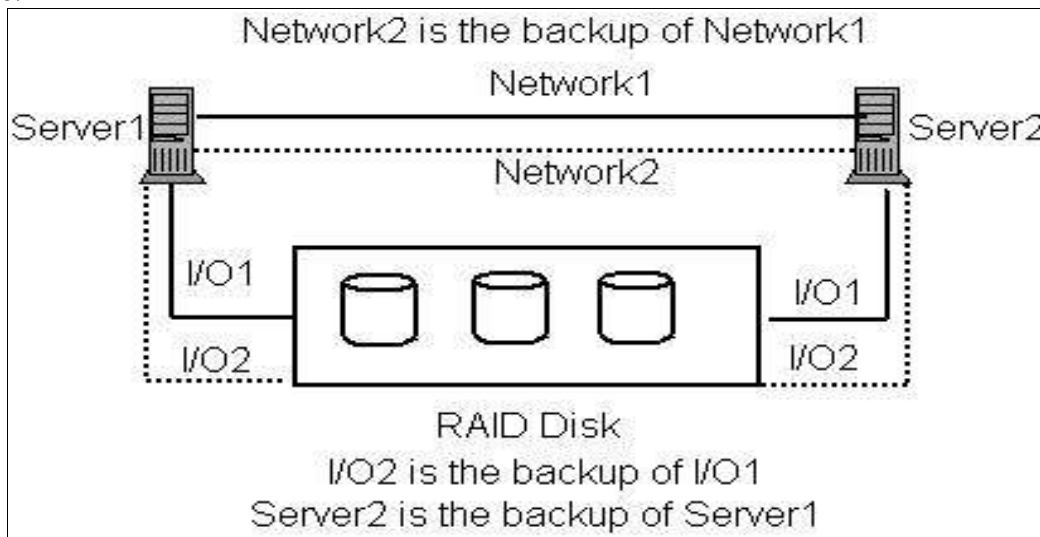
All the services mentioned above are supposed to enhance the system functionality and provide customer convenience.

2.4 Assumptions

All the agents contained in PEC system are supposed to be deployed in a closed environment. The communication channel between agents satisfies the security requirement. Although agent will communicate with other entities through Internet the firewall is supposed to guarantee the security constrains. In addition to firewall mechanism SSL protocol is used between customer and PEC Agent. The sensitive data between agents and web services are encrypted. The security issues are not addressed in this document any more.

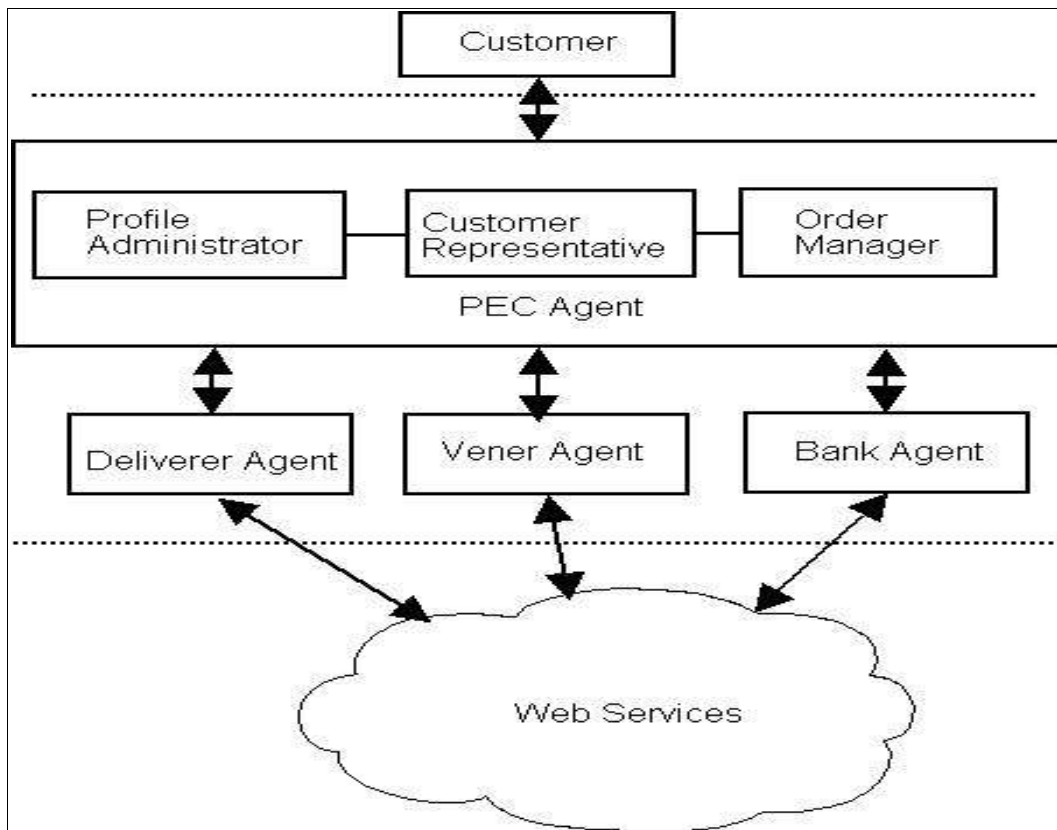
2.5 System Hardware Specification

Depending on the capacity of the users, each agent could be deployed on PC Server or RS/6000 Server. Linux or UNIX (AIX) is recommended to be the operating system. Windows series operating system (NT, XP) is not suggested considering the high availability requirement. All the agents could be deployed in single node as well. The figure shown below denotes the recommend hardware system architecture.



Figures 2 Hardware System Architecture

3. System Architecture



Figures 3 PEC System Architecture

According to the system's specification, the PEC system contains four agents, PEC Agent, Deliverer Agent, Vender Agent, and Bank Agent. The consumer is required to register first in the system and get his/her username and password. Then the consumer can log in the system searching information, comparing products and services, and making orders.

PEC Agent is the bridge between consumer and e-market. It provides web communication interfaces between consumer and PEC system. It represents product and service information to customers and manages customer information and order inventory. In the future, PEC Agent will provide intelligent services for customer, such as product recommendation, service recommendation, and so on. The consumer is required to register first in order to get intelligent services.

Deliverer Agent is used to collect and verify deliverer company information, including their histories, prestigious, guarantee policies, and so on. It also sets up contracts with deliverer company and manages these contracts.

Vender Agent is used to collect product and vender information from Internet. It can collect information dynamically. It keeps vender contracts in its database and take care of them.

Bank Agent is used to verify customers' credit information and ask financial company transfer fund

from customers' account to vender and shipment company's account. In the future bank agent will be developed to loan money to consumers based on consumer's shipping and credit records.

All the roles of each agent will be detailed in subsections.

3.1 PEC Agent

There are three roles parasitizing in this agent.

- **Customer Representative.** It plays as a PEC coordinator communicating with customers through WEB Interface, with the role of 'order manager' and the role of 'profile administrator'. It accepts customer requests and dispatches them to any other roles within the agent or send the requests to other agents. It displays response using HTML format. It is able to handle concurrent customers requests. Product information, Vender information, and Deliverer information are received by this role and presents them to customers. When it cannot retrieve information from its cache buffer it will send requests to appropriate agent and refresh its cache buffer dynamically.
- **Order Manager.** Its major responsibility is to manage customers' orders. It receives message from the Customer Representative. It creates and maintains orders. First it will generate order records and keep them in database if customers make orders . Second it traces orders process status and updates orders status appropriately. Third it could output order statements given to customer or print order statements for the organization to keep the history records.
- **Profile Administrator.** It is used to maintain customers profile. When it receives username and password from the 'Customer Representative' it compares them with the data in database. When a new customer registers in system it adds customer profile record in database. It updates customer record according to customer request. It only sets a flag in according record if customer asks to delete his profile in system. It also checks customer orders information with 'Order Manager' when customer requires to delete his/her account.

PEC Agent is a channel toward to wide e-market and web services from the customer point of view. It also delegates customer from other agents point of view. So it is recognized as the bridge between customer and e-market.

3.2 Bank Agent

It acts as a account management center. Bank agent is used to communicate with financial companies. Either individual customer or business companies held accounts in financial companies. When Bank Agent receives payment request from PEC Agent it first verifies the customer account credit. If the customer account was overdrew it will refuse the payment request. If customer account credit is enough to pay the money it will ask financial company to transfer the fund from customer to vender and deliverers. When the transaction is completed it gives a successful response to PEC Agent. Transaction records are stored in its database. It utilizes such information to generate payment statements.

In order to satisfy security requirement the transaction message transferred between Bank Agent and web services are encrypted. Since we assume the PEC system agent community is a close environment the message transferred among PEC system agents are trusted by each agent.

Bank agent is also able to output payment detail records for financial companies and payment statements for customer, vender, and deliverer companies.

3.3 Deliverer Agent

There are four major functionalities for deliverer agent.

1. Collecting Shipping Companies' information. It searches web services from Internet and collects deliverer service information from web services. The deliverer service information will be stored in its cache buffer. When it receives request from PEC Agent asking deliverer information it sends them back to PEC Agent based on its request. If it cannot find any information according to PEC Agent's request it will issue collection operation immediately called dynamic collection. Refreshing its cache buffer takes place every interval.
2. Providing Information. Two strategies are used to provide information to PEC Agent. One is accurate matching algorithm. According to this algorithm it tries to find out specific deliverer company based on customer requirement. It returns failure response to PEC Agent if it cannot find such company. Definitely it will issue dynamic collection before it sends failure reply to PEC Agent. The other one is smart matching algorithm. It picks up a set of companies based on customer's request from its cache buffers and throw them to PEC agent.
3. Contracting with deliverer company. Once customer makes an order the PEC Agent sends the order information to the deliverer agent. It will set up a contract with such company utilizing web services. If the web services are unreachable it tries to find substitute based on a certain policy and asks the PEC agent(customer at the end) to confirm. It will rate deliverer companies according to their transaction history and selects companies intelligently.
4. Generating Delivery Statement. It records delivery detail and generates delivery statement according to customer request.

Deliverer agent provides delivery alternatives to PEC Agent if the relative web services are temporarily or permanently unavailable.

3.4 Vender Agent

Vender agent collects two kinds of information. One is product information and another one is seller information. All these two kinds of information are collected from web services. Vender agent keeps a cache buffer to store these information and refreshes them within fixed interval. The dynamic collection operation will be driven if it cannot find any information from its cache.

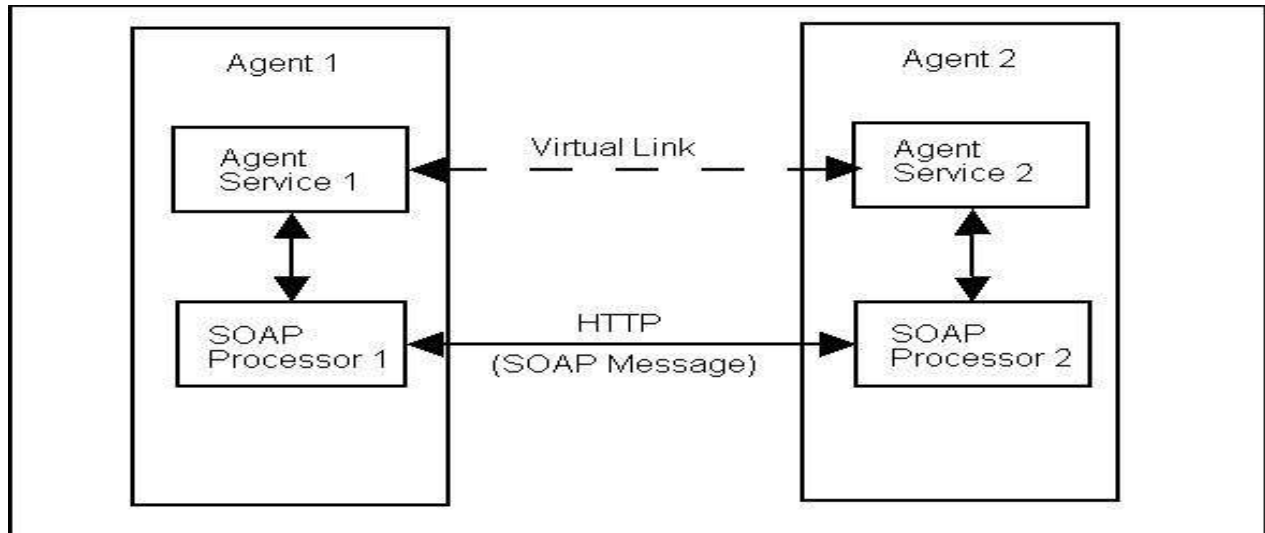
The accurate matching and intelligent matching algorithm are used in its providing information functionality as well. Vender comparing and product comparing services are also provided by it.

Once customer makes an order this agent could select vender according three strategies. One is fixed strategy. Another is policy strategy. The former strategy makes contract with the seller which is determined by customer. The later strategy selects vender based on the policy specified by the customer. The third one is a hybrid approach which first uses fixed strategy and then uses second strategy if fixed strategy fails. The policy strategy is based on the best prestige or the best price.

The statement is also created and maintained by the vender agent. Contract is used to keep track with seller while statement is used to synchronize with PEC agent order manager.

3.5 Agent Internal Architecture

Lots of inter-agent communication languages could be used to tackle agent internal communication. Most application systems use COBRA, Jini, KQML and so on. Simple Object Access Protocol(SOAP) is applied in PEC system. SOAP uses XML as the communication language, and HTTP as the transmission protocol. It is also widely used in web services. The reason why to select SOAP is that PEC agent system is supposed to keep consistence with Internet web services. The architecture using SOAP between two agents is depicted as below.



Figures 4 Agent Internal Architecture

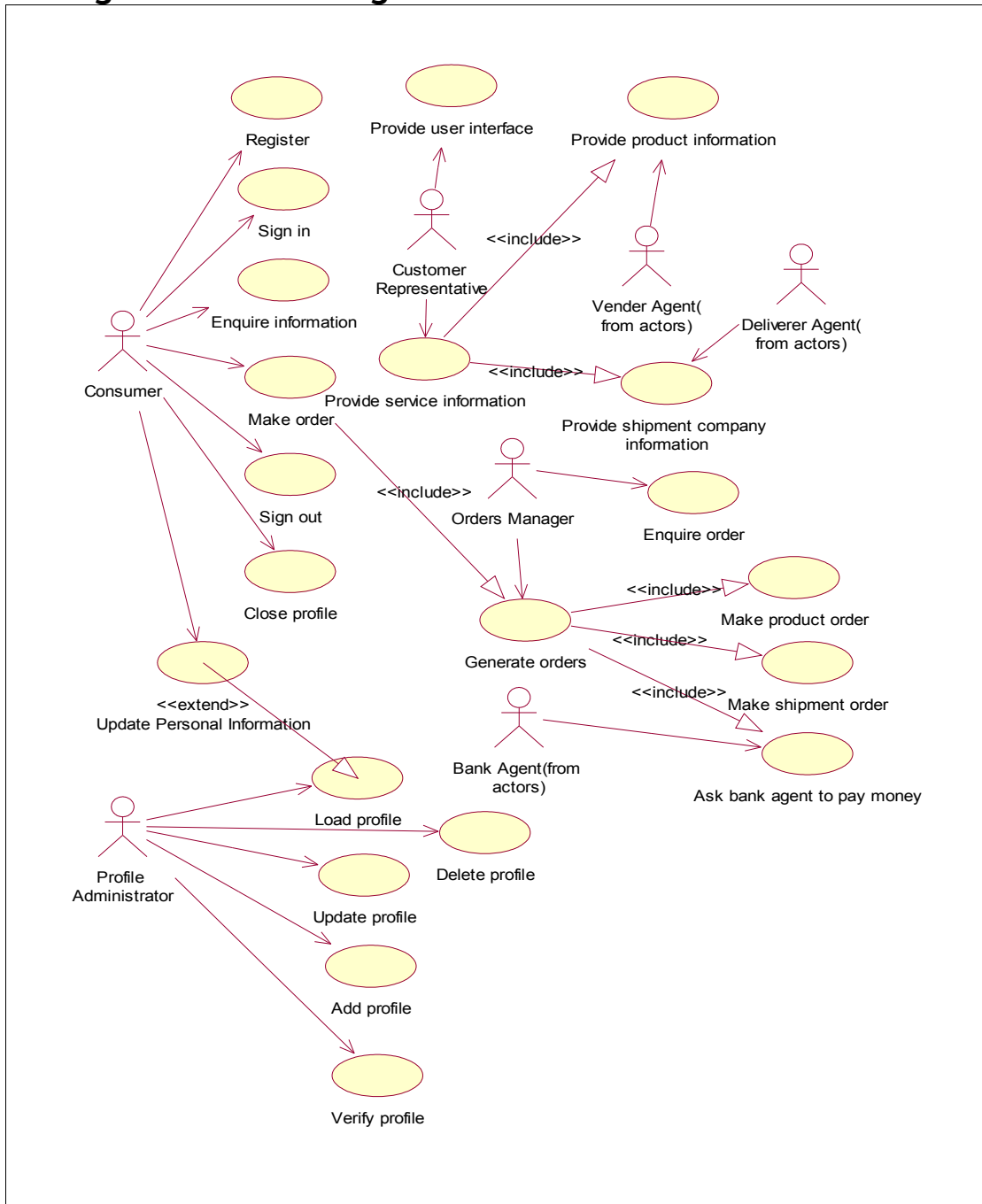
4. Detail Design

The PEC Agent system is detailed in this section. Use Case diagram, class diagram, and sequence diagram will be described here.

4.1 Use Case Diagram

There are four use case diagrams in this subsection.

4.1.1 PEC Agent use case diagram



Figures 5 Use Case Diagram for PEC Agent

The detail use case definition is discussed in the following Table 1.

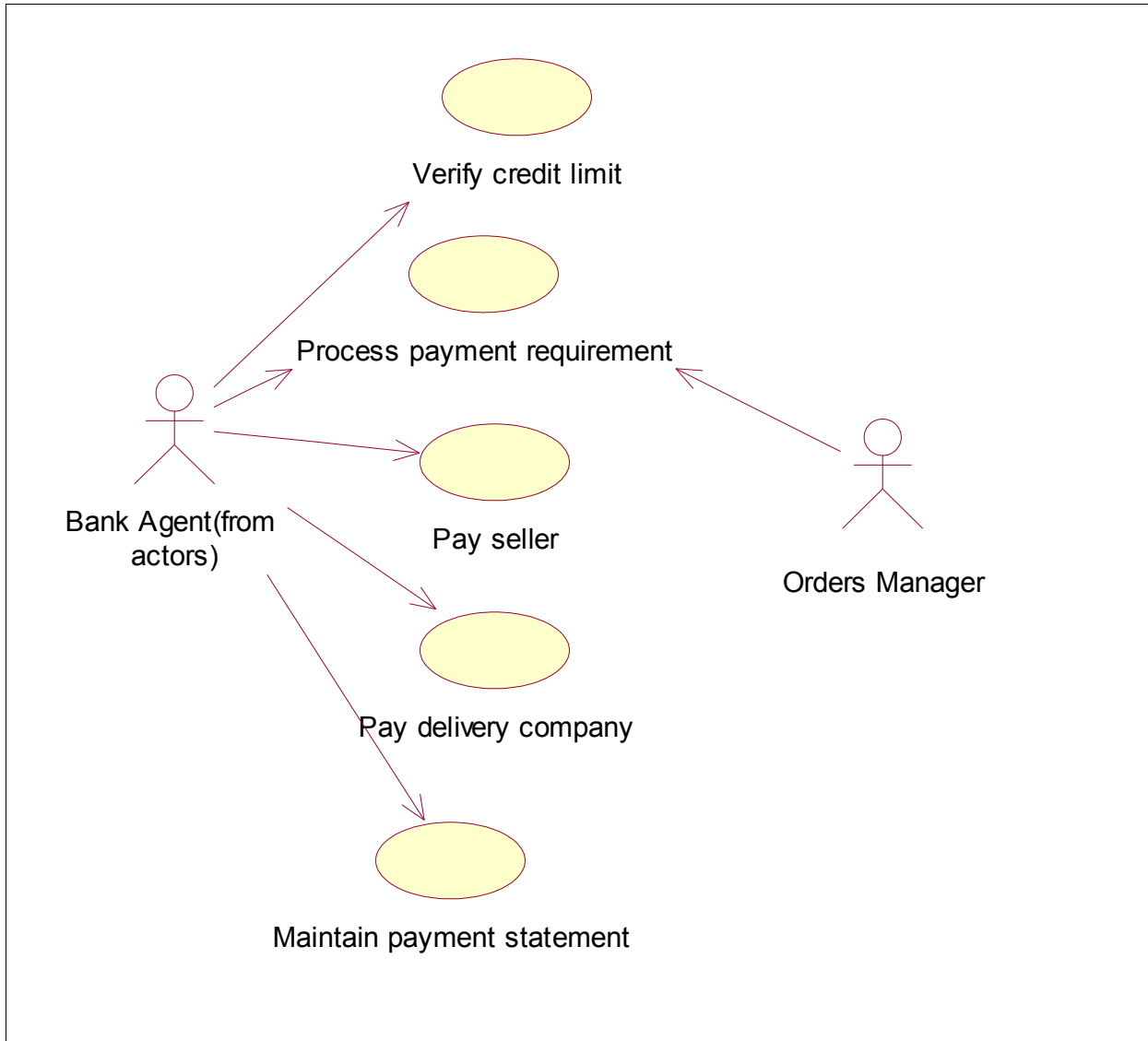
Agent-based Personal Electronic Commerce System

Brief Descriptions:	<i>Consumers use this agent to purchase merchandise from Internet.</i>
Precondition(s):	<i>New consumer is required to register first. Members use username and password to sign in the system.</i>
Post condition(s):	<i>Users interacts with PEC system through this agent.</i>
Process Steps:	
1	<i>New users inputs their expected username, password, address information, telephone information and so on. If the PEC system accepts their request it will confirm their username and password through E-MAIL.</i>
2	<i>System members use their username and password to sign in the system.</i>
3	<i>Customer representative role passes the username and password to 'Profile Administrator' role to identify customer identity.</i>
4	<i>If it's a new user and no overload user name exists, the 'Profile Administrator' insert a new record in database and reply 'Customer representative' to allow customer sign in.</i>
5	<i>If it's an old user and passes the password verification the 'Profile Administrator' informs 'Customer representative' to allow customer sign in.</i>
6	<i>Users could ask 'Customer Representative' to provide merchandise, vender, and deliverer information which are expected by them.</i>
7	<i>PEC Agent communicates with other agents to get relevant information and presents in the front of customers.</i>
8	<i>Customer could ask agent to list comparison information about merchandise, vender and deliverer services.</i>
9	<i>Customer could select product and make orders.</i>
10	<i>'Customer Representative' transfers customer making order request to 'Order Manager'.</i>
11	<i>'Order Manager' communicates with other agents to make orders for customers.</i>
12	<i>'Order Manager' asks other agent to transfer money from customers' accounts to sellers' account and delivery companies account.</i>
13	<i>Customer also could ask 'Profile Administrator' to update their personal information and close their account in PEC system.</i>
14	<i>At the end, customers sign out.</i>
15	<i>'Profile Administrator' update customers logging flag in database.</i>
Exceptions:	
1	<i>PEC Agent prevents invalid users from using PEC system.</i>
2	<i>User's orders requests will be rejected when no credit in their accounts.</i>

3	<i>The ordering request will be refused if the transaction communication is broken and no policy strategy specified by customer.</i>
Relationship:	
Initiating:	<i>Users</i>
Collaborating:	<i>PEC Agent, Bank Agent, Vender Agent, Deliverer Agent</i>
Data Requirements:	
Data Required:	<i>Username, Password, Credit Account, Expired Date, Account Hold Name, Shipping Address, Contact Address, E-MAIL Address, Phone Number, Customer real Name.</i>

Table 1 Detail Use Case Definition for PEC Agent

4.1.2 Bank Agent use case diagram



Figures 6 Use Case Diagram for Bank Agent

The detail use case definition for Bank Agent is listed in Table 2.

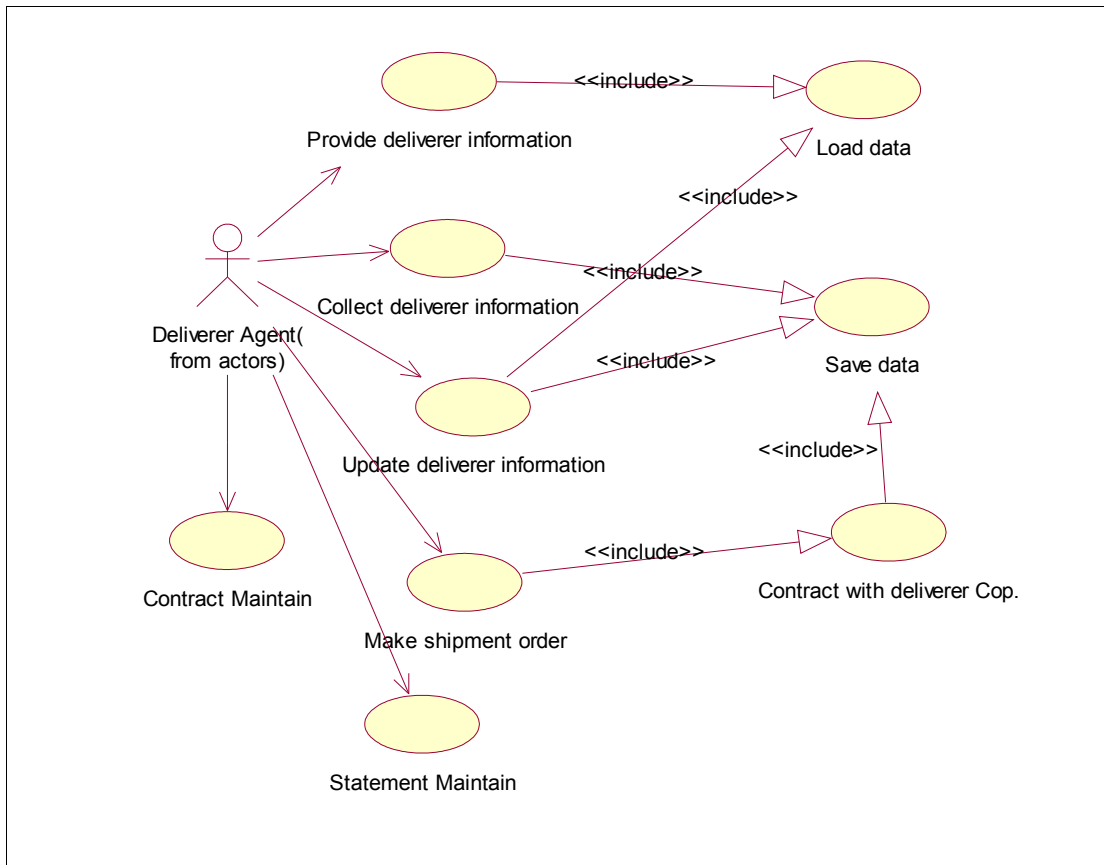
Brief Description:	<i>It receives request from PEC Agent and asks financial company to transfer money from customer account to seller and delivery company account.</i>
Precondition(s):	<i>The account information must be correct and not overdraft.</i>
Post condition(s):	<i>If the transaction is committed it cannot be rollback.</i>
Process Steps:	
1	<i>Bank Agent receives payment request from PEC Agent.</i>
2	<i>The messaged is encrypted utilizing web services to verify account information.</i>

3	<i>If customer account passes verification Bank Agent requires financial company to transfer money from customer account to seller and delivery company account.</i>
4	<i>When it receives successful response from web services through Internet it creates payment statements.</i>
5	<i>It sends payment statements to PEC Agent, seller, and delivery company.</i>
Exceptions:	
1	<i>If financial company web services is broken it will cancel payment request and give failure response to PEC Agent.</i>
Relationship:	
Initiating:	<i>PEC Agent(Order Manager role)</i>
Collaborating	<i>PEC Agent, Web Services</i>
Data Requirements	
Data Required:	<i>Customer Name, Account Hold Name, Account Number, Account Type, Expired Date, Seller Name, Seller Reference Number, Delivery Company Name, Delivery Company Reference Number, Total Payment, Vender Payment, Delivery Payment.</i>

Table 2 Detailed Use Case Definition for Bank Agent

4.1.3 Deliverer Agent use case diagram

The detail use case definition for Deliverer Agent is shown in Table 3.



Figures 7 Use Case Diagram for Deliverer Agent

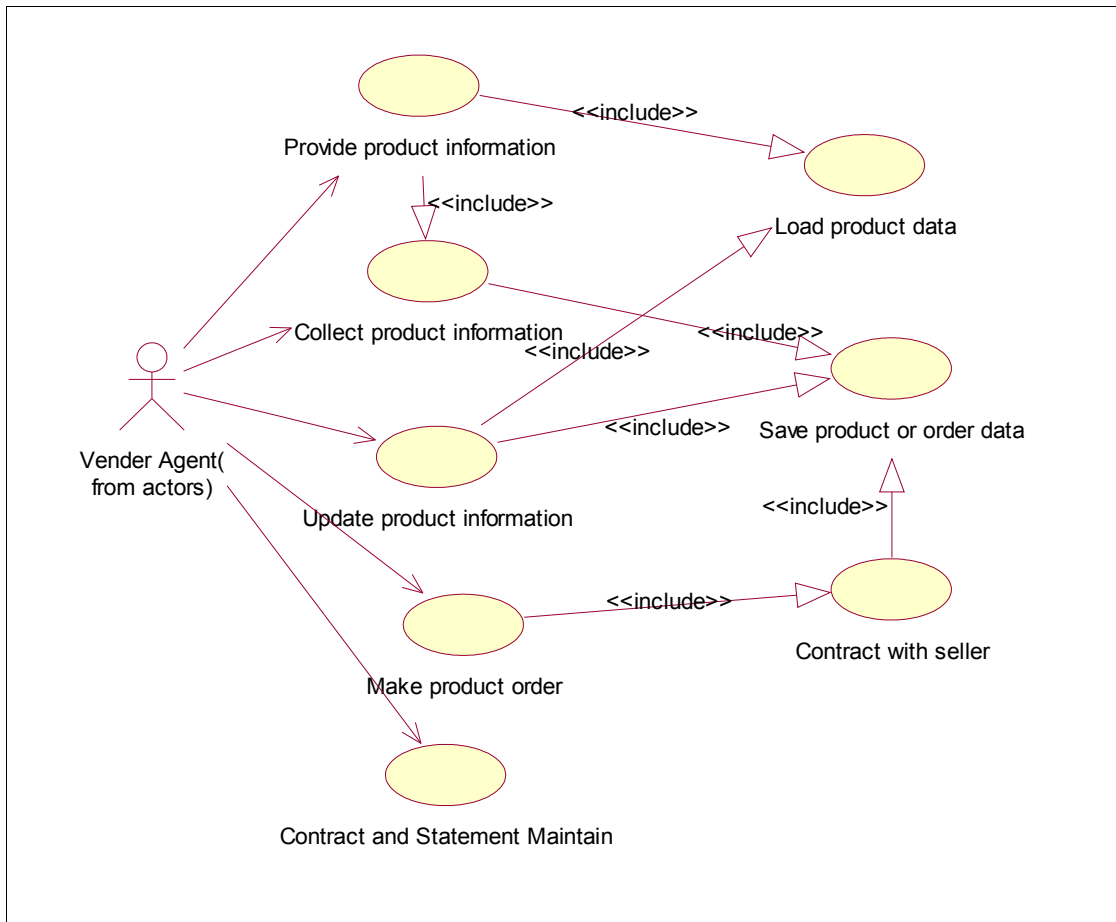
Brief Description:	<i>It provides delivery company and delivery services information for other agent. It contracts with delivery company as well.</i>
Precondition(s):	<i>Contracting with delivery company is based on PEC agent request.</i>
Post condition(s):	<i>N/A</i>
Process Steps:	
1	<i>It collects delivery services and company information utilizing web services within fixed interval.</i>
2	<i>When it receives PEC Agent request for providing delivery information it sends information back if the information could be found in its cache buffer.</i>
3	<i>If the required information could not be found it issues dynamic collection, which means collecting information from Internet according to request immediately.</i>
4	<i>If it cannot find any information required by PEC Agent it returns failure response.</i>

5	<i>When it receives PEC Agent making delivery service order with some delivery company it first tries to communicates with specified delivery company based on request.</i>
6	<i>If the specified delivery company web services is available it contracts with that company.</i>
7	<i>If the specified delivery company web services is unavailable it selects strategy according to customer preference.</i>
8	<i>Three strategies are provided by this agent. One is prestige policy. Another is price policy. The last is speed policy. It selects alternative automatically if customer has specified strategy.</i>
9	<i>Contract will be made based on specified delivery company or alternative.</i>
10	<i>It keeps contracts in its database and maintains statements for other agents.</i>
Exceptions:	
1	<i>If customer specified delivery company web services is unavailable and no intelligent strategy is specified by customer it returns failure response to PEC Agent.</i>
2	<i>If it cannot select any alternative for customer based on strategies it also returns failure response to PEC Agent.</i>
Relationship	
Initiating:	<i>PEC Agent, Deliverer Agent(for automatic collection)</i>
Collaborating:	<i>PEC Agent, Delivery company web services</i>
Data Requirements	
Data Required:	<i>Delivery Company Name, Delivery Company Reference Number, Product Name, Product Model, Product Reference Number, Product Quantity, Seller Address, Customer Address, Order Reference Number, Alternative Selecting Strategy.</i>

Table 3 Detail Use Case Definition for Deliverer Agent

4.1.4 Vender Agent use case diagram

The vender agent use case diagram is shown in Figure 8.



Figures 8 Use Case Diagram for Vender Agent

The detail use case definition for Vender Agent is listed in Table 4.

Brief Description	<i>It collects merchandise and seller information from Internet automatically. It contracts with seller and maintains contracts and statements.</i>
Precondition(s)	<i>The dynamic collection is enabled by PEC Agent. The contract is made according to PEC Agent request.</i>
Post condition(s)	<i>N/A</i>
Process Steps	
1	<i>It collects merchandise and seller information within fixed interval.</i>
2	<i>It keeps these information in its cache buffer.</i>
3	<i>When it receives providing information request from PEC Agent it first seeks information from its cache buffer.</i>
4	<i>It returns information to PEC Agent if they could be found in its cache.</i>
5	<i>If the information could not be found locally it issues dynamic collection.</i>
6	<i>If the information could be found according to dynamic collection they would be returned to PEC Agent.</i>
7	<i>If the required information still could not be found based on dynamic collection a failure response will be sent to PEC Agent.</i>
8	<i>When it receives making order request from PEC Agent it first communicates with the seller specified by customer.</i>
9	<i>If such seller web services is available it contracts with seller.</i>
10	<i>If such seller is unavailable it selects alternative according to strategy specified by customer.</i>
11	<i>Three strategies are provided by Vender Agent. First one is best prestige. Vender Agent selects alternative based on sellers' transaction history. Second on is best price. The seller which provides the cheapest list price will be selected. The third is a hybrid approach. Vender Agent gives prestige and price a different weight and then calculates estimation value for vender. Seller will be selected based on its estimation value.</i>
12	<i>It asks PEC Agent(customer) to confirm the alternative seller.</i>
13	<i>If the alternative is confirmed by customer, it contracts with such seller.</i>
14	<i>It creates contract and statement and keeps them in its database at the same time.</i>
Exceptions	
1	<i>The failure response will be issued if the specified seller web services is unavailable and no intelligent strategy is specified by customer.</i>
2	<i>If the agent could not find out any alternative according to customer strategy the failure response will be sent back.</i>

3	<i>If the required information could not be found the failure response returns back as well.</i>
Relationship	
Initiating	<i>PEC Agent, Vender Agent(for automatic collection)</i>
Collaborating	<i>PEC Agent, Seller Web Services</i>
Data Requirements	
Data Required:	<i>Seller Name, Seller Reference Number, Merchandise Name, Merchandise Model, Merchandise Reference Number, Merchandise Price, Merchandise Quantity, Alternative Selecting Strategy, Customer Name, Order Reference Number.</i>

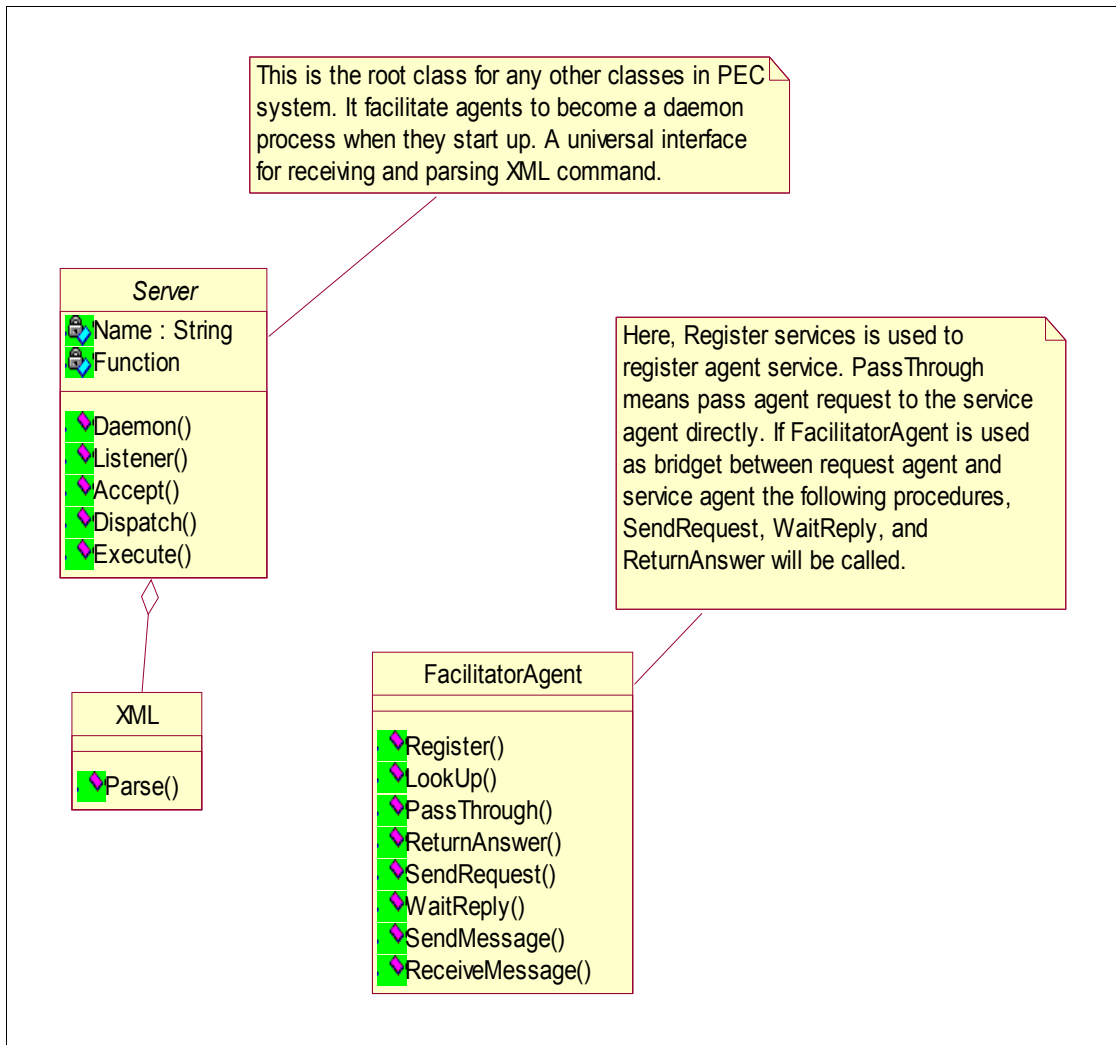
Table 4 Detail Use Case Definition for Vender Agent

4.2 Class and Sequence Diagrams

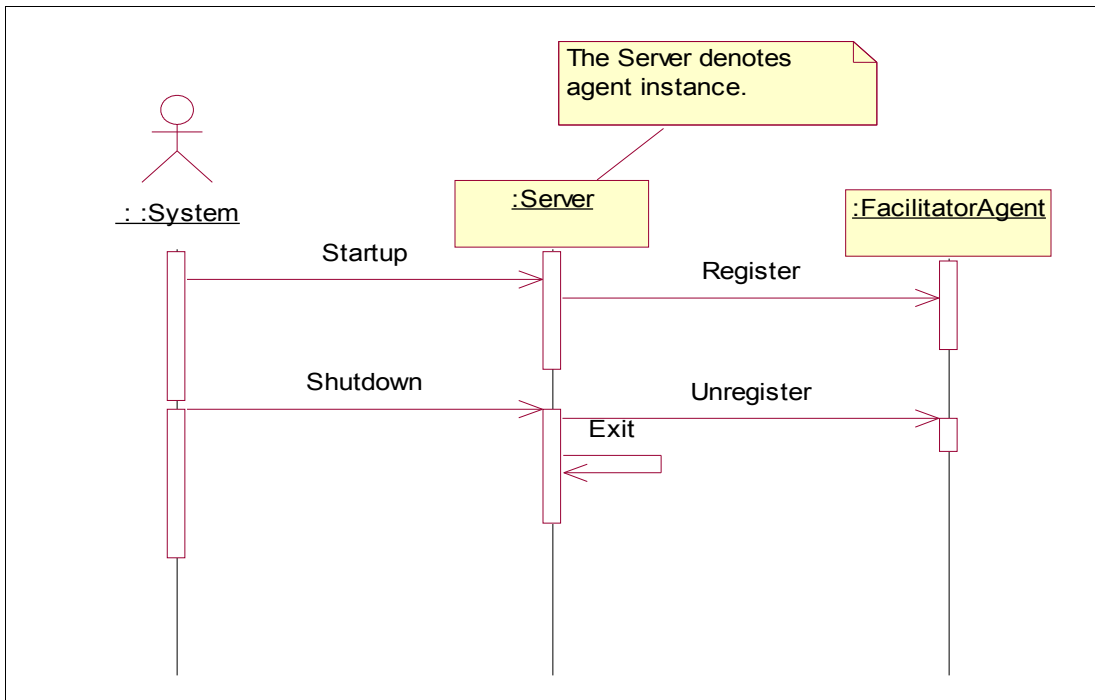
4.2.1 Server Daemon

In PEC system all agents derive from server class. All the instances of server class works as a daemon application. When the agent starts up it will register itself to the 'Facilitator Agent' automatically. Then the agent is listening the coming message, dispatching tasks, processing transaction, and returning response.

The 'Facilitator Agent' records agent services in its registry, helps agent to find out appropriate services, and locates each other in the network.

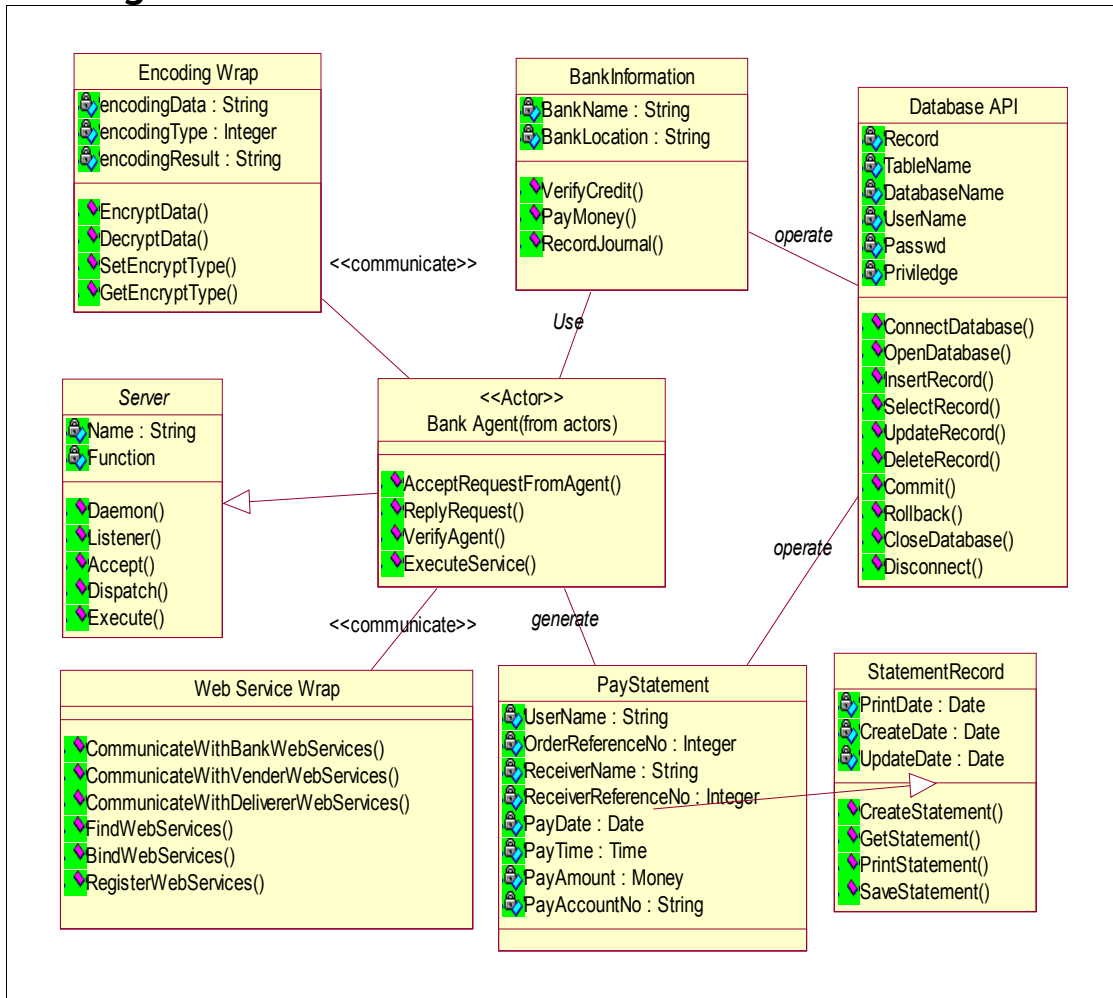


Figures 9 Framework Class Diagram

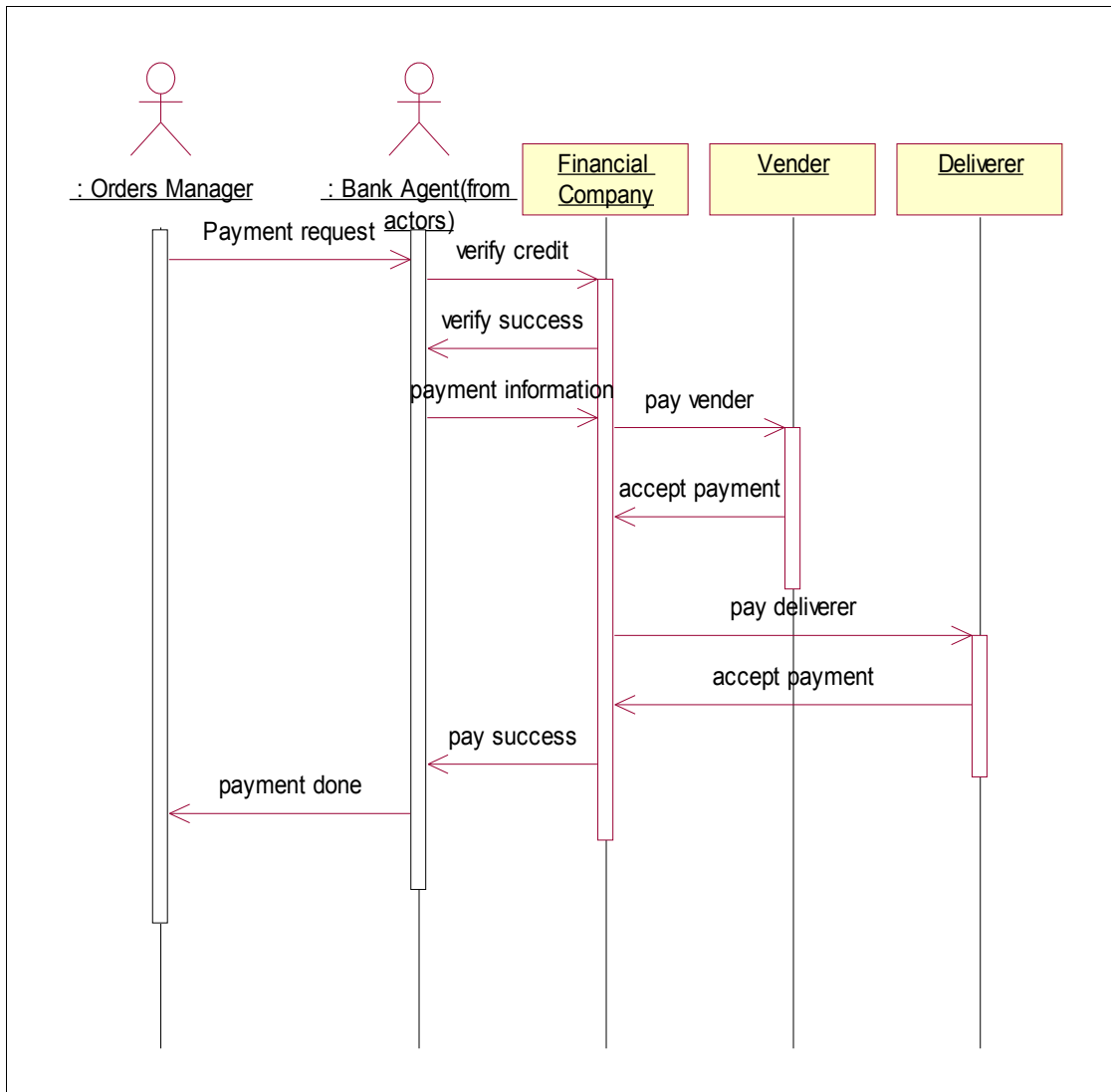


Figures 10 Agent Startup and Shutdown Sequence Diagram

4.2.2 Bank Agent



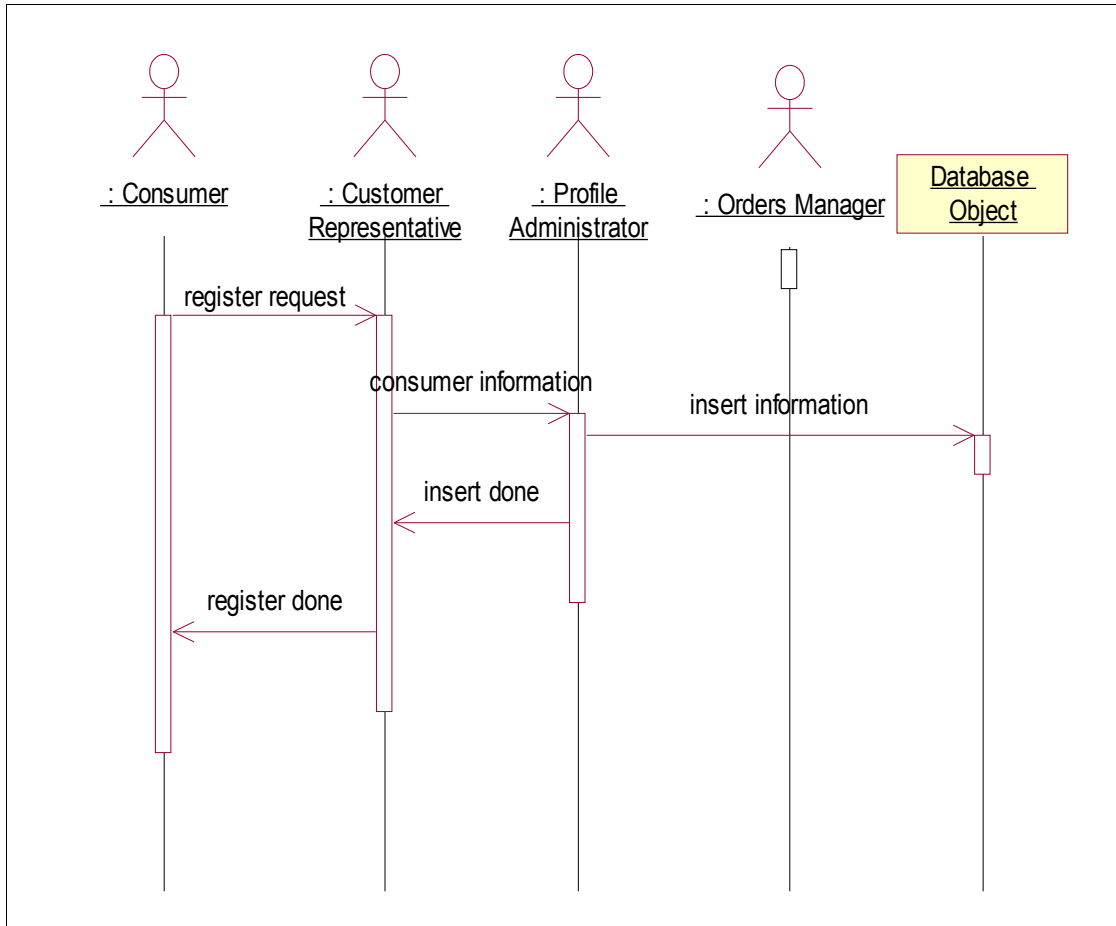
Figures 11 Bank Agent Class Diagram



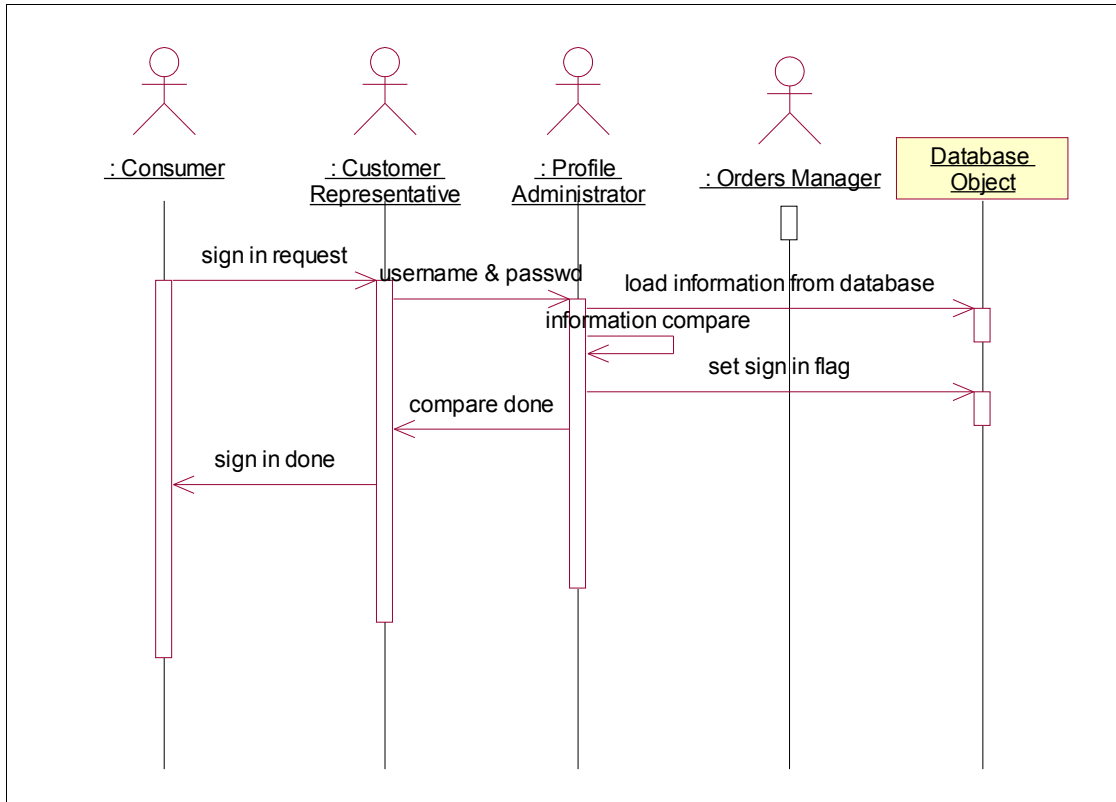
Figures 12 Bank Agent Payment Process Sequence Diagram

4.2.3 PEC Agent

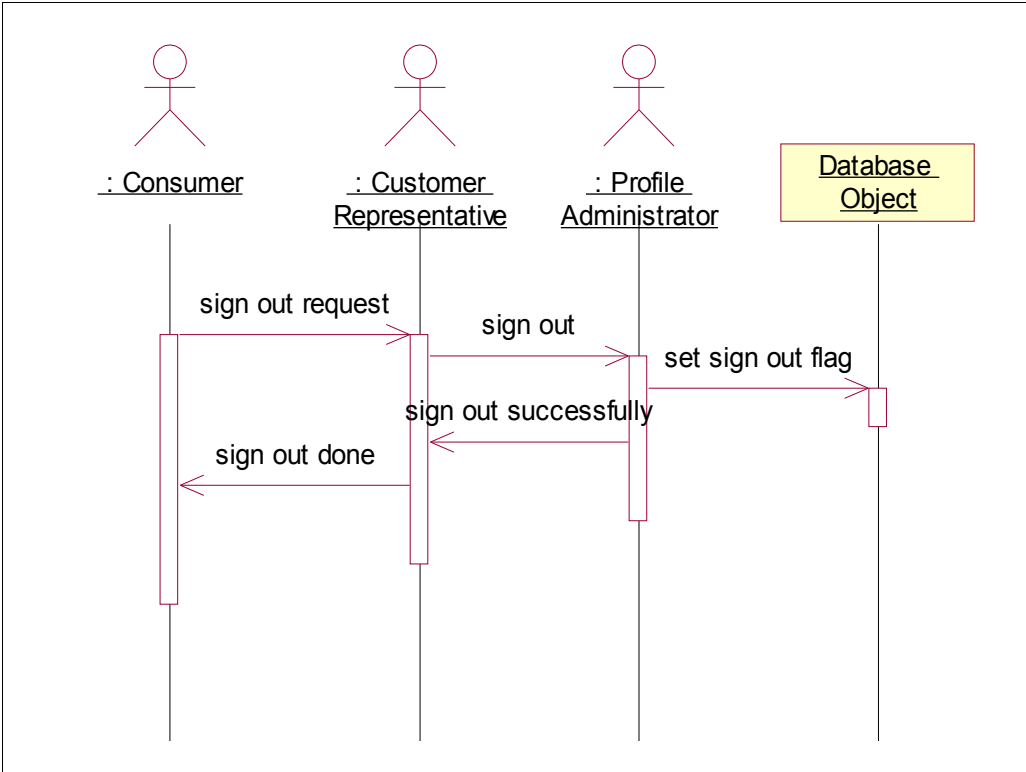
The class diagram of PEC Agent is shown first. The sequence diagrams will be listed following its class diagram.



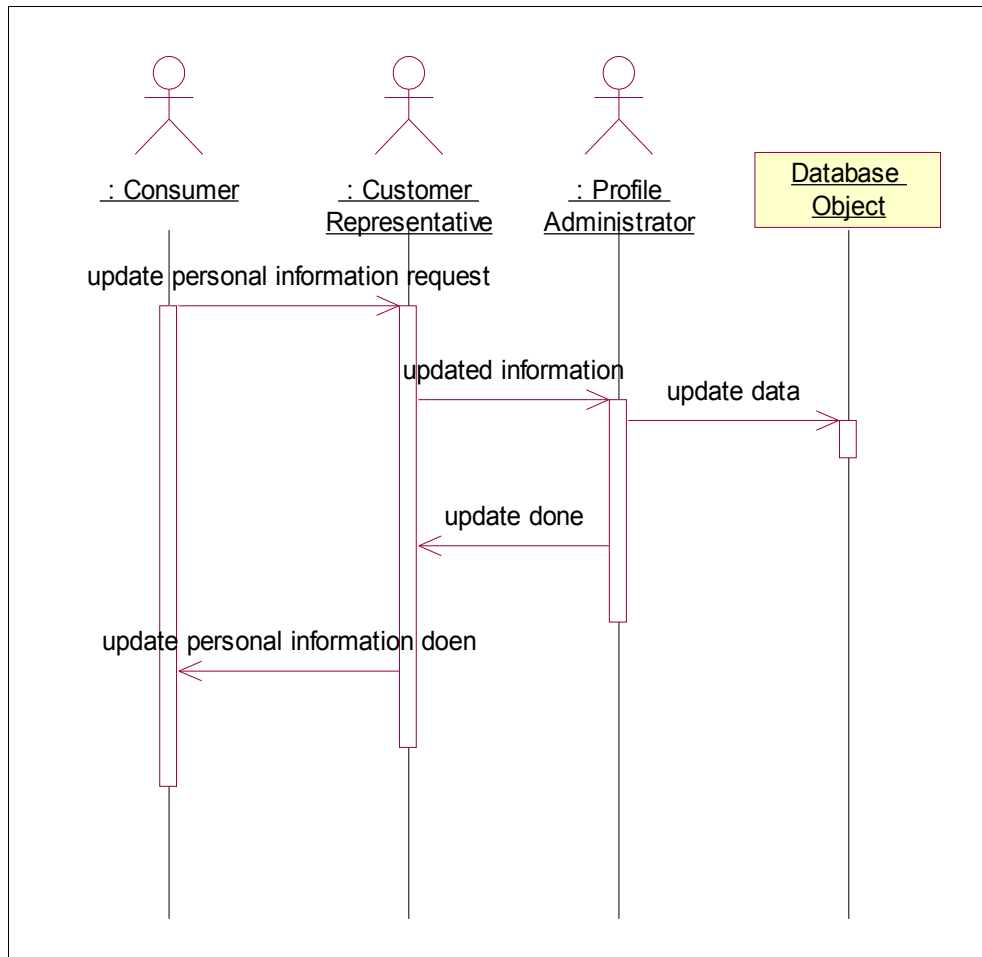
Figures 14 Register Sequence Diagram



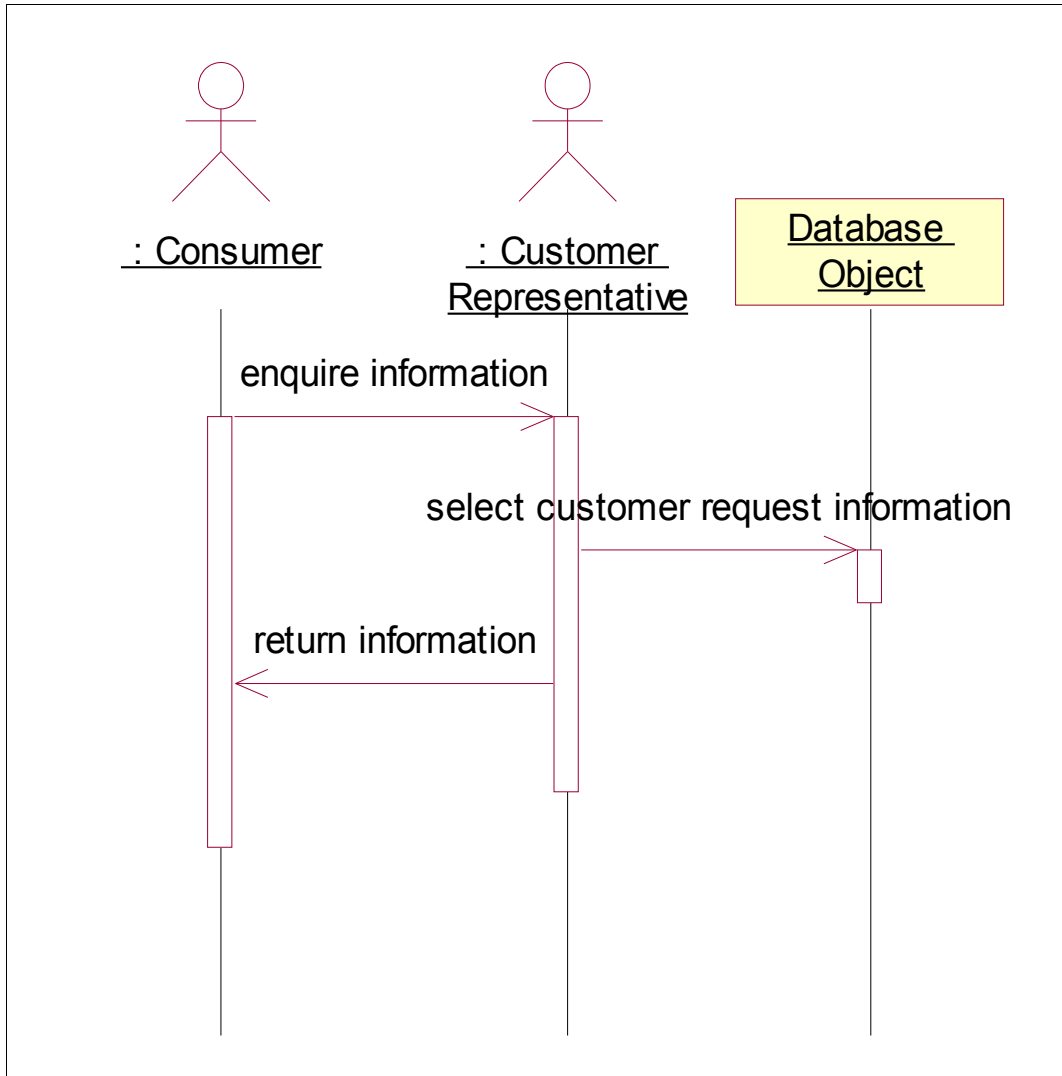
Figures 15 Sign In Sequence Diagram



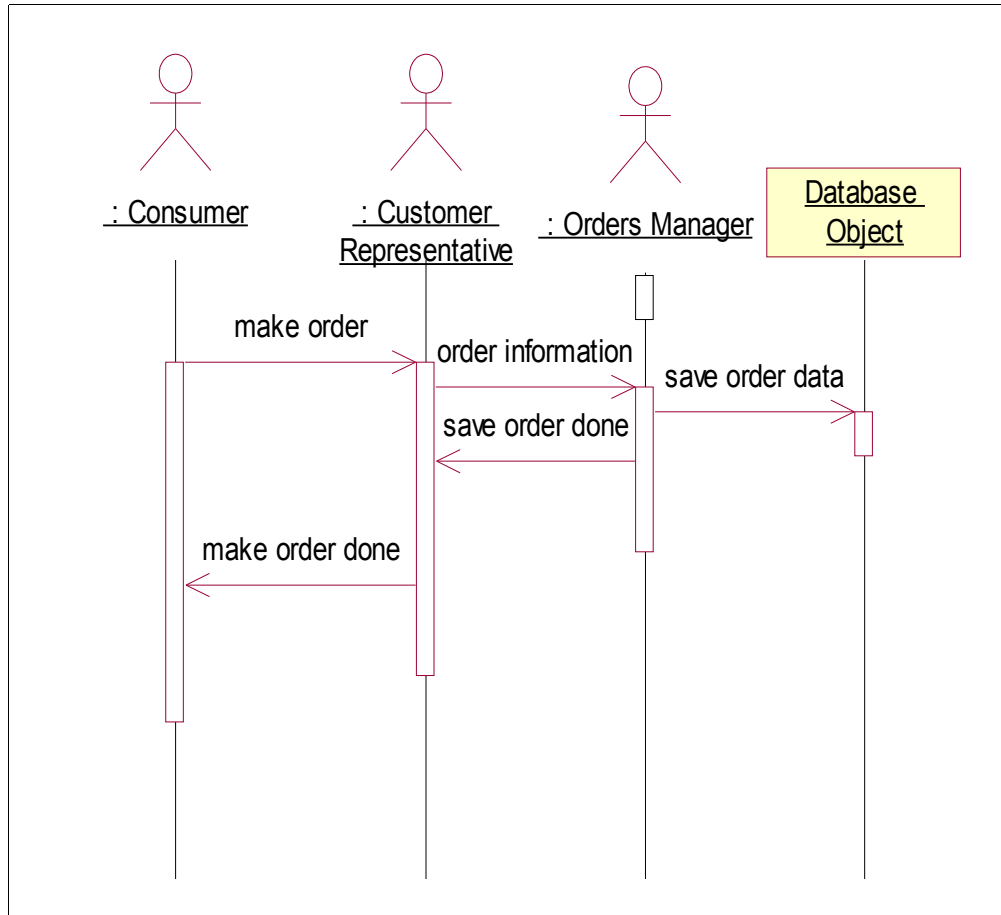
Figures 16 Sign Out Sequence Diagram



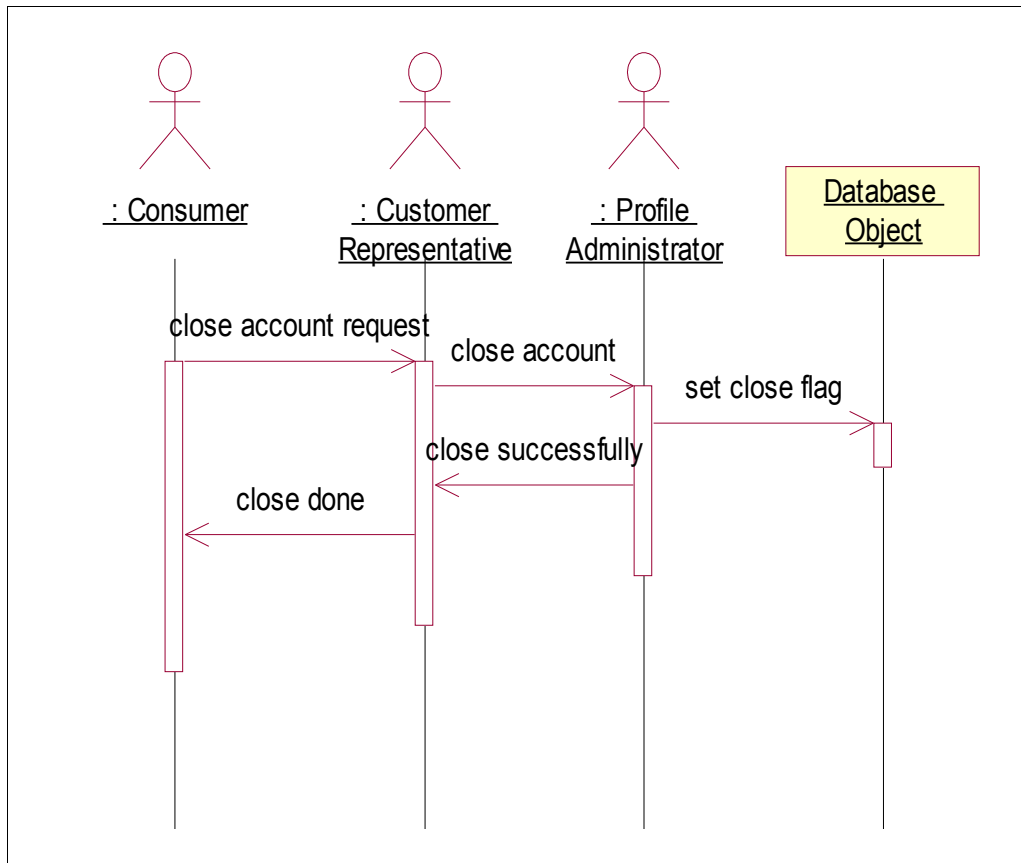
Figures 17 Update Consumer Profile Sequence Diagram



Figures 18 Inquire Sequence Diagram

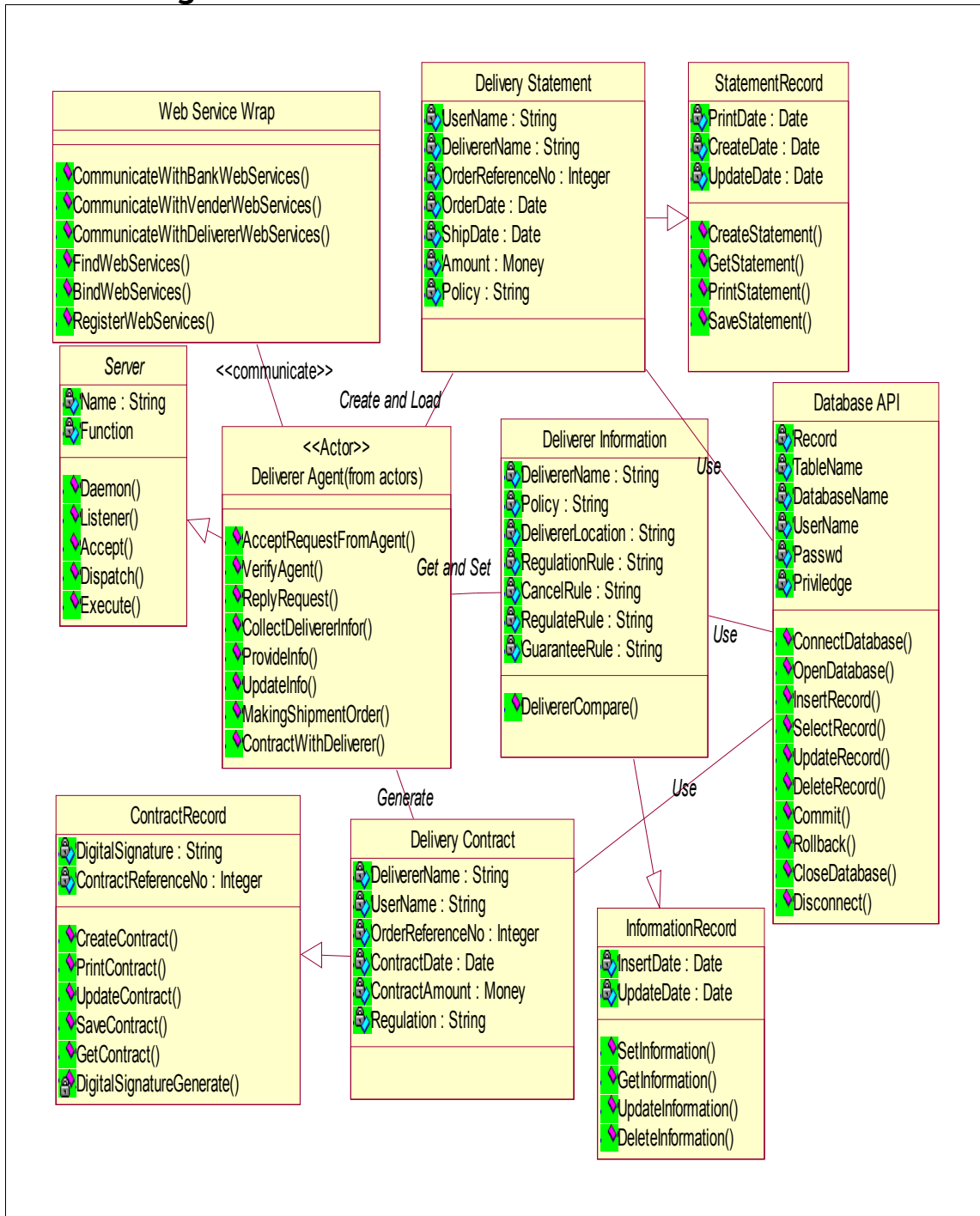


Figures 19 Making order Sequence Diagram

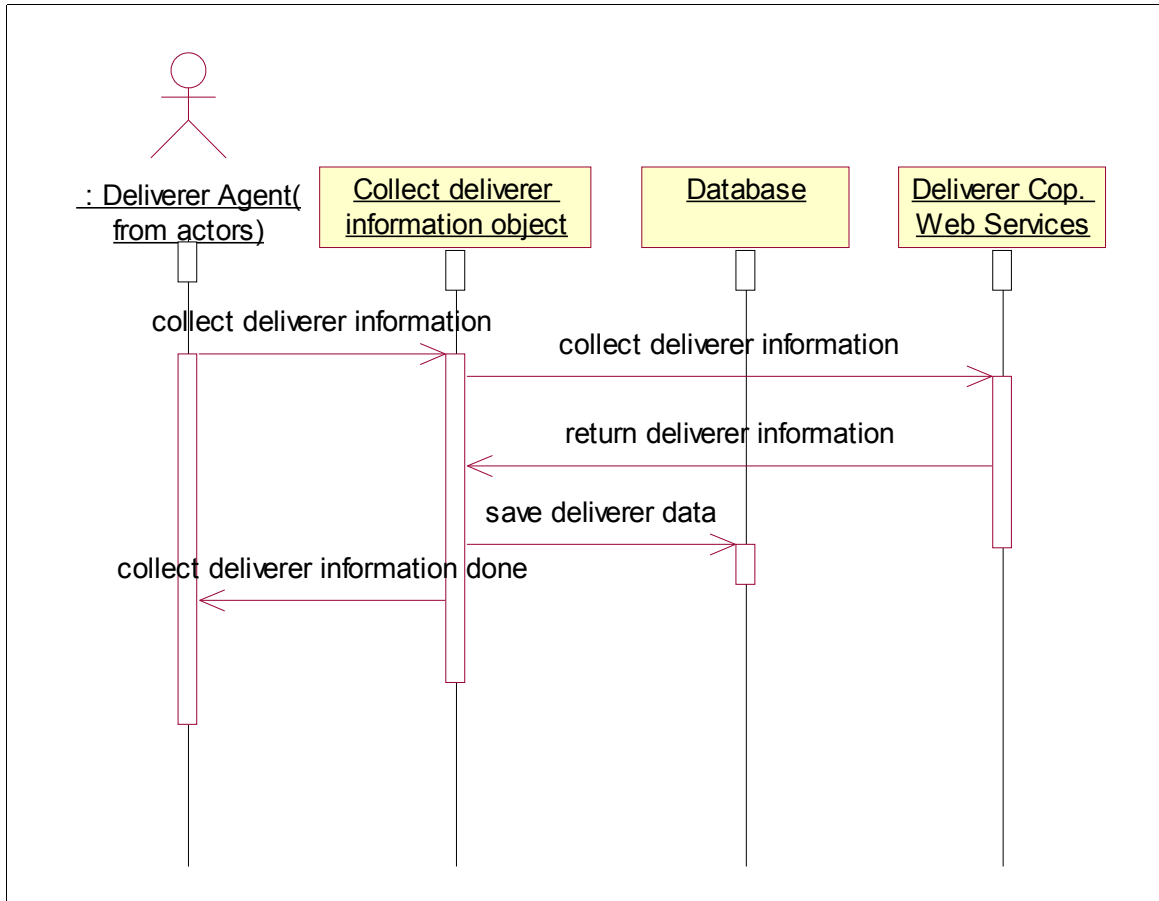


Figures 20 Close Account Sequence Diagram

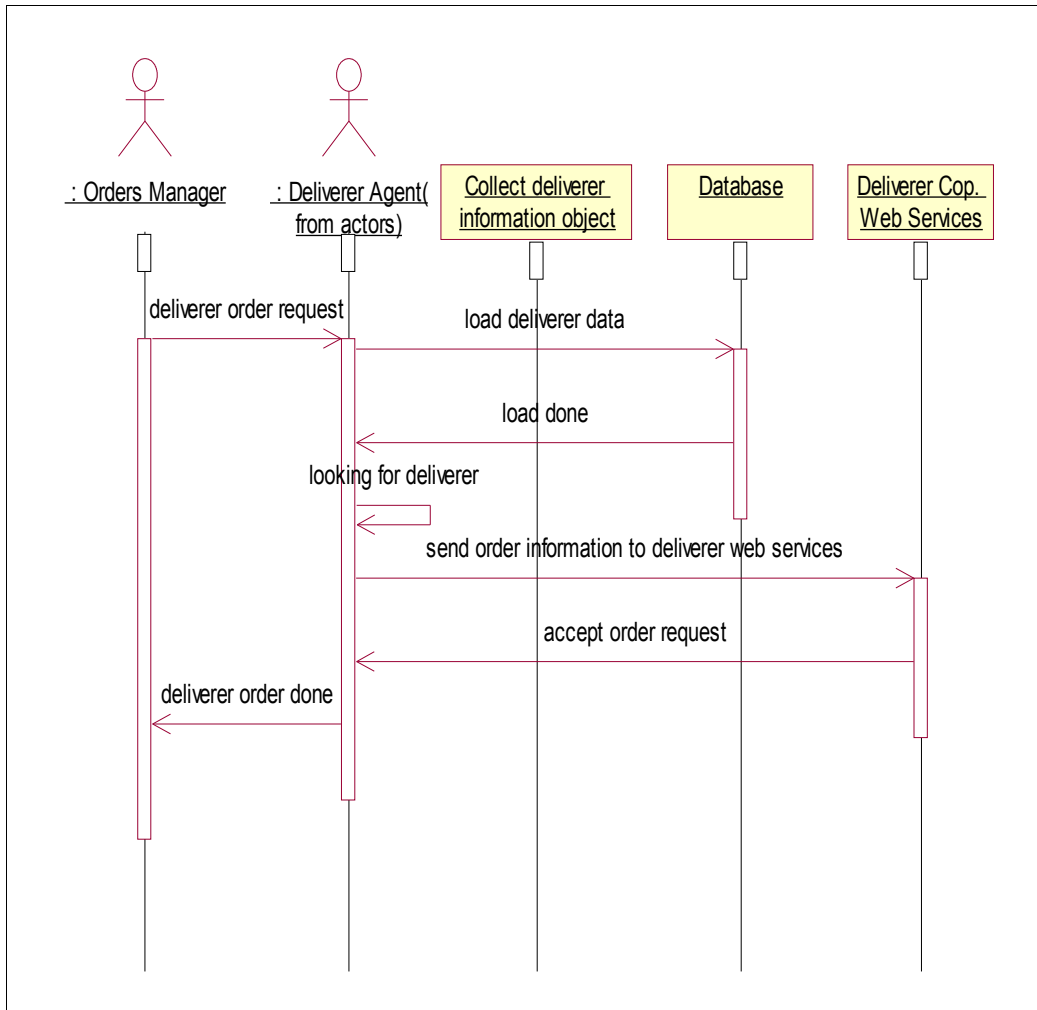
4.2.4 Deliverer Agent



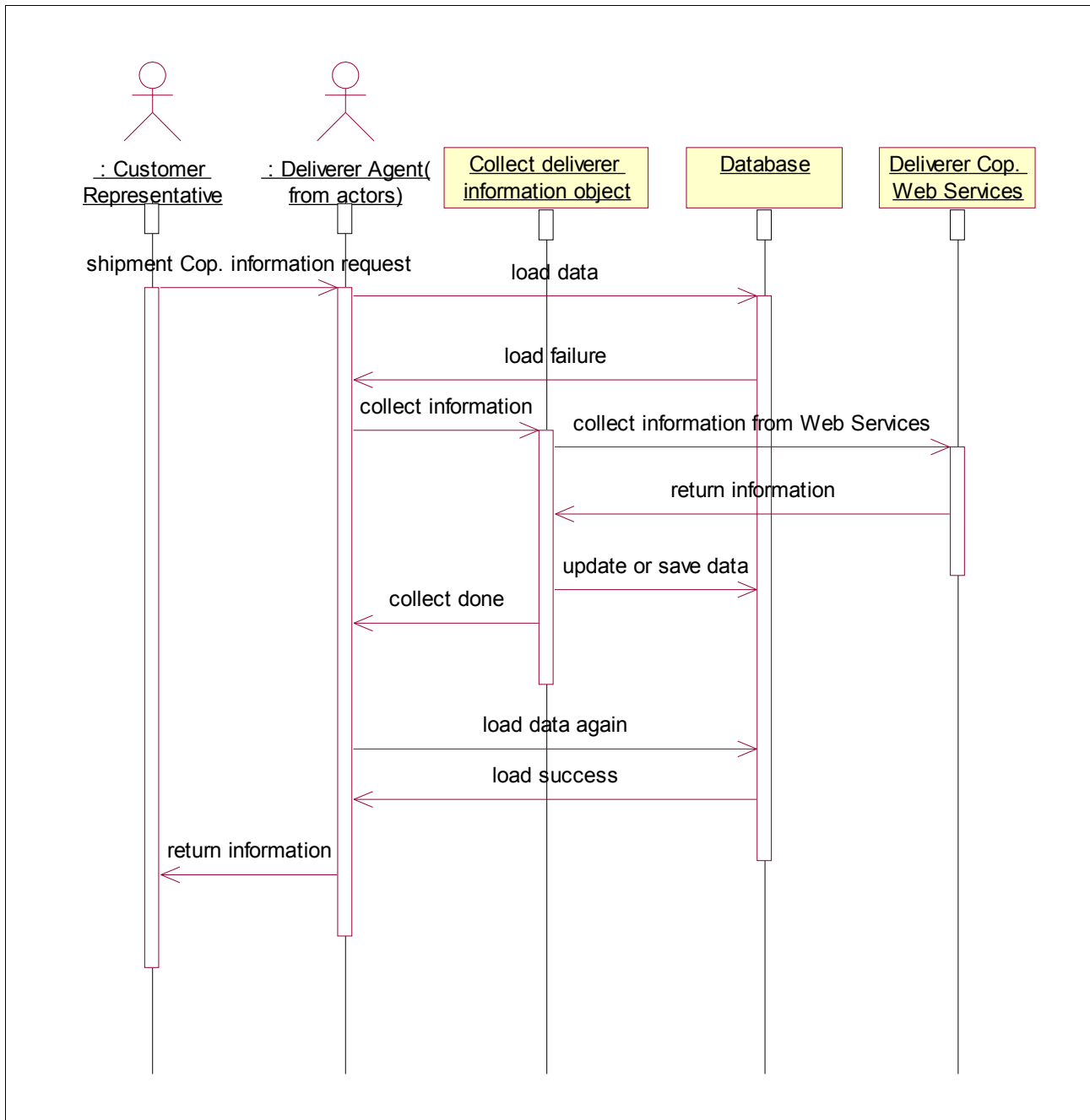
Figures 21 Deliverer Agent Class Diagram



Figures 22 Collect deliverer information Sequence Diagram

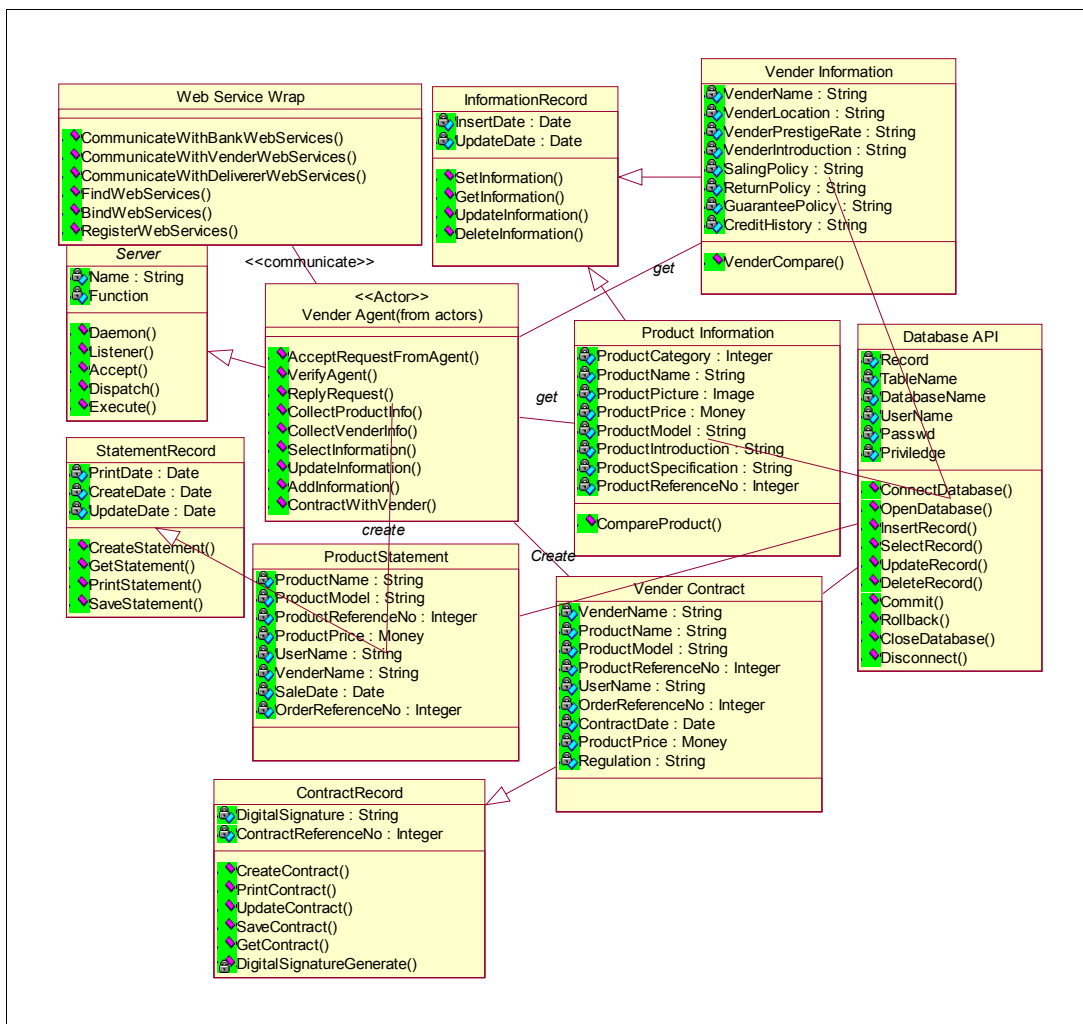


Figures 23 Shipment Order(Contract) Sequence Diagram

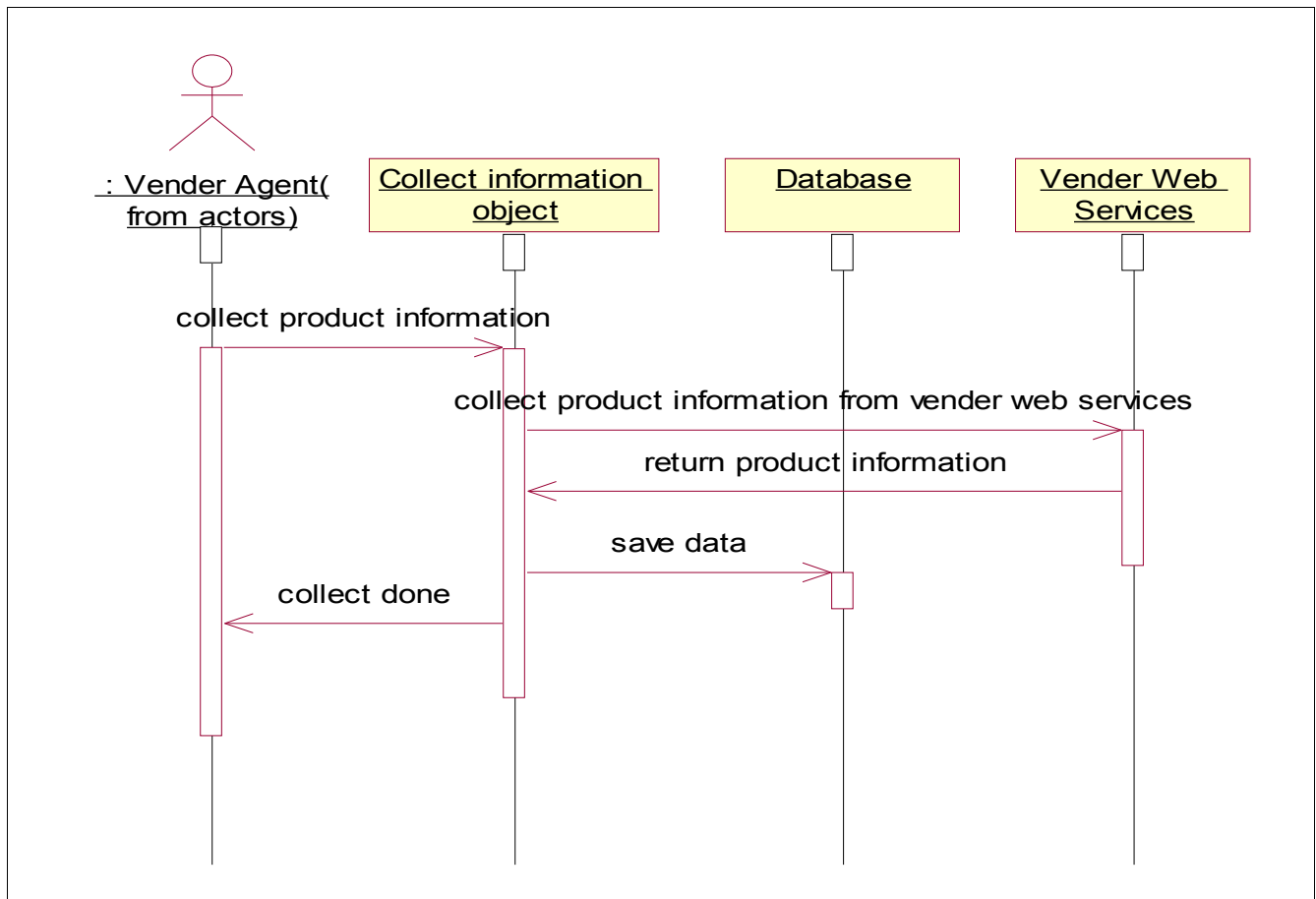


Figures 24 Provide Delivery Company (Services) Sequence Diagram

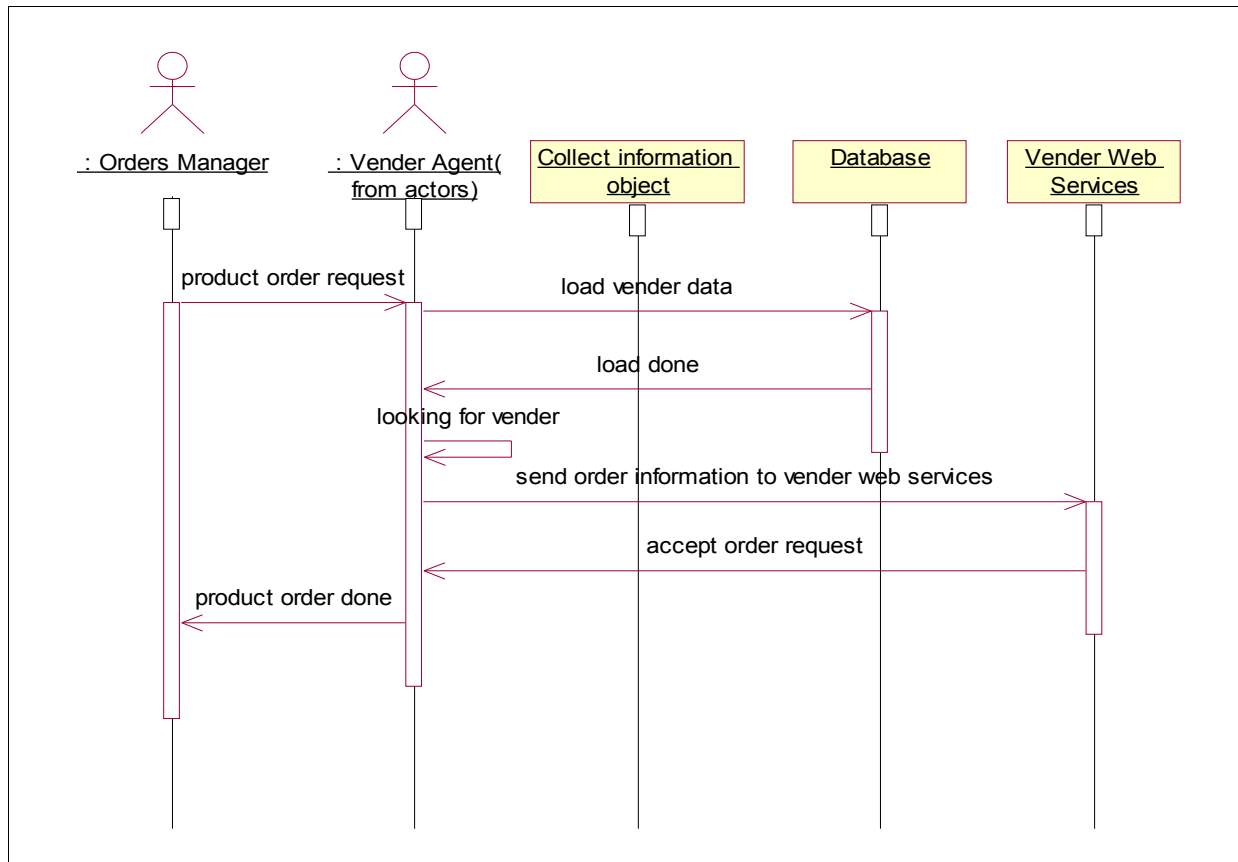
4.2.5 Vender Agent



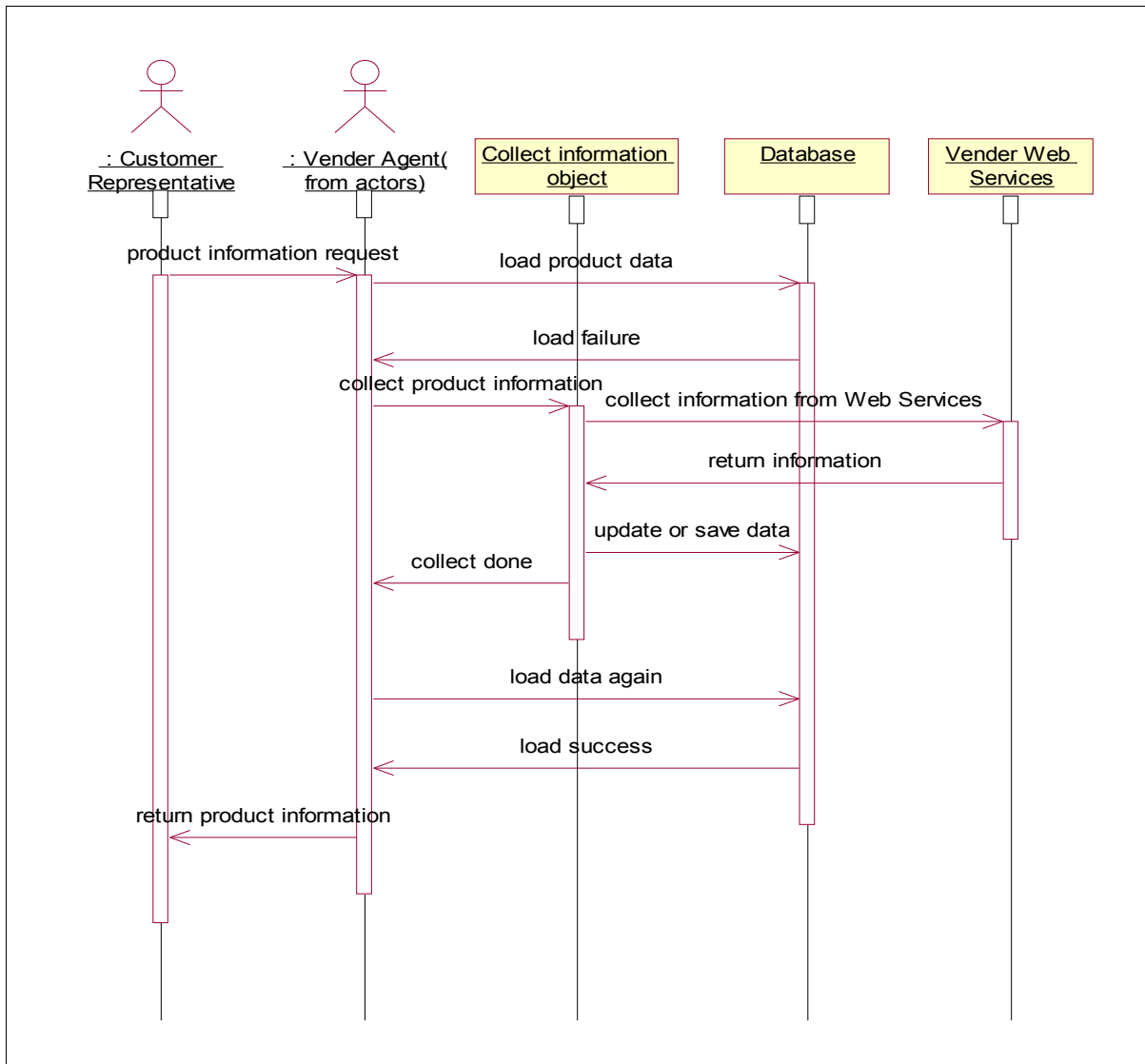
Figures 25 Veder Class Diagram



Figures 26 Collect Product Information Sequence Diagram (Vender)



Figures 27 Making product order Sequence Diagram (Vender)



Figures 28 Collect Product Information Sequence Diagram(Vender)

5. Data Specification

There is no database agent in PEC system. If all the agents running in a single node it is reasonable to have a database agent to complete database operation. It is impossible to let database agent perform database operation if different agents are running in different nodes since lots of communication overhead will reduce system performance. So each agent has its own database to store its data. All tables belonging to different agent will be detailed one by one.

5.1 PEC Agent

Only consumer's profile and order are stored in PEC Agent database. The product, vender, and delivery company information are given by the other agents. These information is only stored in its cache buffers.

5.1.1 Profile Table

<i>Data Element</i>	<i>Description</i>	<i>Type</i>
<i>Username</i>	<i>Unique username. It denotes login name in PEC system. It is primary key.</i>	<i>Char(16)</i>
<i>FirstName</i>	<i>Consumer's firstname.</i>	<i>Char(32)</i>
<i>LastName</i>	<i>Consumer's given name.</i>	<i>Char(32)</i>
<i>Password</i>	<i>Consumer's password</i>	<i>Char(6)</i>
<i>Address</i>	<i>Consumer's mailing address.</i>	<i>Varchar(255)</i>
<i>State</i>	<i>State or province</i>	<i>Varchar(64)</i>
<i>ZipCode</i>	<i>Zip code or postal code</i>	<i>Varchar(16)</i>
<i>Country</i>	<i>Country</i>	
<i>HomePhone</i>	<i>Home phone number</i>	<i>Varchar(24)</i>
<i>BusinessPhone</i>	<i>Business phone number</i>	<i>Varchar(24)</i>
<i>CreditCardType</i>	<i>Only two type will be accepted by system: Visa, Master</i>	<i>Char(1)</i>
<i>ExpireDate</i>	<i>Card's expire date.</i>	<i>Char(5)</i>
<i>CreditCardNo</i>	<i>Credit card number</i>	<i>Char(16)</i>
<i>Customer Id</i>	<i>Consumer's reference no. Unique number in system. Considering the efficiency of joining two tables to set this field.</i>	<i>integer</i>

Table 5 Profile Table

5.1.2 Order Table

<i>Data Element</i>	<i>Description</i>	<i>Type</i>
<i>OrderId</i>	<i>It is primary key. The unique number in the system</i>	<i>Integer</i>
<i>CustomerId</i>	<i>It links to Profile table:CustomerId</i>	<i>Integer</i>
<i>OrderDate</i>	<i>It means the date of making order.</i>	<i>Date</i>
<i>OrderTime</i>	<i>It means the time of making order.</i>	<i>Time</i>
<i>VenderName</i>	<i>The product seller's name.</i>	<i>Varchar(128)</i>
<i>VenderId</i>	<i>The seller's index number.</i>	<i>Integer</i>
<i>VenderContractNo</i>	<i>The value of this field receives from vender agent.</i>	<i>Integer</i>
<i>DelivererName</i>	<i>It denotes shipment company name.</i>	<i>Varchar(128)</i>
<i>DeliveryId</i>	<i>The value of this field receives from deliverer agent.</i>	<i>Integer</i>
<i>DeliveryContractNo</i>	<i>The value of this field receives from deliverer agent.</i>	<i>Integer</i>
<i>DeliveryPrice</i>	<i>The money customer pays to delivery company.</i>	<i>Money</i>
<i>DeliveryDate</i>	<i>Delivery date</i>	<i>Date(8)</i>
<i>ProductName</i>	<i>The merchandise customer ordered.</i>	<i>Varchar(128)</i>
<i>ProductModel</i>	<i>The category of merchandise.</i>	<i>Varchar(128)</i>
<i>ProductId</i>	<i>The index of merchandise.</i>	<i>Integer</i>
<i>ProductPrice</i>	<i>The list price of merchandise.</i>	<i>Money</i>
<i>TotalPrice</i>	<i>The sum of productprice and deliveryprice.</i>	<i>Money</i>
<i>DigitalSignature</i>	<i>It is created by system in order to prevent record being modified manually.</i>	<i>Char(16)</i>

Table 6 Order Table

5.2 Bank Agent

There are two tables in this agent.

5.2.1 Bank Information

<i>Data Element</i>	<i>Description</i>	<i>Type</i>
<i>BankName</i>	<i>Bank name</i>	<i>Varchar(256)</i>
<i>BankLocation</i>	<i>Bank location</i>	<i>Varchar(256)</i>
<i>BankId</i>	<i>Bank Id</i>	<i>integer</i>

Table 7 Bank Information

5.2.2 Transaction Record

<i>Data Element</i>	<i>Description</i>	<i>Type</i>
<i>TransactionId</i>	<i>It is the primary key. Unique number in this table.</i>	<i>Integer</i>
<i>OrderId</i>	<i>It is from PEC agent.</i>	<i>Integer</i>
<i>CustomerId</i>	<i>It is from PEC agent. It denotes which customer makes the order.</i>	<i>integer</i>
<i>ReceiverName</i>	<i>It is from PEC agent. It could be seller or delivery company.</i>	<i>Integer</i>
<i>ReceiverId</i>	<i>It is from PEC agent. It could denote seller or delivery company.</i>	<i>Integer</i>
<i>PayDate</i>	<i>The date of transaction.</i>	<i>Date</i>
<i>PayTime</i>	<i>The time of transaction</i>	<i>Time</i>
<i>PayAmount</i>	<i>The amount of payment.</i>	<i>Money</i>
<i>PayAccount</i>	<i>The account denotes where the money withdraws from.</i>	<i>Money</i>
<i>ReceiveAccount</i>	<i>The account denotes where the money deposits to.</i>	<i>money</i>

Table 8 Transaction Record

5.3 Deliverer Agent

5.3.1 Delivery Company Information

<i>Data Element</i>	<i>Description</i>	<i>Type</i>
<i>DeliveryId</i>	<i>It is the primary key in this table.</i>	<i>Integer</i>
<i>DeliveryName</i>	<i>The name of delivery company.</i>	<i>Varchar(128)</i>
<i>DeliveryLocation</i>	<i>The company's address.</i>	<i>Varchar(256)</i>
<i>PolicyDescription</i>	<i>It represents services policy.</i>	<i>Varchar(256)</i>
<i>GuaranteeDescription</i>	<i>If the field 'policydescription' could not contain all the services policy the rest of the policy could be stored in this field.</i>	<i>Varchar(256)</i>
<i>DeliveryPrice</i>	<i>The list price of the services.</i>	<i>money</i>

Table 9 Delivery Company Information

5.3.2 Contract Information

This table contains the contract information between agent and delivery company.

<i>Data Element</i>	<i>Description</i>	<i>Type</i>
<i>ContractsId</i>	<i>The primary key of this table.</i>	<i>Integer</i>
<i>OrderId</i>	<i>It is from PEC agent.</i>	<i>Integer</i>
<i>DeliveryId</i>	<i>It denotes the delivery company.</i>	<i>Integer</i>
<i>ContractDate</i>	<i>The date when customer makes order.</i>	<i>Date</i>
<i>ContractAmount</i>	<i>The transaction amount.</i>	<i>Money</i>
<i>Deadline</i>	<i>Customer's merchandise should be delivered before this date.</i>	<i>Date</i>
<i>ShippingDate</i>	<i>Shipping Date</i>	<i>Date</i>

Table 10 Contract Information (Agent and Delivery Company)

5.4 Vender Agent

5.4.1 Product Information

<i>Data Element</i>	<i>Description</i>	<i>Type</i>
<i>ProductId</i>	<i>The primary key of this table.</i>	<i>Integer</i>
<i>ProductName</i>	<i>Product name</i>	<i>Varchar(256)</i>
<i>ProductModel</i>	<i>Product model</i>	<i>Varchar(64)</i>
<i>ProductIntroduction</i>	<i>The brief description of products</i>	<i>Varchar(256)</i>
<i>ProductSpecification</i>	<i>The detail description of products</i>	<i>Varchar(256)</i>
<i>ProductPicture</i>	<i>The image of product.</i>	<i>Image</i>
<i>ProductPrice</i>	<i>The list price of product.</i>	<i>Money</i>
<i>ProductCategory</i>	<i>The class of product.</i>	<i>integer</i>

Table 11 Product Information

5.4.2 Seller Information

<i>Data Element</i>	<i>Description</i>	<i>Type</i>
<i>VenderId</i>	<i>The primary key of this table.</i>	<i>Integer</i>
<i>VenderName</i>	<i>The company's name.</i>	<i>Varchar(128)</i>
<i>VenderLocation</i>	<i>The address of the company.</i>	<i>Varchar(256)</i>
<i>VenderPrestigeRate</i>	<i>It is assigned by agent in order to rank the seller.</i>	<i>Char(1)</i>
<i>VenderIntroduction</i>	<i>The brief description of seller.</i>	<i>Varchar(256)</i>
<i>SalingPolicy</i>	<i>The services policy.</i>	<i>Varchar(256)</i>
<i>ReturnPolicy</i>	<i>If the customer want to return merchandise he/she should be obey this policy.</i>	<i>Varchar(256)</i>
<i>GuaranteePolicy</i>		<i>Varchar(256)</i>
<i>Currency</i>	<i>The currency that is chosen by seller</i>	<i>Varchar(256)</i>

Table 12 Seller Information

5.4.3 Contract Information

This table contains the contract information between agent and product seller company.

<i>Data Element</i>	<i>Description</i>	<i>Type</i>
<i>ContractsId</i>	<i>The primary key of this table.</i>	<i>Integer</i>
<i>OrderId</i>	<i>It is from PEC agent.</i>	<i>Integer</i>
<i>VenderId</i>	<i>It denotes the seller company.</i>	<i>Integer</i>
<i>ContractDate</i>	<i>The date when customer makes order.</i>	<i>Date</i>
<i>ContractAmount</i>	<i>The transaction amount.</i>	<i>Money</i>
<i>ProductName</i>	<i>Product name</i>	<i>Varchar(128)</i>
<i>ProductModel</i>	<i>Product model</i>	<i>Varchar(64)</i>
<i>ProductId</i>	<i>Product Id</i>	<i>Integer</i>

Table 13 Contract Information (Agent and Seller)

6. PEC System Messages

As mentioned before SOAP is used to link inter-agents. SOAP uses XML as the communication language. Input and output messages used in the system is described. The detail content of the SOAP is left out.

6.1 Register

When customers first use this system they are asked to register first.

Request:

```
<Register>
  <FirstName>string</FirstName>
  <LastName>string</LastName>
  <UserName>string</UserName>
  <PassWord>string</PassWord>
  <Address>string</Address>
  <State>string</State>
  <Country>string</Country>
  <ZipCode>string</ZipCode>
  <HomePhone>string</HomePhone>
  <BusniessPhone>string</BusinessPhone>
  <AccountType>string</AccountType>
  <ExpiredDate>string</ExpiredDate>
  <AccountNo>string</AccountNo>
</Register>
```

Response:

```
<Register>
  <ValidationResult>string</ValidationResult>
</Register>
```

6.2 Sign in

Request:

```

<SignIn>
  <UserName>string</UserName>
  <PassWord>string</PassWord>
</SignIn>

```

Response:

```

<SignIn>
  <ValidationResult>string</ValidationResult>
</SignIn>

```

6.3 Sign out

Request:

```

<SignOut>
  <UserName>string</UserName>
</SignOut>

```

Response:

```

<SignOut>
  <ValidationResult>string</ValidationResult>
</SignOut>

```

6.4 Inquire information

Request:

```

<InquireInformation>
  <ProductName>string</ProductName>
  <ProductType>string</ProductType>
  <DeliveryName>string</DeliveryName>
  <DeliveryService>string</DeliveryService>
</InquireInformation>

```

Response:

Request:

```
<InquireInformation>
  <ProductName>string</ProductName>
  <ProductPicture>image</ProductPicture>
  <ProductCategory>integer</ProductCategory>
  <ProductModel>string</ProductModel>
  <ProductId>integer</ProductId>
  <ProductPrice>money</ProductPrice>
  <ProductSpecification>string</ProductSpecification>
  <DeliveryCompany>string</DeliveryCompany>
  <DeliveryServicePolicy>string</DeliveryServicePolicy>
  <DeliveryId>integer</DeliveryId>
  <ServicePrice>money</ServicePrice>
  <SellerName>string</SellerName>
  <SellerIntroduction>string</SellerIntroduction>
  <SellerId>integer</SellerId>
  <SalingPolicy>string</SalingPolicy>
  <GuaranteePolicy>string</GuaranteePolicy>
</InquireInformation>
```

6.5 Make order**Request:**

```
<MakeOrder>
  <ProductId>integer</ProductId>
  <SellerId>integer</SellerId>
  <DelivererId>integer</DelivererId>
  <UserName>string</UserName>
  <TotalPrice>money</TotalPrice>
</MakeOrder>
```

Response:

Request:

```
<MakeOrder>
  <OrderId>integer</OrderId>
  <ProductName>string</ProductName>
  <ProductModel>string</ProductModel>
  <ProductPrice>money</ProductPrice>
  <SellerName>string</SellerName>
  <SellerId>integer</SellerId>
  <DeliveryName>string</DeliveryName>
  <DeliveryId>integer</DeliveryId>
  <DeliveryPrice>money</DeliveryPrice>
  <TotalPrice>money</TotalPrice>
  <Date>date</Date>
  <Time>time</Time>
</MakeOrder>
```

6.6 Update profile

Request:

```
<UpdateProfile>
  <PassWord>string</PassWord>
  <Address>string</Address>
  <State>string</State>
  <Country>string</Country>
  <ZipCode>string</ZipCode>
  <HomePhone>string</HomePhone>
  <BusniessPhone>string</BusinessPhone>
  <AccountType>string</AccountType>
  <ExpiredDate>string</ExpiredDate>
  <AccountNo>string</AccountNo>
</UpdateProfile>
```

Response:

```
<UpdateProfile>  
  <ValidationResult>string</ValidationResult>  
</UpdateProfile>
```

6.7 Close profile

Request:

```
<CloseProfile>  
  <UserName>string</UserName>  
  <PassWord>string</PassWord>  
</CloseProfile>
```

Response:

```
<CloseProfile>  
  <ValidationResult>string</ValidationResult>  
</CloseProfile>
```

6.8 Ask Payment

This message is between PEC Agent and Bank Agent.

Request:

```

<AskPayment>
  <FirstName>string</FirstName>
  <LastName>string</LastName>
  <AccountType>string</AccountType>
  <AccountNo>string</AccountNo>
  <ExpiredDate>date</ExpiredDate>
  <TotalPayment>money</TotalPayment>
  <SellerName>string</SellerName>
  <SellerId>integer</SellerId>
  <PaySeller>money</PaySeller>
  <DeliveryName>string</DeliveryName>
  <DeliverId>integer</DeliverId>
  <PayDelivery>money</PayDelivery>
  <OrderId>integer</OrderId>
</AskPayment>
  
```

Response:

```

<AskPayment>
  <SuccessOrFailure>string</SuccessOrFailure>
</AskPayment>
  
```

6.9 Require PayStatement

Request:

```

<RequirePayStatement>
  <OrderId>integer</OrderId>
  <FirstName>string</FirstName>
  <LastName>string</LastName>
</RequirePayStatement>
  
```

Response:

```
<RequierPayStatement>
  <FirstName>string</FirstName>
  <LastName>string</LastName>
  <OrderId>integer</OrderId>
  <ReceiverName>string</ReceiverName>
  <ReceiverId>string</ReceiverId>
  <PayDate>date</PayDate>
  <PayTime>time</PayTime>
  <PayAmount>money</PayAmount>
</RequirePayStatemetn>
```

6.10 Ask Product Information

This message is between PEC Agent and Vender Agent.

Request:

```
<AskProductInfo>
  <ProductName>string</ProductName>
  <ProductModel>string</ProductModel>
  <ProductCategory>string</ProductCategory>
</AskProductInfo>
```

Response:

```
<AskProductInfo>
  <ProductSpecification>string</ProductSpecification>
  <ProductPrice>money</ProductPrice>
  <ProductPicture>image</ProductPicture>
  <ProductIntroduction>string</ProductIntroduction>
  <ProductId>integer</ProductId>
</AskProductInfo>
```

6.11 Ask Vender Information

This message is between PEC agent and Vender Agent.

Request:

```
<AskSellerInfo>
  <SellerName>string</SellerName>
</AskSellerInfo>
```

Response:

```
<AskSellerInfo>
  <SellerName>string</SellerName>
  <SellerLocation>string</SellerLocation>
  <SellerPrestige>string</SellerPrestige>
  <SellerIntroduction>string</SellerIntroduction>
  <SalingPolicy>string</SalingPolicy>
  <ReturnPolicy>string</ReturnPolicy>
  <GuaranteePolicy>string</GuaranteePolicy>
</AskSellerInfo>
```

6.12 Ask Order Product

This message is issued if PEC agent asks Vender agent to order some product.

Request:

```
<AskOrderProduct>
  <ProductId>integer</ProductId>
  <ProductName>string</ProductName>
  <ProductPrice>money</ProductPrice>
  <SellerName>string</SellerName>
  <SellerId>integer</SellerId>
  <OrderId>integer</OrderId>
</AskOrderProduct>
```

Response:

```
<AskOrderProduct>
  <SuccessOrFailure>string</SuccessOrFailure>
</AskOrderProduct>
```

6.12 Ask Delivery Information

This message is between PEC agent and Deliverer Agent.

Request:
<pre><AskDeliveryInfo> <DeliveryName>string</DeliveryName> </AskDeliveryInfo></pre>
Response:
<pre><AskDeliveryInfo> <DeliveryName>string</DeliveryName> <DeliveryLocation>string</DeliveryLocation> <DeliveryPolicy>string</DeliveryPolicy> <GuaranteePolicy>string</GuaranteePolicy> <DeliveryId>integer</DeliveryId> </AskDeliveryInfo></pre>

6.13 Ask Order Delivery Service

Request:
<pre><AskDeliveryServices> <DeliveryName>string</DeliveryName> <UserName>string</UserName> <OrderId>integer</OrderId> <DeliveryId>integer</DeliveryId> <DeliveryPrice>money</DeliveryPrice> <DeliveryRegulation>string</DeliveryRegulation> </AskDeliveryServices></pre>
Response:
<pre><AskDeliveryServices> <SuccessOrFailure>string</SuccessOrFailure> </AskDeliveryServices></pre>

6.14 Ask Delivery Statement

Request:

```
<AskDeliveryStatement>  
  <OrderId>integer</OrderId>  
  <UserName>string</UserName>  
</AskDeliveryStatement>
```

Response:

```
<AskDeliveryStatement>  
  <UserName>string</UserName>  
  <DeliveryName>string</DeliveryName>  
  <OrderId>integer</OrderId>  
  <DeliveryId>integer</DeliveryId>  
  <OrderDate>date</OrderDate>  
  <ShipDate>date</ShipDate>  
  <Price>money</Price>  
</AskDeliveryStatement>
```

7. Conclusion

Analyzing and designing an agent based system are not a simple work, especially for the students like us who just got to know the agent based software engineering. Picking up an appropriate topic and starting to analyze and design require a lot of domain knowledge. This is the reason we chose to design the Personal Electronic Commerce System because of our financial and retail backgrounds. We believe that these backgrounds helped us to build a more realistic system with reasonable functionalities.

During the implementation of this project, we were trying to identify enough agents, to assign as many as roles to the agents, and to design as many as communications among the agents. We realized that system design could cost so much time because the understanding of the system and the requirements of the users could change. Analyzing and identifying the roles of each agent are so helpful for the further system design.

Interactions among the agents are crucial to our agent based system. So we identified enough interaction messages among the agents and the result of this effort is that our system looks more realistic and more implementable.

The design presented in this document does not include everything a PEC system should have because of the limitation of the time frame. We have identified the wishing list which includes the functionalities that are nice to have in the future.

Overall, this project has given us the chance to understand the agent based system concept and methodologies more deeper and broader, and, sharpened the analyzing and designing skills of ours.

8. References

- [1] Dr. B.H. Far, Course slides for SENG609.22 Agent Based Software Engineering
- [2] Luis Ennser, Pietro Leo, Tamas Meszaros, Eric Valade, "The XML Files: Using XML for Business-to-Business and Business-to-Consumer Applications", ibmo.com/redbooks
- [3] John Ganci, Sanjoy Banik, Fabrizio Boaglio, Ashish Cowlagi, Miroslav Holec, Siva Kumar, "e-commerce Patterns for Building B2C Web Sites", ibm.com/redbooks
- [4] Frank Guerin and Jeremy Pitt, "Guaranteeing Properties for E-Commerce Systems", Intelligent and Interactive Systems, Department of Electrical & Electronic Engineering, Imperial College of Science, Technology & Medicine, {f.guerin, j.pitt}@ic.ac.uk
- [5] Alexander Artikis, Frank Guerin, and Jeremy Pitt, "Integrating Interaction Protocols and Internet Protocols for Agent-Mediated E-Commerce", Intelligent and Interactive Systems, Department of Electrical & Electronic Engineering, Imperial College of Science, Technology & Medicine, {a.artikis, f.guerin, j.pitt}@ic.ac.uk