Design and Implementation of Distributed File Access for Mobile Devices

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Abstract

The objective of this project is to explore a proposal to provide seamless file transferring between mobile device and remote servers, while the mobile device is moving among local stations based on IP network. At first, three proposals are presented. One of the best proposals (the third one) is selected for implementation. The implementation is done by taking advantage of several prevailing software techniques: J2ME, RMI and Java Servlet. J2ME is a platform to simulate the mobile devices(PDA). RMI is a Java package to construct a distributed system, which is an interpreter among the mobile device, local stations and remote server. The protocol used in the communication between mobile device and local station is HTTP, which is supported by Java Servlet.

There are two challenges in the implementation of the proposal. The first one is how to choose the techniques to connect mobile devices and the fixed IP stations and server. J2ME and RMI work perfectly with each other, in the simulation of the mobile connectivity among a distributed system. The second challenge is how to design the system in order to guarantee the file transferring seamlessly. Making three separate classes, MobileAgent, Placeholder and Requestholder, successfully solves this problem.

By Using the above three java based techniques, the result of the implementation of the proposal shows a good performance in simulating mobile file transfer between mobile devices and file servers.

Acknowledgements

I would like to express my sincere gratitude to my supervisor, my mentor – Dr. R.Jayakumar, for accepting me as his student, instructing me so much in this field.

I am also thankful to Dr.T.Radhakrishnan. Without his contribution, this report would not have been possibly completed.

Specially, I would like to thank my dearest parents and my beloved husband. Their greatest love is always my invincible backup.

Table of Contents

List of Figures

1. Introduction

Although the Internet offers access to information sources worldwide, typically we do not expect to benefit from that access until we arrive at some familiar point--whether home, office, or school. However, the increasing variety of wireless devices offering IP connectivity, such as PDAs, handhelds, and digital cellular phones, is beginning to change our perception of the Internet.

To understand the contrast between the current realities of IP connectivity and future possibilities, consider the transition toward mobility that has occurred in telephony over the past 20 years. An analogous transition in the domain of networking, from dependence on fixed points of attachment to the flexibility afforded by mobility, has just begun.

Mobile computing and networking should not be confused with the portable computing and networking we have today. In mobile networking, computing activities are not disrupted when the user changes the computer's point of attachment to the Internet. Instead, all the needed reconnection occurs automatically without any interaction [15].

Considering the above fact, it is worth to setup a system connecting mobile devices and fixed local stations based on IP network. Three proposals are presented in this paper to show the possibility of the system for this purpose. The first one is a broadcasting based solution. The location of a mobile device is broadcasted to all the adjacent local stations, such that the mobile device immediately knows where mobile device moves from, when mobile device roams to local station. Although using a centerlized station can optimize the solution, it introduces other new problems such as bottleneck and session state movement. The second solution gives a different way of describing the mobile location, which gives the coordinate (X,Y) of a mobile device by means of Global Position System (GPS). The third solution three is a query-based one. When a mobile device is moving around local stations, the location of the mobile device is always stored and updated in one remote server. The local station has to query the remote server to get the location where the mobile device moves from.

After consideration of various aspects, the third proposal is chosen as the test bed for the purpose of simulating and testing the solution. The technique is another important consideration in deciding how the system is implemented. Three Java based techniques, J2ME, RMI and Servlet, are chosen as the tools to implement the proposal, because Java is nicely independent of platform.

J2ME is a new, very small Java application environment. It is a framework for the deployment and use of Java technology in the post-PC world. It is suitable for the simulation of the mobile devices in the proposal stated in this project.

Java Remote Method Invocation (RMI) enables the programmer to create distributed Java technology-based to Java technology-based applications, in which the methods of remote Java objects can be invoked from other Java virtual machines, possibly on different hosts. A Java technology-based program can make a call on a remote object once it obtains a reference to the remote object, either by looking up the remote object in the bootstrap naming service provided by RMI or by receiving the reference as an argument or a return value. A client can call a remote object in a server, and that server can also be a client of other remote objects. RMI uses object serialization to marshal and unmarshal parameters and does not truncate types, supporting true object-oriented polymorphism.

Java Servlet technology provides web developers with a simple, consistent mechanism for extending the functionality of a web server and for accessing existing business systems. A servlet can almost be thought of as an applet that runs on the server side -- without a face. Java servlets have made many web applications possible. We use HTTP protocol to transfer the file between mobile devices and local IP stations.

The implementation system consisted of three remote Unix hosts simulating local IP stations and Home Agent respectively, and one windows station simulating the mobile device.

2. Research on Mobile Devices and distributed network system

2.1 Terminology

Mobile agent: An autonomous program performs that some task on its own and moves across a computer network in order to complete its calculation.[10]

Mobile Object: It is the object of mobile agent that handles all the information about the Mobile Device. It moves between two or more Foreign Agent (FA), as Mobile Device moves around.[10]

Object Serialization: Object Serialization is the process of writing the state of an object to a byte stream. This is useful when you want to store the state of an object in the persistent storage for example to a file. Once the objects state is stored in a persistent storage area, the object deserialization process restores the object state back. The object serialization process is required in Java RMI (Remote Method Invocation). Once the object is serialized you can send the object to a hard disk or across the network . You can also say object serialization is the process of converting the Java object into bit-blot.[11]

Serialization: The mechanism used by RMI to pass objects between JVMS, either as arguments in a method invocation from a client to a server or as return values from a method invocation. Main uses of serialization are:[6]

- As a persistence mechanism, if the stream being used is FileOutputStream, then the data will automatically be written to a file.

- As a copy mechanism ByteArrayOutputStream to create duplicates of the original objects.
- As a communication mechanism: if the stream is coming from a socket, it can be automatically sent over the wire to a receiving socket.

Distributed system: A collection of loosely coupled processors interconnected by a communication network.[8]

Distributed File System (DFS): It is a file-service system whose users, servers, and storage devices are dispersed among the various sites of a distributed system.[8]

3. The concept of Mobile Distributed File Access System (MDFAS)

Before the description of three solutions based on the three proposals, it is necessary to introduce the concept of Mobile File Access Distributed System (MDFAS).

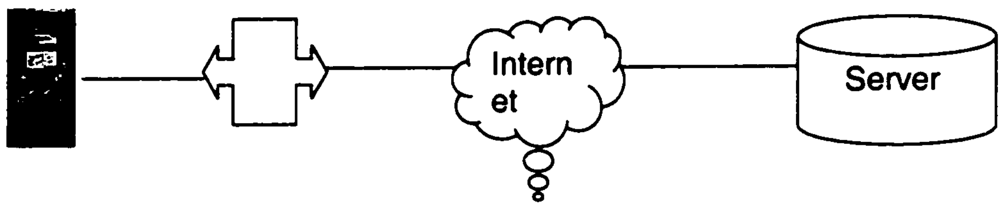
3.1 Definition of MDFAS

The MDFAS is a combination of mobile access distributed system and file transfer system. It gives the mobile devices (i.e. PDA, cell phone) the ability of transferring files between the file server and itself, while it is in mobile status. In general, MDFAS should be automated to support accurate services for Mobile Devices. It has the following features:

- A Mobile device is able to send/receive files while it is moving around local stations.
- File must be transferred/stored in a safe way.
- The response time, when mobile device moves from one station to another, should be short enough to keep the file transfer seamless.

3.2 Requirement of MDFAS

The elements involved in MDFAS is shown in the following figure:



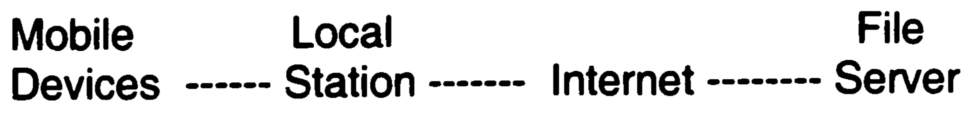


FIGURE 3-1 Requirement of MDFAS

The MDFAS basically consists of four elements: mobile device, local station, and Internet connection and file server. The connection between a mobile device and local station is wireless. Local station is actually a node with two interfaces. The mobile side interface is in charge of the communication with the mobile device. It can handle the roaming of the mobile device. The network side interface is in charge of connection between local station and file server. All the data transfer from the mobile device to IP network has to be nicely handled in local station, in order to guarantee the correctness and entirety of the data. File server has to keep a record of the necessary information (i.e., the location of the mobile device).

The key point in MDFAS is how to synchronize the data transfer when mobile device is moving around local stations. Certain technology must be utilized to realize this function.

4. Solutions

According to the ideas presented in the three proposals, three solutions are introduced in this report. All three solutions are the extensions of the basic MDFAS model. Their system structure and functionalities will be stated in detail in the following.

4.1 Solution 1

Solution 1 provides a broadcasting based solution that the location of mobile device is broadcast to all the adjacent local stations so that mobile device immediately knows where a mobile device moves from. When a mobile device roams to a new local station, the station can get all session states from old location. Using a centralized station, called Home Agent, the solution can be optimized although it still introduces other new problems such as the problem that Home Agent may be involved in session state movement. The following figure shows the optimized solution.

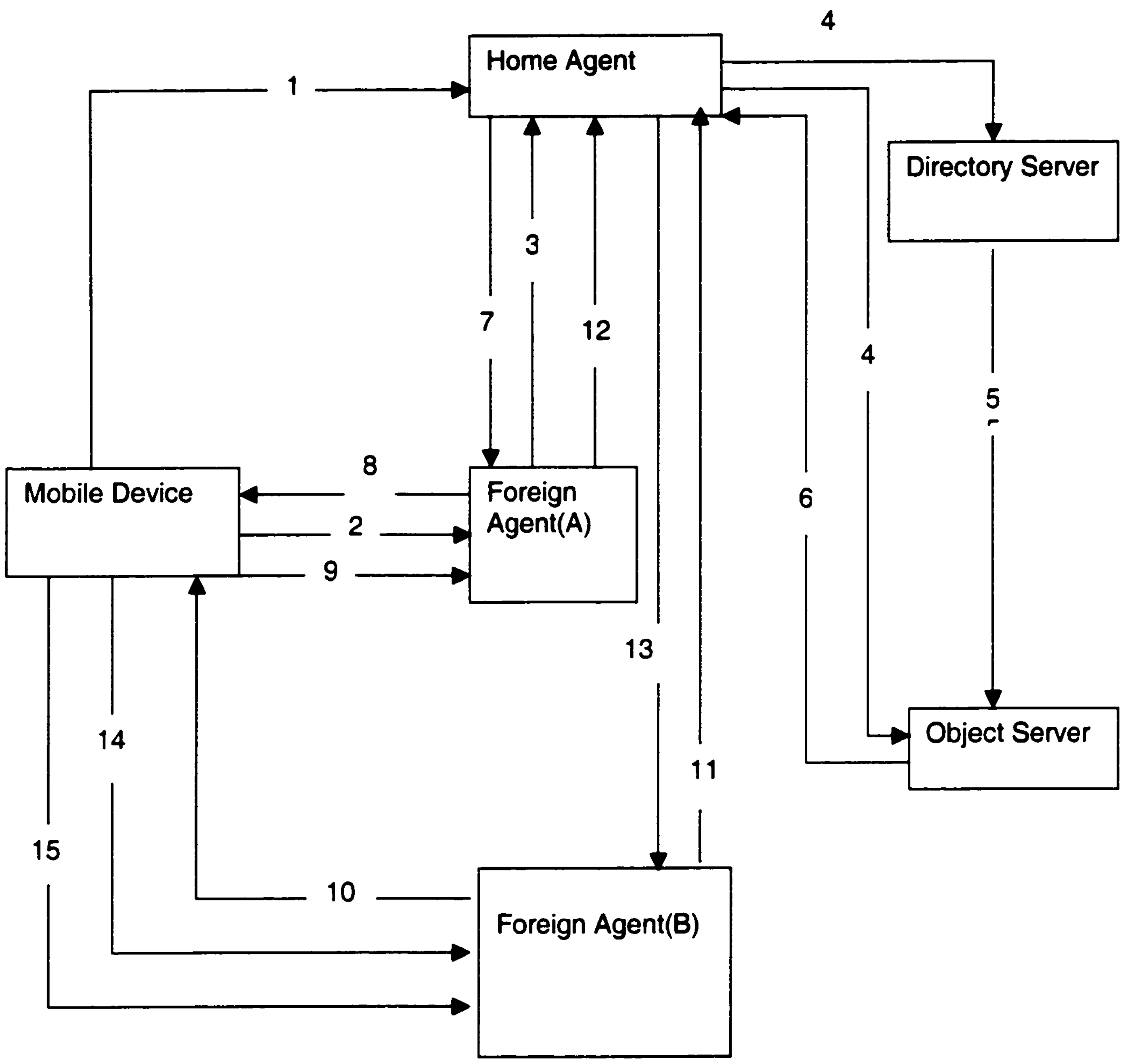


FIGURE 4-1 SYSTEM ARCHITECTURE OF SOLUTION 1

4.1.1 Functionality of the system

- Manually initialize a MOBILE DEVICE
- Display the current read/write information

- Update the current read/write information
- Handle data transfer between a MOBILE DEVICE and servers
- Store middleware status information when a MOBILE DEVICE is online
- Relocate new address from local area
- Provide a MOBILE DEVICE interface for read/write

4.1.2 Scenario of the system

The following steps (as indicated in Figure 4.1) illustrate the operation:

1. MOBILE DEVICE sends initial registration request to Home Agent
2. MOBILE DEVICE sends data service request to Foreign Agent (A) and update location information
3. Foreign Agent (A) forwards update location request to Home Agent
4. Home Agent sends data service request to directory server and object server
5. Directory server sends data service request to object server
6. Object server acknowledges the data service request to Home Agent (A) and returns required data.
7. Home Agent then responds to Foreign Agent (A) about data information.
8. Foreign Agent (A) continues responding to MOBILE DEVICE about data information.
9. MOBILE DEVICE sends other data service request commands, for example: read file, write file.
10. When MOBILE DEVICE moves from Foreign Agent(A) to Foreign Agent(B), MOBILE DEVICE is detected by Foreign Agent(B)

11. Foreign Agent (B) informs Home Agent immediately about the new MOBILE DEVICE by sending update location request.
12. At the same time, when Foreign Agent(A) disconnects from MOBILE DEVICE, Foreign Agent (A) have to upload the current information about MOBILE DEVICE to Home Agent
13. Home Agent receives the latest status information about MOBILE DEVICE, and Home Agent forwards status information to Foreign Agent(B)
14. New connection between MOBILE DEVICE and Foreign Agent (B) is set up
15. MOBILE DEVICE receives updated data from Foreign Agent(B)

4.1.3 Mobile Devices and Middleware(FA, HA)

The following figure shows the type of messages exchanged among them.

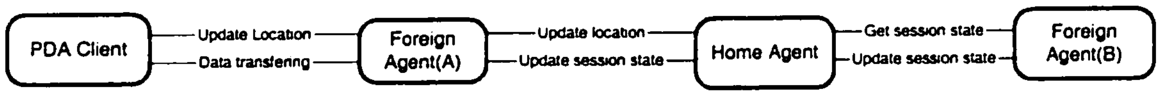


FIGURE 4-2 DIAGRAM OF MOBILE DEVICES AND MIDDLEWARE

The PDA client can send updatelocation and data transferring to foreign agent A. When foreign agent A receives the updatelocation request, it will forward to home agent. When the PDA client moves to another foreign agent B, foreign agent B sends getsessionstate request to home agent, home agent will send updatesessionstate request to foreign agent A, Upon receiving response, Home agent will send updatesession request to foreign agent B.

4.2 Solution 2

4.2.1 Problem Statement

Global Server Mobile(GSM) Functionality:

In this section we will describe the functions of GSM from the perspective of users. The GSM system consists of three major interconnected subsystems that interact with each other and with the users through certain network interfaces. The subsystems are called the Base Station Subsystem (BSS), Network and Switching Subsystem (NSS), and the Operation Support Subsystem (OSS). The Mobile Station (MS) is also a subsystem, but is usually considered to be a part of the OSS for architectural purpose.

4.2.2 Functionality of the system

This solution gives a different way of describing the mobile location, which gives the coordinate (X,Y) of the mobile device by means of Global Position System (GPS). Therefore, at the edge area where mobile may move to a new location, the Old Foreign Agent can find more suitable other Foreign Agent and move its object to the other Foreign Agent. The following figure shows the principle.

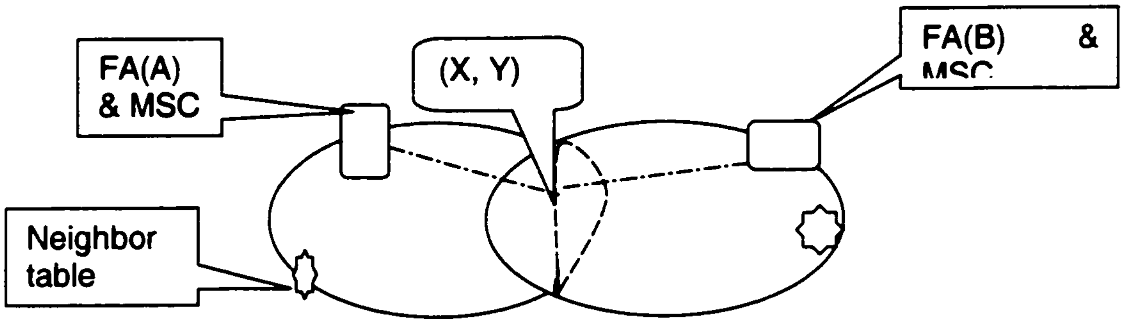


FIGURE 4-3 GSM IN MOBILE DEVICES FILE ACCESS SYSTEM

MSC: Mobile Server Center

GSM: Global Server Mobile

NT : neighbour table

- FA(foreign agent) can move to different object host(station)
- FA can decide when, how and where to move at the new address
- Mobile Station Center can calculate the coordinate(x,y) of the Mobile device

4.2.3 Scenario of the system

1 Mobile device sends signal every 10 seconds

2 When FA gets this information, FA find out whether or not the Mobile device is on the edge of the area.

3 When Mobile device is at the edge of the area, FA checks neighbor table on the current object host (server). Every object host has different neighbor table, it means it is configured manually in static manner.

4 When the Mobile device is in the area, the connection between the Mobile device and the Station continues.

5 FA can move to different object host after FA gets the new address of the station.

6 In GSM, mobile devices send signal in several seconds, two adjacent mobile station accept these signals.

7 FA can move one mobile object to a new suitable FA.

4.3 Solution 3

This solution is an inquiry-based system from the perspective of Mobile Device(MD) address searching. The IP addresses are stored in home agent. When MD moves from FA1 to FA2, FA2 does not know where MD moves from. FA2 must ask home agent (HA) where MD comes from. After getting the IP address of FA1 from HA, FA2 is now able to get mobile agent from FA1.

4.3.1 Architecture of the system

In Foreign Agent station, there are three objects, Mobile Agent object, which does data processing, PlaceHolder object, which moves mobile agent by using RMI and query location information with HomeAgent, RequestHolder object, which communicates with the Mobile device.

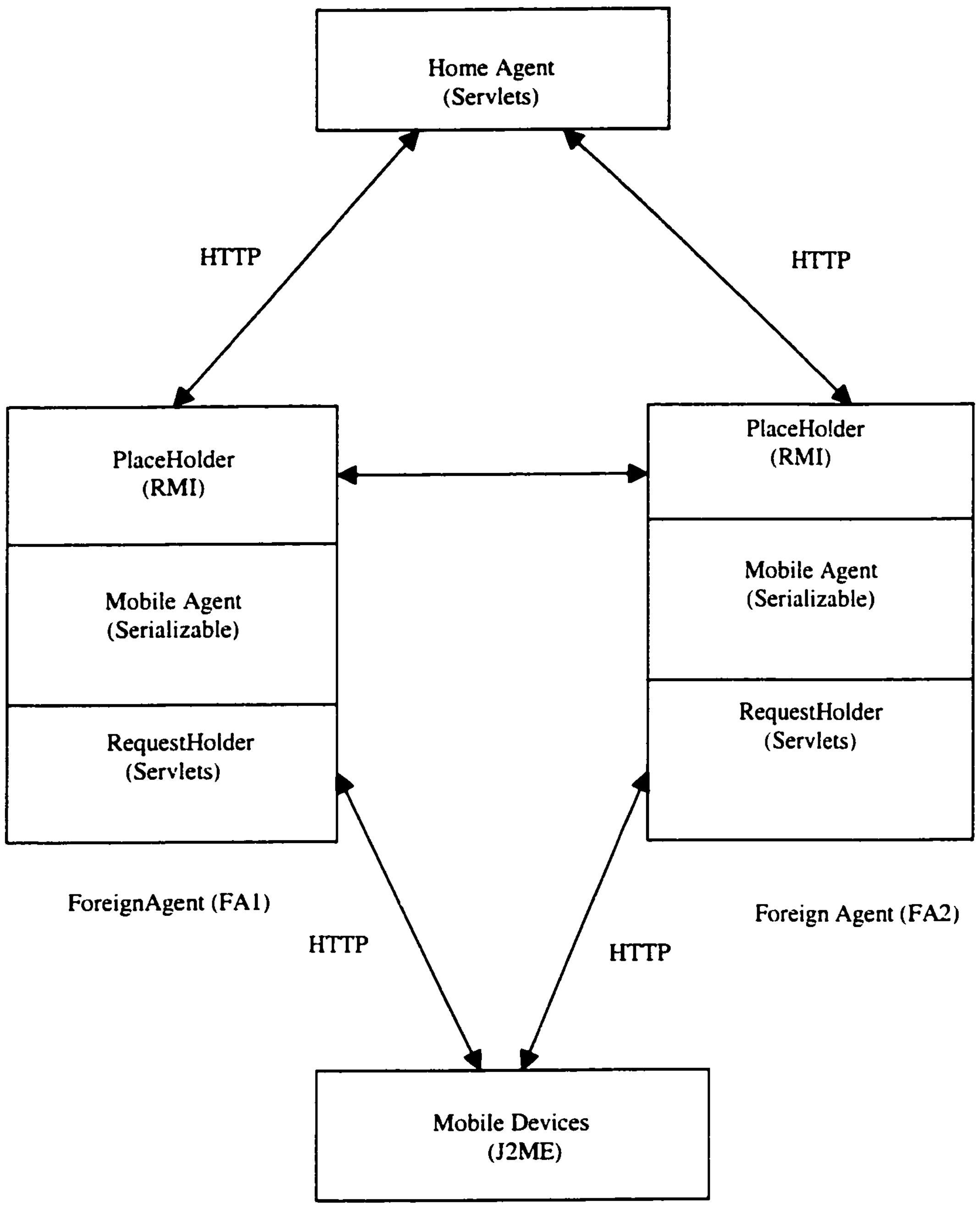


FIGURE 4-4 SYSTEM ARCHITECTURE OF SOLUTION 3

4.3.2 System functional requirement

This system consists of three elements: mobile device (MD), Foreign Agent (FA) and Home Agent (HA). MD is the mobile equipment (i.e., PDA or cell phone). Foreign Agent is actually the local station in the IP network, which is the connection point of the mobile device and the IP network. Home Agent (HA) is a node in the IP network playing the role of the file server, and address management for mobile devices. The above three elements work together to set up a system of MDFAS. The functionalities of each element are specified as follows:

Mobile Device

Mobile agent is simulated by the tool, J2ME, as an independent simulation program. It communicates with FAs by means http protocol. It is the mobile end of the file transfer.

Foreign Agent

Foreign agent is the core of the system. It is the intermediary between mobile devices and file server. As a result, it brings up three basic requirements:

- Communicate with mobile devices: All the data, either from the transferred file, or from the communication messages, must be properly handled by FA, so that when the mobile device moves around FAs, the connectivity is seamless. This is done by RequestHolder.

- Handle the mobile agent: Each mobile agent containing the dynamic status information for the session of file transfer corresponds to one mobile device. When a mobile device moves around FAs, the mobile agent corresponding to that mobile device moves around in consequence. The action of the mobile agent movement among FAs must be handled by FA appropriately. This is done by PlaceHolder.
- Communicate with Home Agent: The data for file transfer and mobile location tracking must be updated by the Home Agent.

Home Agent

Home agent is actually the place registering and storing the current address of the mobile agent.

4.3.3 System Non-Functional requirements

- The users must manually activate the Mobile device at first time from the original FA
- Three conditions must be satisfied to run the system
  1. Three remote hosts, one for HA, two for FA.
  2. Windows machine running simulation of Mobile device.
  3. Valid Internet connection.

4.3.4 Scenario of the system in FA

The FA consists of three parts: RequestHolder, PlaceHolder and Mobile Agent, corresponding to the three functional requirements described above. How they cooperate to complete the migration of mobile agent is the key point in the design of this system.

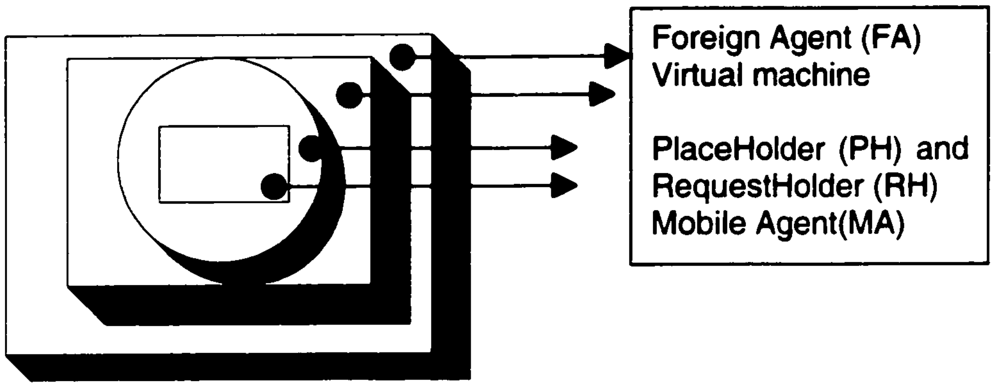


FIGURE 4-5 SYSTEM CONSTRUCTION

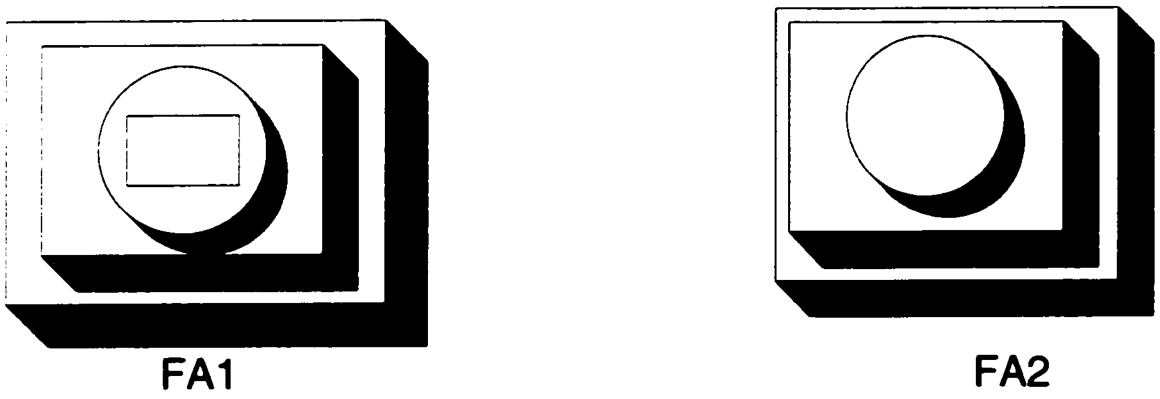


FIGURE 4-6 BEFORE AGENT MOVING

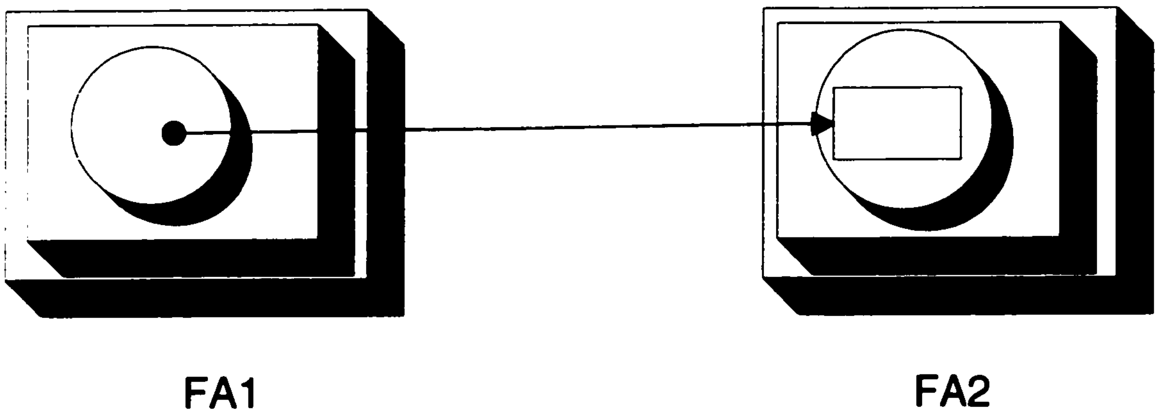


FIGURE 4-7 AFTER AGENT MOVING

1. RequestHolder gets the request from MD.
2. PlaceHolder(PH) in FA2 gets the object of Mobile Agent (MA) through RMI
3. PH2 calls moveto() of PH1 to inform PH1 of the new address where MA has moved to.
4. PH2 gets the object reference of PH2 through using RMI
5. PH1 calls method pass() of PH2 to transfer the object of MA of PH1 to PH2.
6. Agent manager 1 kills it's mobile agent
7. Agent manager 2 loads the agent which was transferred from FA1
8. Agent Manager 2 creates new object from real agent
9. New object agent starts to work

4.3.5 Use case design

As shown in Figure 4-8, the Foreign Agent has four function modules, one is for processing requests from the Mobile PDA, one is for Handling Read/Update Data requests. The other two are for Handling Move procedure and Get/Update agent location information module.

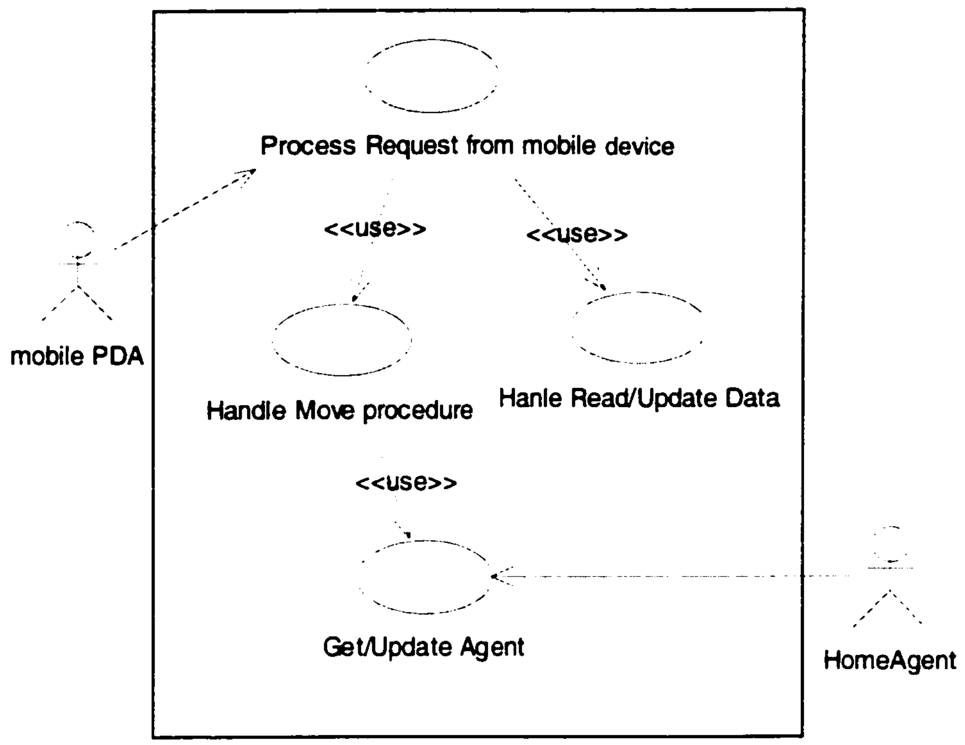


FIGURE 4-8 USE CASE DIAGRAM OF FOREIGN AGENT

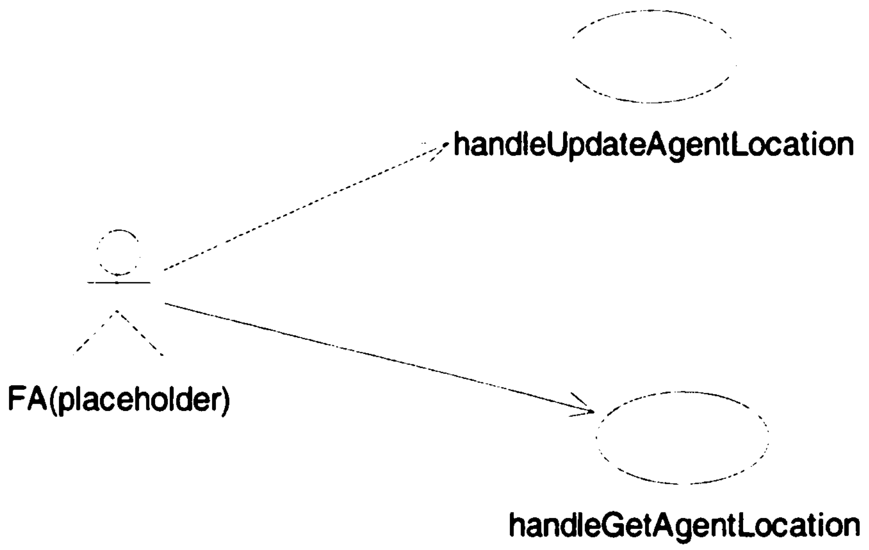


FIGURE 4-9 USE CASE DIAGRAM OF HOME AGENT

The Home Agent has two function modules as shown in Figure 4-9, one is to handle updateAgentLocation request from FA, the other is to handle GetAgentLocation request from FA.

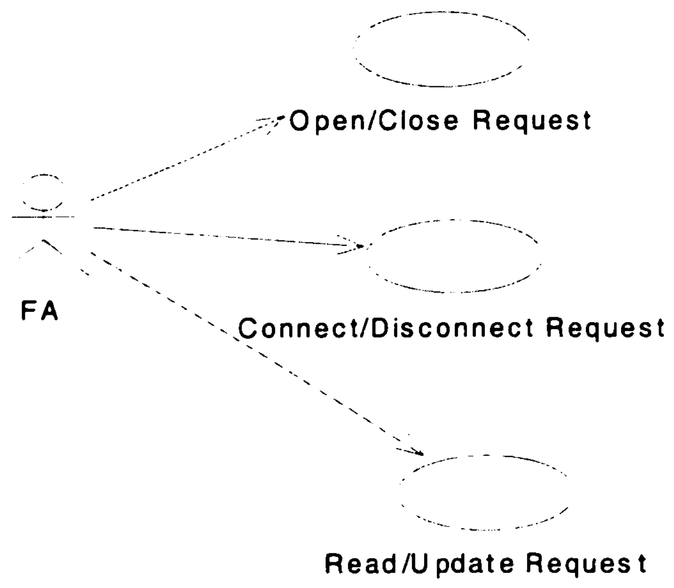


FIGURE 4-10 USE CASE DIAGRAM OF MOBILE

The Mobile has three function modules(Figure 4-10), one is to send Open/Close request to FA, one is to send Connect/Disconnect Request to FA, the third one is to send Read/Updaterequest to FA.

4.3.6 Class diagram design

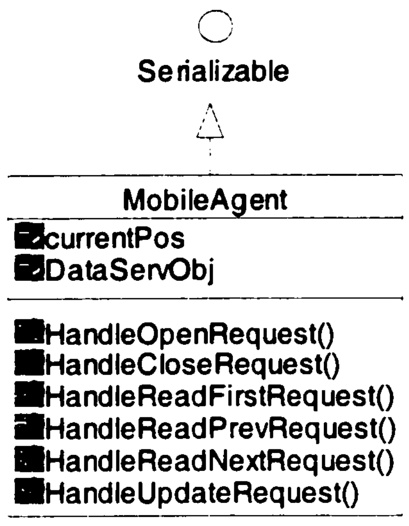


FIGURE 4-11 MOBILEAGENT CLASS DIAGRAM

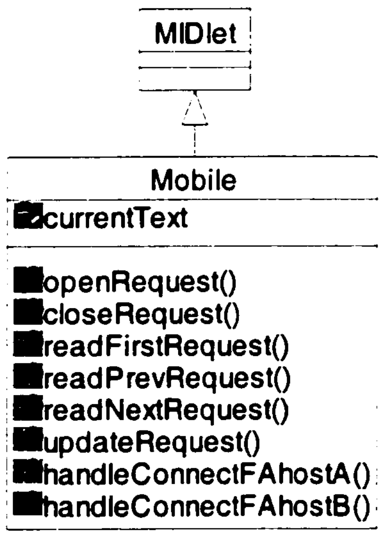


FIGURE 4-12 MOBILE CLASS DIAGRAM

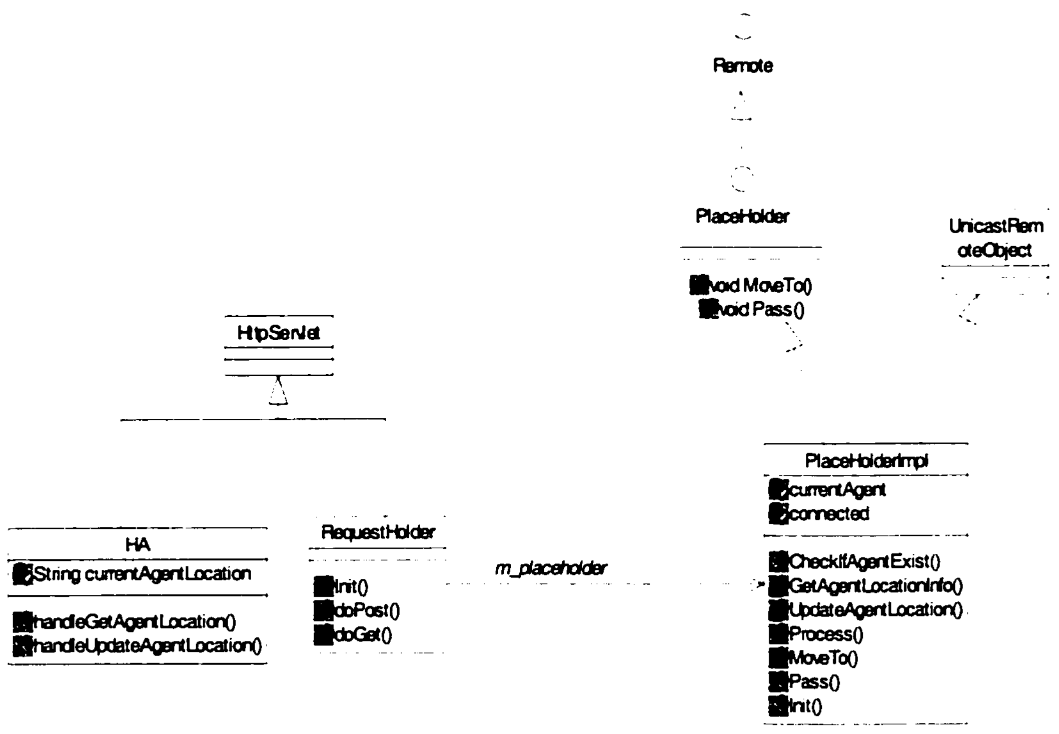


FIGURE 4-13 HA & FA CLASS DIAGRAM

4.3.7 Sequence diagram of the design

4.3.7.1 Connect FA1

As shown in Figure 4-14, Mobile handles to connect FA1, then invokes init method of FA1 RequestHolder to init FA1 RequtestHolder and to init FA1 PlaceHolder object with its local Naming Service.

FA1 RequestHolder receives Get Http request from mobile and forwards it to its local PlaceHolder object. FA1 PlaceHolderImpl will responsible for processing the request. It will first check if local mobile agent exists. If the mobile agent exists, it will process the request from mobile. Otherwise, it will send request to ask the Home Agent the location of the mobile agent. If the mobile agent doesn't exist in any Foreign Agent, a new mobile agent will be created in local agent. Then, send request to inform Home Agent that agent location will be updated.

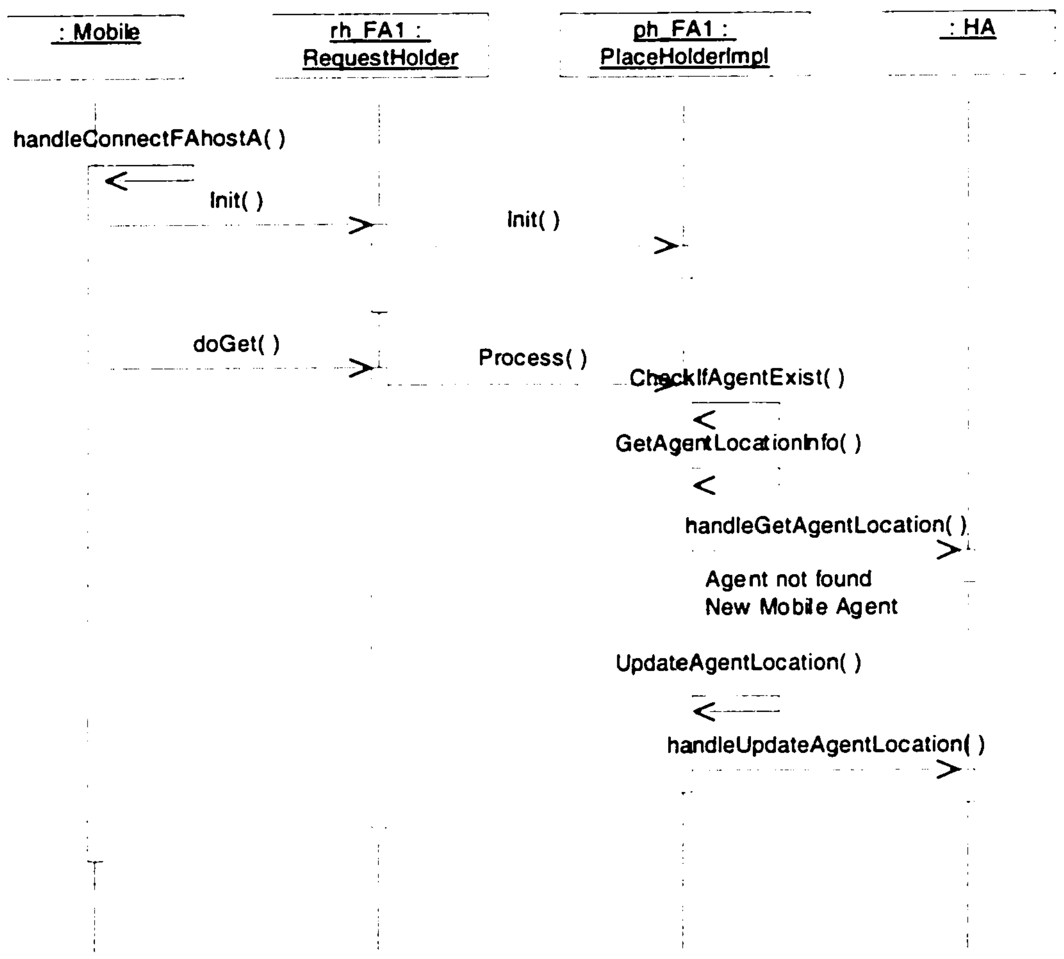


FIGURE 4-14 CONNECT FA1 SEQUENCE DIAGRAM

4.3.7.2 Connect FA2

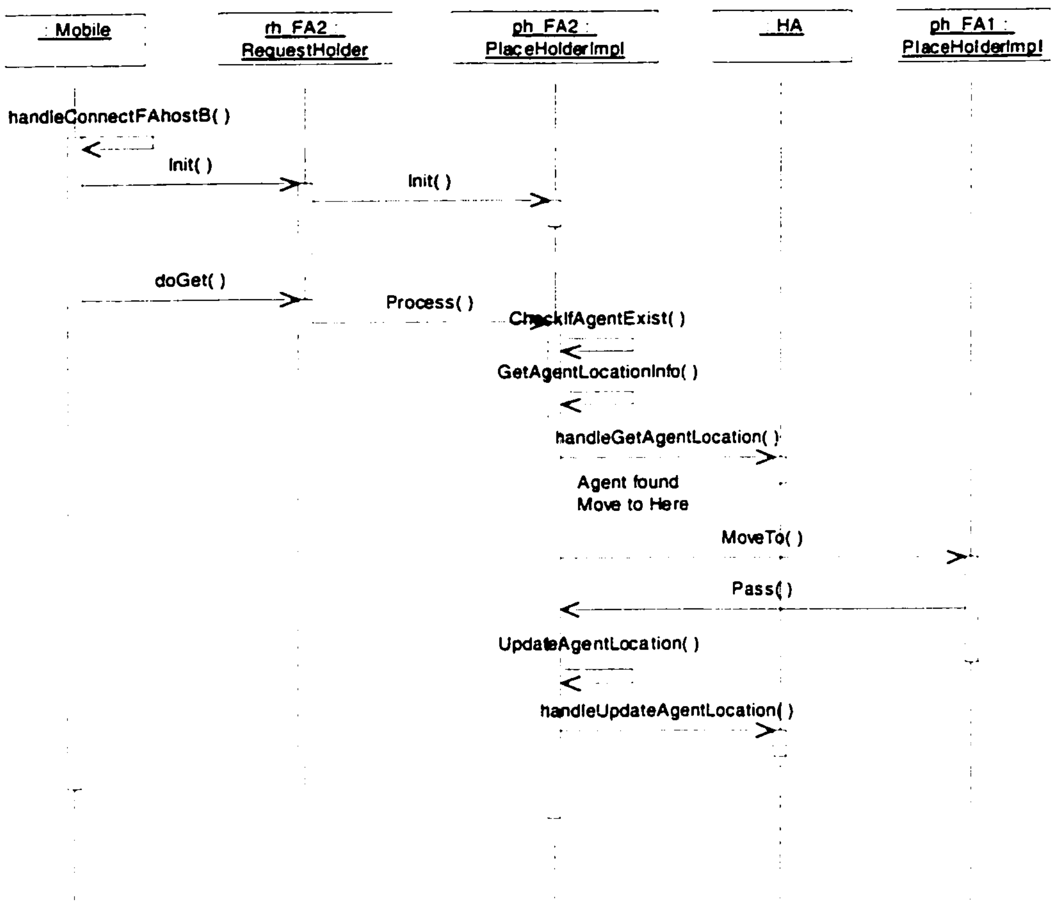


FIGURE 4-15 CONNECT FA2 SEQUENCE DIAGRAM

Mobile handles to connect FA2, then invokes init method of FA2 RequestHolder to init FA2 ReqtutestHolder and to init FA2 PlaceHolder object with its local Naming Service. FA2 RequestHolder receives Get Http request from mobile and forwards it to its local PlaceHolder object. FA2 PlaceHolderImpl is responsible for processing this request. It will first check if local mobile agent exists. If the mobile agent doesn't exist, it will send request to ask the Home Agent the locatin of the mobile agent. If the mobile agent exists in a remote Foreign Agent, FA2 will get the remote Agent location from Home Agent while move mobile agent from FA1 to FA2.Then, send request to inform Home Agent that agent location will be updated.

4.3.7.3 Data Request If Agent Exist

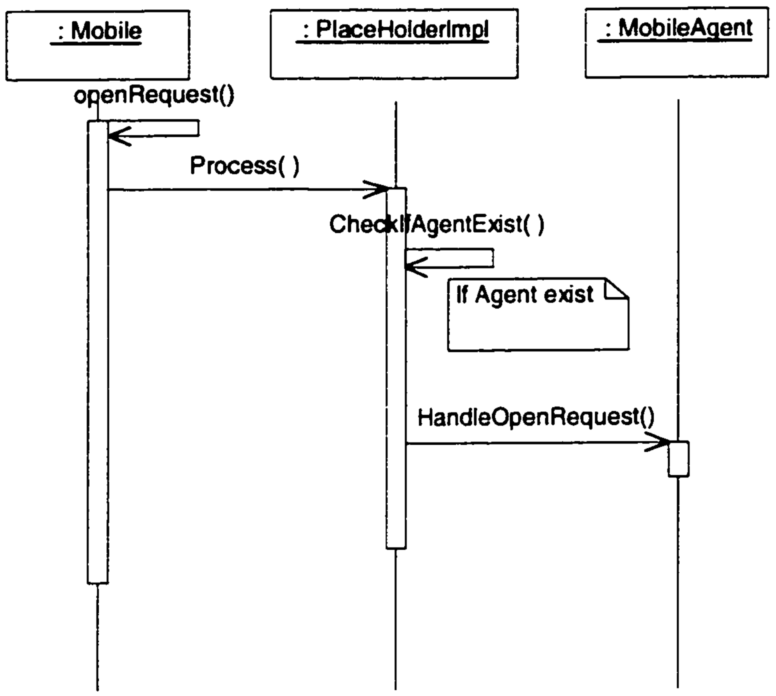


FIGURE 4-16 DATA REQUEST IF AGENT EXIST SEQUENCE DIAGRAM

Mobile executes open request, PlaceHolderImpl processes the request. First, PlaceHolderImpl checks if Agent exists in local station. If it exists, Mobile Agent opens one of the remote files on distributed file system and loads the whole contents of file into its local buffer when mobile sends open request.

4.3.7.4 Data Request If Agent not exist

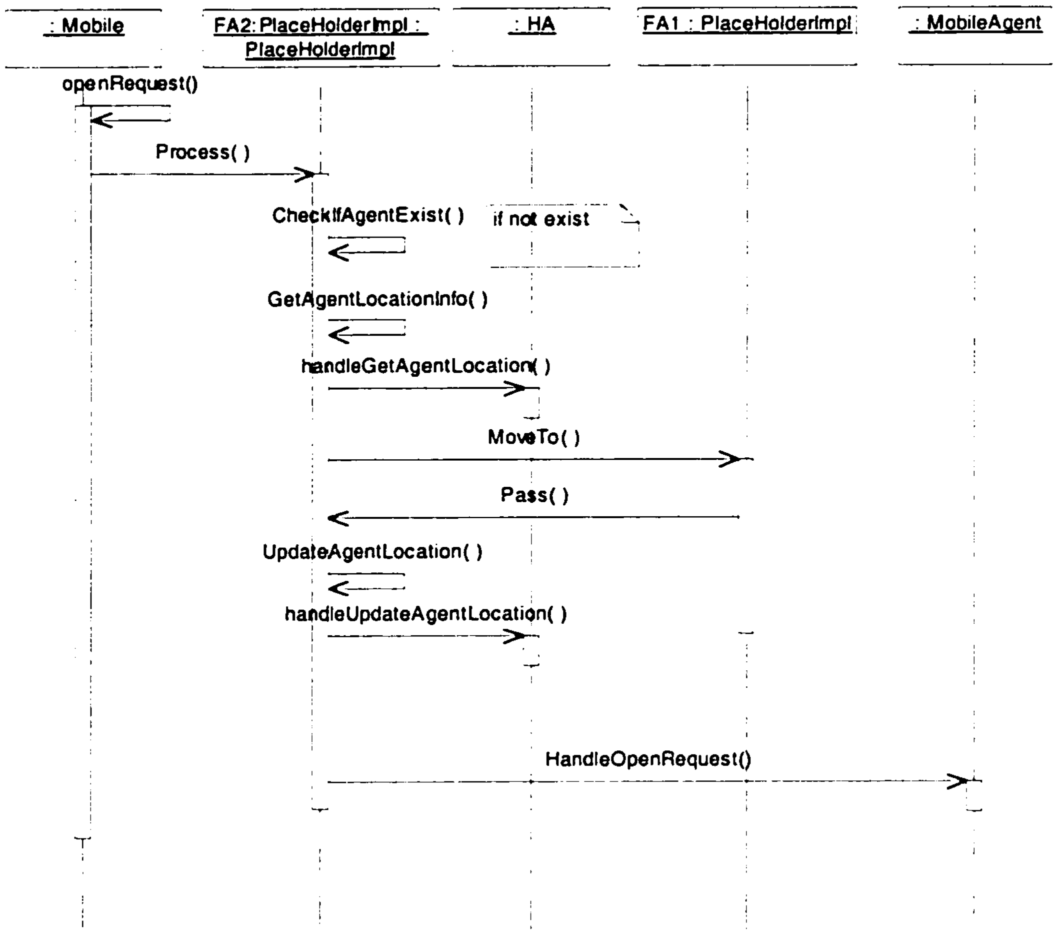


FIGURE 4-17 DATA REQUEST IF AGENT NOT EXIST SEQUENCE DIAGRAM

Mobile executes open request, PlaceHolderImpl processes the request. First, PlaceHolderImpl checks if Agent exists in local station. If it doesn't exist, it will send request to ask the Home Agent the location of the mobile agent. If the mobile agent exists in a remote Fcreign Agent, FA2 will get the remote Agent location from Home Agent while moving the mobile agent from FA1 to FA2.Then, it sends request to inform Home Agent that agent location will be updated. Mobile

Agent opens one of remote files on the distributed file system and loads the whole contents of file into its local buffer when mobile sends open request.

4.3.7.5 Move Procedure

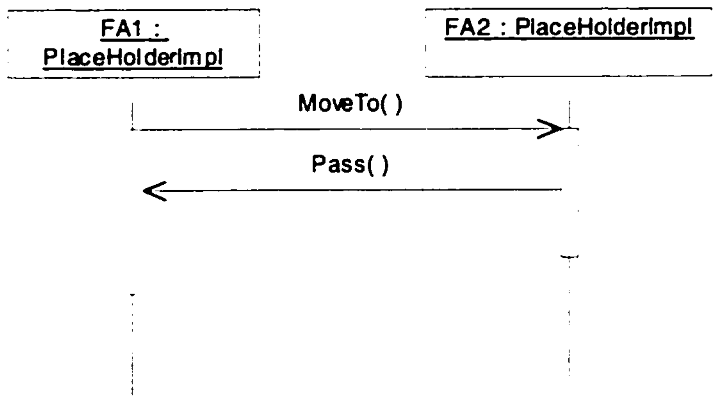


Figure 4-18 Move Procedure sequence diagram

FA1 PlaceHolderImpl calls MoveTo method of FA2 with location address of FA1, FA2 PlaceHolderImpl calls Pass method of FA1 with Mobile Agent of FA2.

4.3.8 Summary

In summary, the tracking of the location of mobile agent has to be done through the inquiring of HA. This makes FA less loaded in terms of determining the trace of mobile agent. But it results in longer time locating the location of mobile agent. When the system carries time critical data transfer, real time application for example, certain mechanism must be found to solve the problem of slow response. Apparently, the system structure in this design is rather simple, which implies great advantage in the employment of this technique in real world.

5. Implementation

5.1 Requirement for system development:

- Hardware:

  IBM compatible PC with CPU equivalent to Intel Pentium 200 or higher

  Minimum hard disk space: 50 MB

  Minimum RAM: 64MB

  Operating system: Microsoft Windows 2000/RedHat Linux 6.0 higher

- Software:

  JDK 2 standard edition [11] version 1.2.1 or later

  J2EE Enterprise Edition [16]

  SSH secure shell client [12]

  JSDK2.1 small server [13]

  J2ME wireless Toolkits for Windows 1.0.4 [14]

5.2 Class description

We select solution 3 as the system configuration for implementation. The coding is all based on Java technology. Following is the description of the classes. The description of methods is given in the Appendix.

5.2.1 Class *MobileAgent*

MobileAgent class is responsible for processing the file access request, such as Open, Close, Read, and Update from mobile devices. For the consideration of object mobility, Class MobileAgent inherits from Class Serializable because any objects inheriting Serializable can be used as a parameter in RMI method to provide mobility functionality from one location to the other location without loss of state the object.

5.2.2 Class *PlaceHolder*

PlaceHolder class is an interface, which inherits from Class Remote, to define two public methods (MoveTo, Pass) that can be invoked remotely by RMI.

5.2.3 Class *PlaceHolderImpl*

PlaceHolderImpl class, which inherits from unicastRemoteObject class and PlaceHolder interface, is used to analyze requests from the mobile device and manage mobility of the Mobile Agent by implementing MoveTo and Pass method of PlaceHolder interface.

5.2.4 Class *RequestHolder*

RequestHolder class, which inherits HttpServlet class, is responsible for the reception of HTTP requests (GET and POST) from the mobile devices and forwards its request to its local PlaceHolder Object.

5.2.5 Class *Mobile*

Mobile class, which inherits Midget class and CommandListener class, is responsible for simulating any mobile device, such as palm device, that can use J2ME to communicate with foreign agent server.

5.2.6Class *HomeAgent*

Home Agent class, which inherits HttpServlet class, is responsible for the HTTP request from FA to get or update location request.

5.3 How to install the software for the system

- *Server side installation*

1. Install Java 2 Platform, Standard Edition, (J2SE).

   Download J2SE from java.sun.com, then install it.

2. Install Java 2 Platform, Enterprise Edition, (J2EE).

   Download J2EE, and install it.

3. Install Java Servlet Development Kit 2.1 (J2SDK), a small web server.

4. Set CLASSPATH

   ```
   setenv CLASSPATH /usr/java1.2/bin:~/jsdk2.1/servlet.jar:.:
   ```

5. Set permission

   ```
   chmod 700 startserver
   chmod 700 stopserver
   ```

6. Copy servlet

   copy servlet class and other compiled class to

   /jsdk2.1/webpages/WEB-INF/servlets

- Mobile side installation
  1. Install Java 2 Platform, Standard Edition, (J2SE).

     Download J2SE from java.sun.com, then install it.
  2. Install Java 2 Platform, Micro Edition(J2ME)

     Download J2ME from java.sun.com, then install it.
  3. copy the directory of mobile to /j2me/apps directory

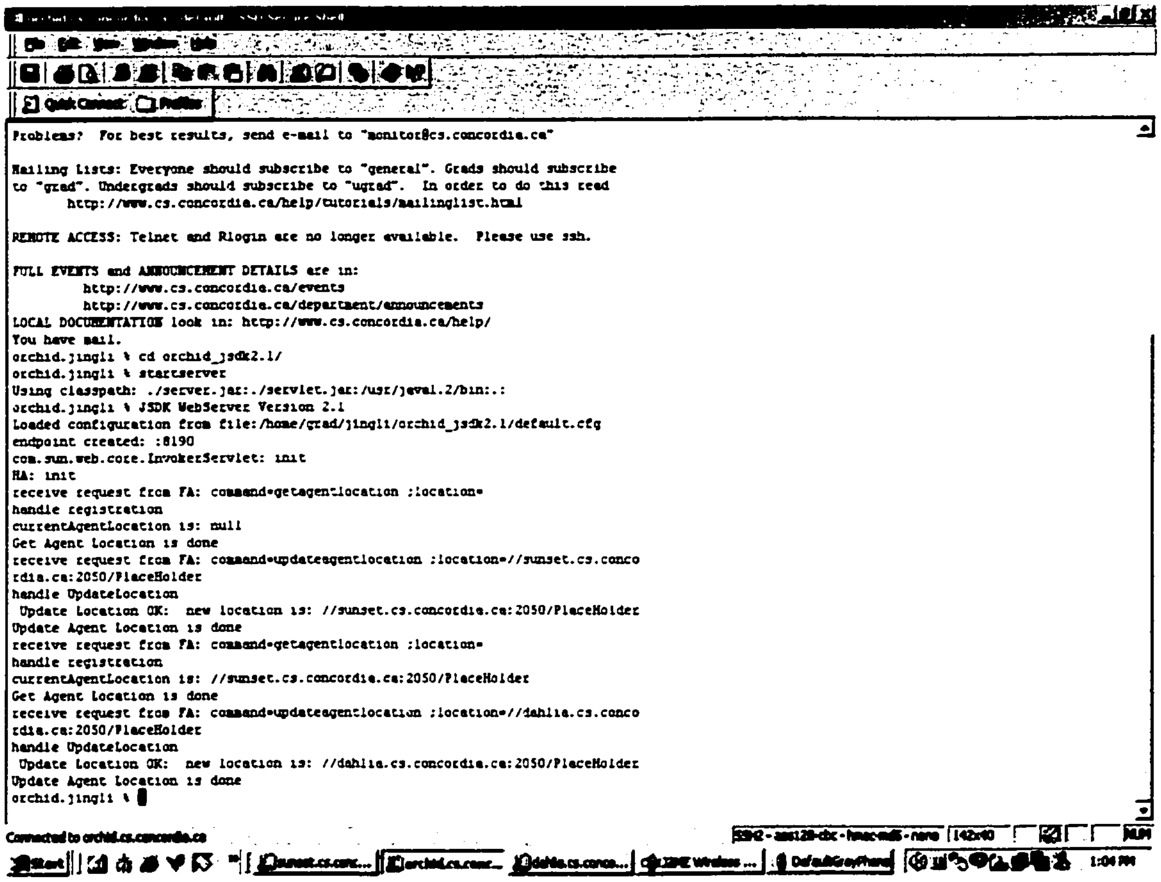
5.4 How to Run the system

We have described the system deployment steps above. It is time to put all the things together to see how the entire system works on both the server side and the client side.

Server Side:

1. For Home Agent (HA):

- Connect to orchid.cs.concordia.ca
- cd /home/grad/jingli/orchid-jsdk2.1
- run startserver



```
Problems?  For best results, send e-mail to "monitor@cs.concordia.ca"

Mailing Lists: Everyone should subscribe to "general". Grads should subscribe
to "grad". Undergrads should subscribe to "ugrad".  In order to do this read
       http://www.cs.concordia.ca/help/tutorials/mailinglist.html

REMOTE ACCESS: Telnet and Rlogin are no longer available.  Please use ssh.

FULL EVENTS and ANNOUNCEMENT DETAILS are in:
         http://www.cs.concordia.ca/events
         http://www.cs.concordia.ca/department/announcements
LOCAL DOCUMENTATION look in: http://www.cs.concordia.ca/help/
You have mail.
orchid.jingli % cd orchid_jsdk2.1/
orchid.jingli % startserver
Using classpath: ./server.jar:./servlet.jar:/usr/java1.2/bin:.:
orchid.jingli % JSDK WebServer Version 2.1
Loaded configuration from file:/home/grad/jingli/orchid_jsdk2.1/default.cfg
endpoint created: :8190
com.sun.web.core.InvokerServlet: init
HA: init
receive request from FA: command=getagentlocation :location=
handle registration
currentAgentLocation is: null
Get Agent Location is done
receive request from FA: command=updateagentlocation :location=//sunset.cs.conco
rdia.ca:2050/PlaceHolder
handle UpdateLocation
 Update Location OK:  new location is: //sunset.cs.concordia.ca:2050/PlaceHolder
Update Agent Location is done
receive request from FA: command=getagentlocation :location=
handle registration
currentAgentLocation is: //sunset.cs.concordia.ca:2050/PlaceHolder
Get Agent Location is done
receive request from FA: command=updateagentlocation :location=//dahlia.cs.conco
rdia.ca:2050/PlaceHolder
handle UpdateLocation
 Update Location OK:  new location is: //dahlia.cs.concordia.ca:2050/PlaceHolder
Update Agent Location is done
orchid.jingli % 
```

FIGURE 5-1 HA(ORCHID.CS.CONCORDIA.CA) SIDE SCREEN

Using classpath: ./server.jar:./servlet.jar:/usr/java1.2/bin:.:

orchid.jingli % JSDK WebServer Version 2.1

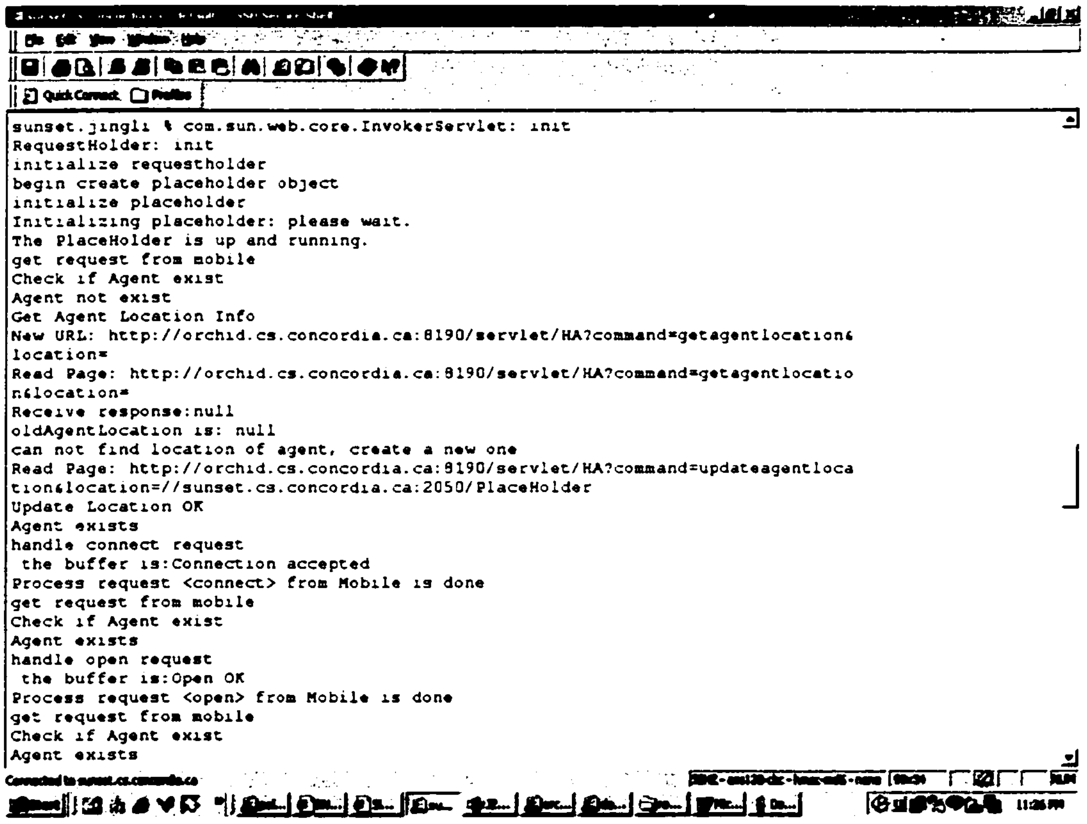
Loaded configuration from file:/home/grad/jingli/orchid_jsdk2.1/default.cfg

endpoint created: :8190

Note: Serverlet is running at port 8190, which is specified in the code. It can be modified to any free port for user in the host. But the code needs to be recompiled to effect the change.

2. Foreign Agent1(FA1):

- Connect to sunset.cs.concordia.ca
- cd ~/sunset_jsdk2.1/webpages/WEB-INF/servlets
- rmiregistry 2050 &
- cd ~/sunset_jsdk2.1/
- run startserver



```
sunset.jingli % com.sun.web.core.InvokerServlet: init
RequestHolder: init
initialize requestholder
begin create placeholder object
initialize placeholder
Initializing placeholder: please wait.
The PlaceHolder is up and running.
get request from mobile
Check if Agent exist
Agent not exist
Get Agent Location Info
New URL: http://orchid.cs.concordia.ca:8190/servlet/HA?command=getagentlocation&
location=
Read Page: http://orchid.cs.concordia.ca:8190/servlet/HA?command=getagentlocatio
n&location=
Receive response:null
oldAgentLocation is: null
can not find location of agent, create a new one
Read Page: http://orchid.cs.concordia.ca:8190/servlet/HA?command=updateagentloca
tion&location=//sunset.cs.concordia.ca:2050/PlaceHolder
Update Location OK
Agent exists
handle connect request
 the buffer is:Connection accepted
Process request <connect> from Mobile is done
get request from mobile
Check if Agent exist
Agent exists
handle open request
 the buffer is:Open OK
Process request <open> from Mobile is done
get request from mobile
Check if Agent exist
Agent exists
```

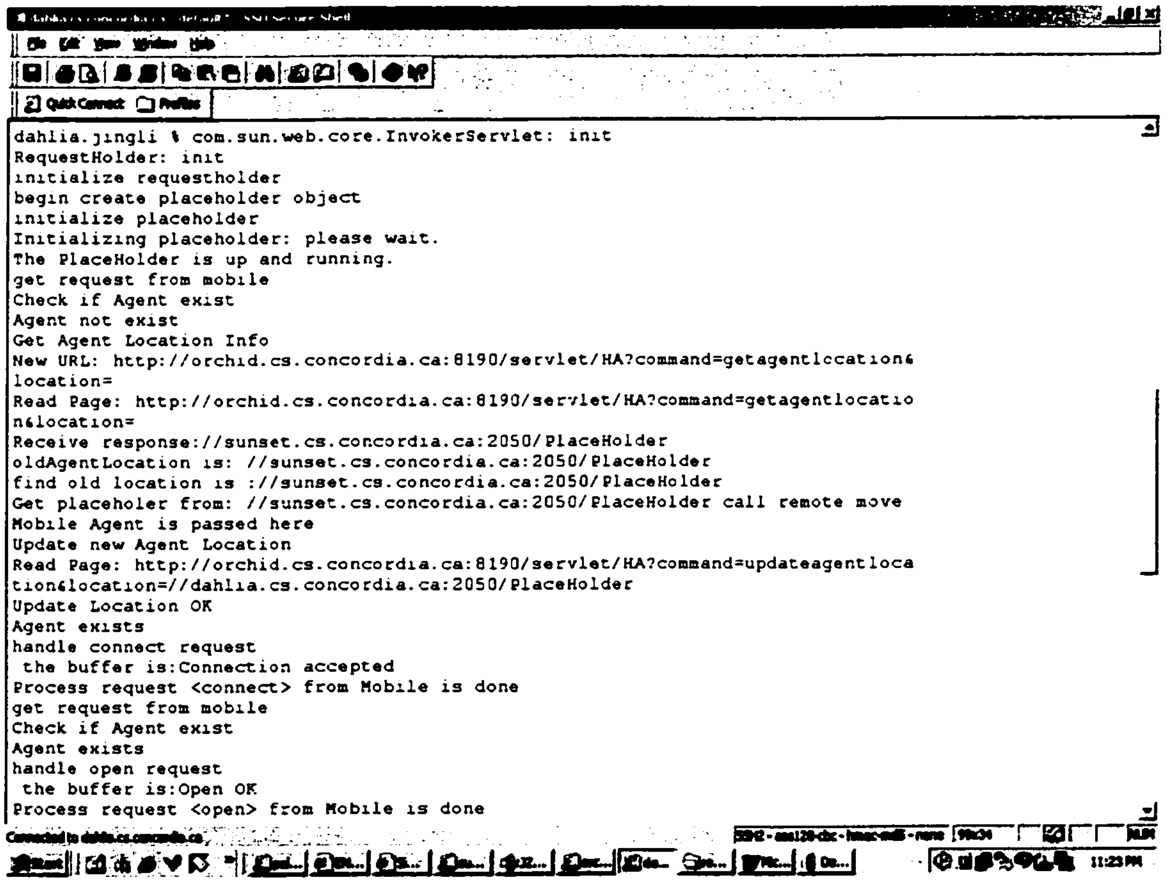
FIGURE 5-2 FA1(SUNSET.CS.CONCORDIA.CA) SDIE SCREEN

Note: Serverlet is running at port 2050, which is specified in the code. It can be modified to any free port for user in the host. But the code needs to be recompiled to effect the change. To recompile the source code of PlaceHolderImpl.class

```
Rmic –v1.2 PlaceHolderImpl
```

3. Foreign Agent2 (FA2)

- Connect to dahlia.cs.concordia.ca by SSH
- Cd ~/dahlia_jsdk2.1/webpages/WEB-INF/servlets
- rmiregistry 2050 &
- Cd ~/dahlia_jsdk2.1
- Run startserver



```
dahlia.jingli % com.sun.web.core.InvokerServlet: init
RequestHolder: init
initialize requestholder
begin create placeholder object
initialize placeholder
Initializing placeholder: please wait.
The PlaceHolder is up and running.
get request from mobile
Check if Agent exist
Agent not exist
Get Agent Location Info
New URL: http://orchid.cs.concordia.ca:8190/servlet/HA?command=getagentlocation&
location=
Read Page: http://orchid.cs.concordia.ca:8190/servlet/HA?command=getagentlocatio
n&location=
Receive response://sunset.cs.concordia.ca:2050/PlaceHolder
oldAgentLocation is: //sunset.cs.concordia.ca:2050/PlaceHolder
find old location is ://sunset.cs.concordia.ca:2050/PlaceHolder
Get placeholer from: //sunset.cs.concordia.ca:2050/PlaceHolder call remote move
Mobile Agent is passed here
Update new Agent Location
Read Page: http://orchid.cs.concordia.ca:8190/servlet/HA?command=updateagentloca
tion&location=//dahlia.cs.concordia.ca:2050/PlaceHolder
Update Location OK
Agent exists
handle connect request
 the buffer is:Connection accepted
Process request <connect> from Mobile is done
get request from mobile
Check if Agent exist
Agent exists
handle open request
 the buffer is:Open OK
Process request <open> from Mobile is done
```

FIGURE 5-3 FA2 (DAHLIA.CS.CONCORDIA.CA) SIDE SCREEN

Using classpath: ./server.jar:./servlet.jar:/usr/java1.2/bin:.:

dahlia.jingli % JSDK WebServer Version 2.1

Loaded configuration from file:/home/grad/jingli/dahlia_jsdk2.1/default.cfg

endpoint created: :8190

Note: Serverlet is running at port 8190, which is specified in the code. It can be modified to any free port for user in the host. But the code needs to be recompiled to effect the change.

Client side:

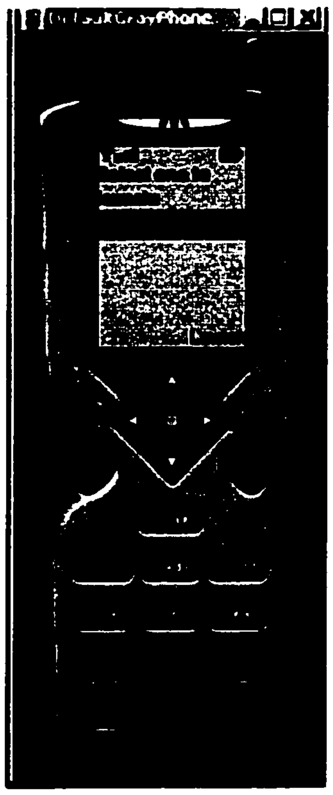


FIGURE 5-4 MOBILE SIDE SCREEN 1

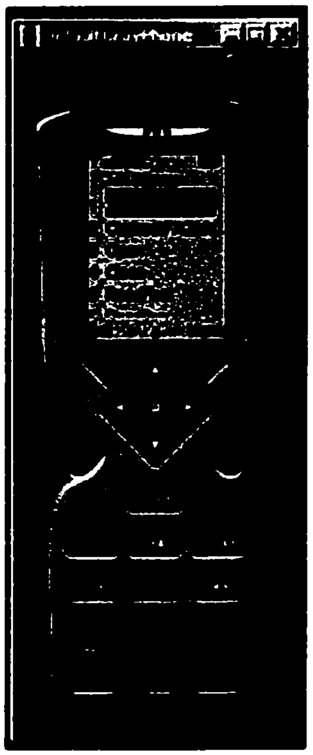
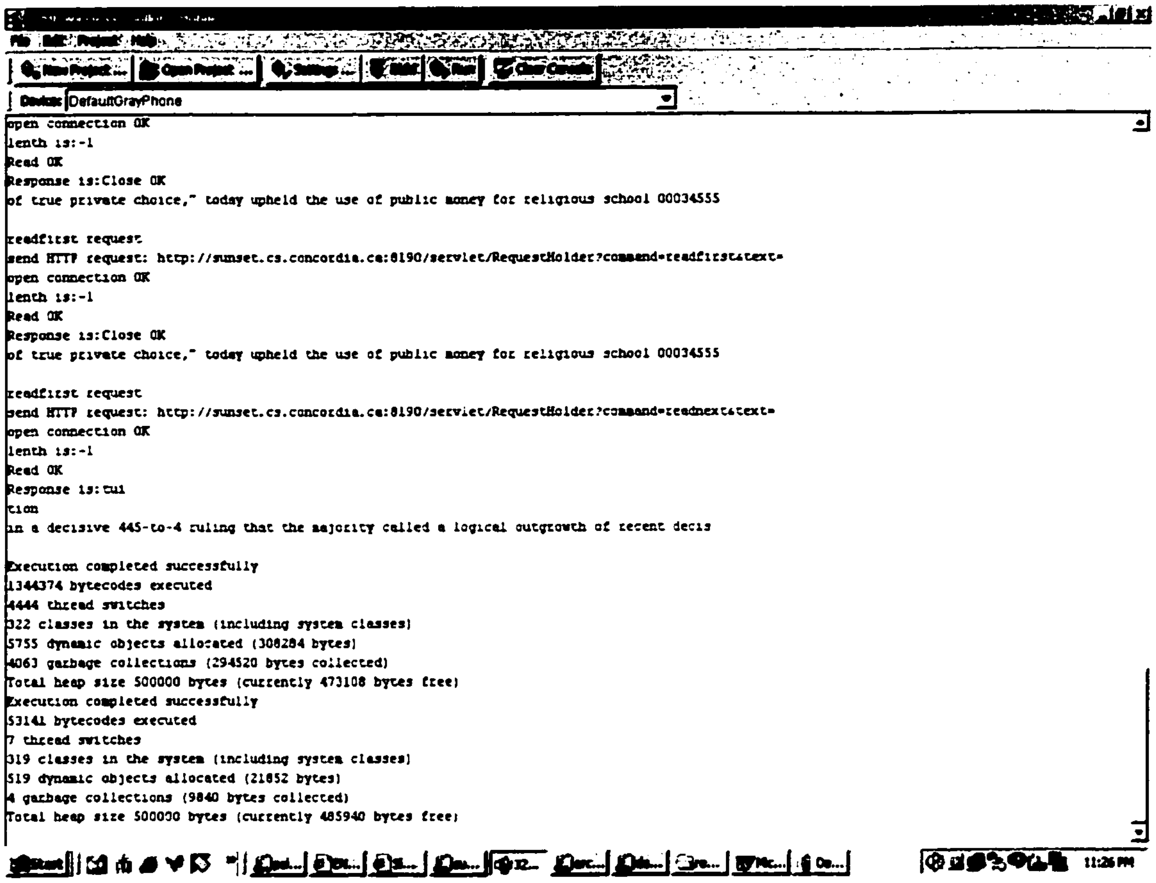


FIGURE 5-5 MOBILE SIDE SCREEN 2

The Mobile side needs to have the J2ME Wireless Toolkit to run Mobile project. From the mobile interface, select launch, then screen display menu from which one can select any command to connect FA1 or FA2.



```
open connection OK
lenth is:-1
Read OK
Response is:Close OK
of true private choice," today upheld the use of public money for religious school 00034555

readfirst request
send HTTP request: http://sunset.cs.concordia.ca:8190/servlet/RequestHolder?command=readfirst&text=
open connection OK
lenth is:-1
Read OK
Response is:Close OK
of true private choice," today upheld the use of public money for religious school 00034555

readfirst request
send HTTP request: http://sunset.cs.concordia.ca:8190/servlet/RequestHolder?command=readnext&text=
open connection OK
lenth is:-1
Read OK
Response is:tui
tion
in a decisive 445-to-4 ruling that the majority called a logical outgrowth of recent decis

Execution completed successfully
1344374 bytecodes executed
4444 thread switches
322 classes in the system (including system classes)
5755 dynamic objects allocated (308284 bytes)
4063 garbage collections (294520 bytes collected)
Total heap size 500000 bytes (currently 473108 bytes free)
Execution completed successfully
53141 bytecodes executed
7 thread switches
319 classes in the system (including system classes)
519 dynamic objects allocated (21852 bytes)
4 garbage collections (9840 bytes collected)
Total heap size 500000 bytes (currently 485940 bytes free)
```

FIGURE 5-6 J2ME WIRELESS TOOLKIT 1.0.4 SCREEN

6. Test

6.1 Objectives

Software testing is one of the major processes of system development. The objective of testing is to ensure that the system conforms to its requirement specifications (i.e. Software Verification) and the system implementation has met the expectation of the customer (i.e. Software Validation). A successful testing process should systematically uncover different classes of errors in a minimum amount of time and with a minimum amount of effort. It also demonstrates that the software is working as stated in the specifications. The data collected through testing can provide an indication of the software's reliability and quality.

6.2 Detail testing in this project

Since this project is using several java based technologies, such as JDK, J2ME, Servlet and RMI, software debug giving and testing is not as easy as in the IDE like JBuilder and VC++. Due to this reason, a number of print commands were added outputting messages indicating the processing of the program. It is a kind of debug/test information, which gives the developer real run time information. Those test information are listed as follows:

- When MA is connected to FA1

  HA displays:

  ```
  com.sun.web.core.InvokerServlet: init
  HA: init
  ```

```
receive request from FA: command=getagentlocation ;location=
handle registration
currentAgentLocation is: null
Get Agent Location is done
receive request from FA: command=updateagentlocation
;location=//sunset.cs.concordia.ca:2050/PlaceHolder
handle UpdateLocation
 Update Location OK: new location is:
//sunset.cs.concordia.ca:2050/PlaceHolder
Update Agent Location is done
```

FA1 displays:

```
RequestHolder: init
initialize requestholder
begin create placeholder object
initialize placeholder
Initializing placeholder: please wait.
The PlaceHolder is up and running.
get request from mobile
Check if Agent exist
Agent not exist
Get Agent Location Info
```

```
New                                                            URL:
http://orchid.cs.concordia.ca:8190/servlet/HA?command=getagentl
ocation&location=
Read                                                           Page:
http://orchid.cs.concordia.ca:8190/servlet/HA?command=getagentl
ocation&location=
Receive response:null
oldAgentLocation is: null
can not find location of agent, create a new one
Read                                                           Page:
http://orchid.cs.concordia.ca:8190/servlet/HA?command=updateag
entlocation&location=//sunset.cs.concordia.ca:2050/PlaceHolder
Update Location OK
Agent exists
handle connect request
 the buffer is:Connection accepted
Process request <connect> from Mobile is done
```

- When MA move from FA1 to FA2

  FA1 displays:

```
begin move
Agent exists in my location, begin call remote pass
```

FA2 displays:

```
RequestHolder: init

initialize requestholder

begin create placeholder object

initialize placeholder

Initializing placeholder: please wait.

The PlaceHolder is up and running.

get request from mobile

Check if Agent exist

Agent not exist

Get Agent Location Info

New                                                              URL:

http://orchid.cs.concordia.ca:8190/servlet/HA?command=getagentl

ocation&location=

Read                                                             Page:

http://orchid.cs.concordia.ca:8190/servlet/HA?command=getagentl

ocation&location=

Receive response://sunset.cs.concordia.ca:2050/PlaceHolder

oldAgentLocation is: //sunset.cs.concordia.ca:2050/PlaceHolder

find old location is ://sunset.cs.concordia.ca:2050/PlaceHolder

Get   placeholer   from:   //sunset.cs.concordia.ca:2050/PlaceHolder

call remote move

Mobile Agent is passed here
```

```
Update new Agent Location
Read Page:
http://orchid.cs.concordia.ca:8190/servlet/HA?command=updateag
entlocation&location=//dahlia.cs.concordia.ca:2050/PlaceHolder
Update Location OK
Agent exists
handle connect request
 the buffer is:Connection accepted
Process request <connect> from Mobile is done
```

HA displays:

```
receive request from FA: command=getagentlocation ;location=
handle registration
currentAgentLocation is:
//sunset.cs.concordia.ca:2050/PlaceHolder
Get Agent Location is done
receive request from FA: command=updateagentlocation
;location=//dahlia.cs.concordia.ca:2050/PlaceHolder
handle UpdateLocation
 Update Location OK: new location is:
//dahlia.cs.concordia.ca:2050/PlaceHolder
Update Agent Location is done
```

- When MA open a file from FA1:

  FA1 displays:

  ```
  get request from mobile
  Check if Agent exist
  Agent exists
  handle open request
   the buffer is:Open OK
  Process request <open> from Mobile is done
  ```

- When MA send ReadFirst command to FA1:

  FA1 displays:

  ```
  get request from mobile
  Check if Agent exist
  Agent exists
  handle readfirst request
  Agent handle read first
  the buffer is: Close OK
  of true private choice," today upheld the use of public money for
  religious 0s2345tuitio
  n
  Process request <readfirst> from Mobile is done
  ```

- When MA send ReadNext command to FA1

FA1 displays:

```
get request from mobile

Check if Agent exist

Agent exists

handle readnext request

Agent handle read next

 the buffer is:

i

n a decisive 445-to-4 ruling that the majority called a logical outgrowth of recent decisions and

Process request <readnext> from Mobile is done
```

- When MA send Update command to FA2:

  FA2 displays:

```
get post request from mobile

Check if Agent exist

Agent exists

handle update request

begin get text str:

length is:18

the buffer is:

Open connection OK. updated text string is:Open connection OK

Agent handle update
```

- When MA send Close command to FA2

  FA2 displays:

```
get request from mobile

Check if Agent exist

Agent exists

handle close request

the buffer is: Close OK

Process request <close> from Mobile is done
```

7. Conclusion and Future work

7.1 Conclusion

According to the description of the proposal and the result of the implementation, it looks pretty promising that mobile file transferring could be implemented in IP network, by taking advantage of the new software techniques. Compared with the traditional telephone network, it effectively utilizes the existing tremendous IP network, which has the advantage of low cost.

7.2 Future work

The mechanism proposed in this paper is far less mature.

- There should be more FA involved the simulations.
- The protocol used to transfer the object among FAs should be TCP/UDP.
- Mobile devices should be able to recognize the wireless connection.
- The speed responding the mobile devices should be taken into account as one essential aspect of the system design/implementation.

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Appendix

A. The description of Class methods of Solution 3

A.1 MobileAgent

Method *HandleOpenRequest()*

This method simulates the functionality that the Mobile Agent opens one of remote files on distributed file system and loads the whole contents of the file into its local buffer when the mobile device sends open request.

Method *HandleCloseRequest()*

This method simulates the functionality that the Mobile Agent writes all updated buffer to the remote file on the distributed file system and closes it when the mobile device sends close request.

Method *HandleReadFirstRequest()*

This method reads the first 100 characters(default value) of the remote file from its local buffer which is already initiated by HandleOpenRequest() method and keeps the current read position value into variable currentPos.

Method *HandleReadprevRequest()*

This method reads the previous 100 characters of remote file from its local buffer and keeps the current read position value into variable currentPos.

Method *HandleReadNextRequest()*

This method reads the next 100 characters of remote file from its local buffer and keeps the current read position value into variable currentPos.

Method *HandleUpdateRequest()*

This method updates part of its local buffer with the contents from mobile.

Method *Read*()

This method gets 100 characters from its local buffer.

Method *ReadWhole()*

This method reads the contents of remote file into wholebuffer.

Method *WriteWhole()*

This method writes the wholebuffer into remote file.

A.2 Class PlaceHolderImpl

Method CheckIfAgentExist()

This method checks if the mobile agent object exists in its local machine.

Method *Process()*

The flow chart of method Process

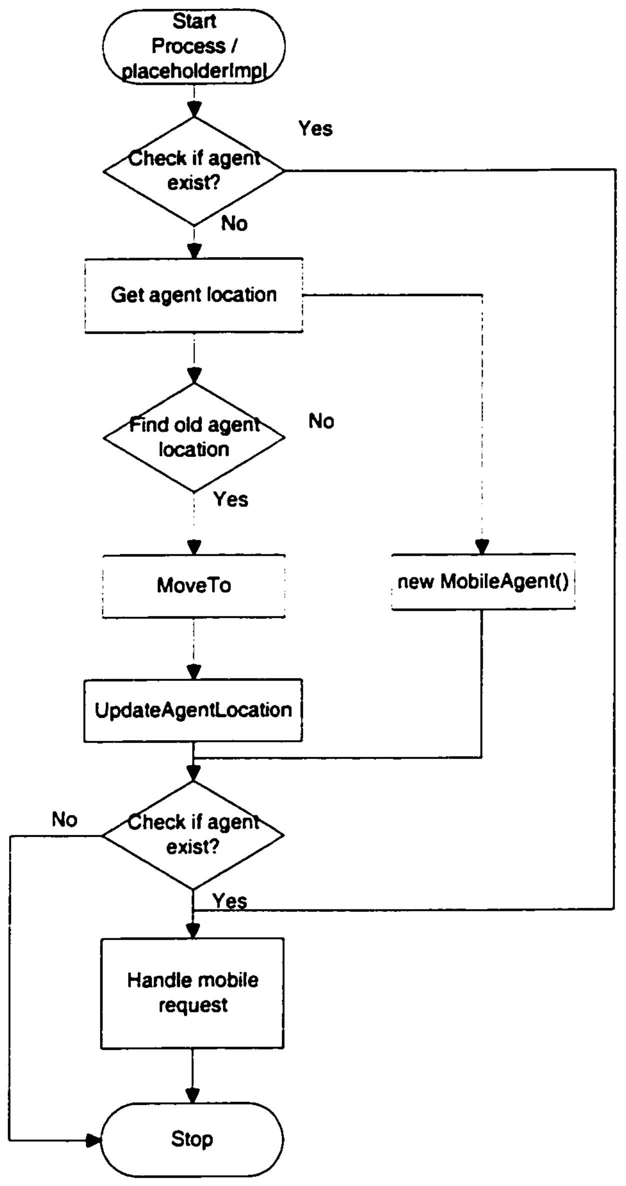


FIGURE A-1 THE FLOW CHART OF METHOD PROCESS

This method is mainly responsible for analyzing request from the mobile device, and moving the mobile agent from remote location to its local location. It will first check if local mobile agent exists. If the mobile agent exists, it will process the request from mobile and call corresponding method of mobile agent according to the kind of request from the mobile device. Otherwise, it will send request to ask the Home Agent server the location of the mobile agent. If no mobile agent exists in any Foreign Agent server, a new mobile agent will be created in the local server. If the mobile agent exists in a remote Foreign Agent Server, it will call remote MoveTo method to inform the remote Foreign Agent Server to pass mobile agent in its local machine.

Method *getTextStr()*

This method is used to get text string that is going to be updated.

Method *sendBack()*

This method is used to send updated text string back.

Method *MoveTo()*

This method is invoked by the remote foreign agent server that needs the mobile agent. The method will then invoke Pass method of the remote foreign agent server to pass its local mobile agent to remote foreign agent server.

Method *Pass()*

This method is invoked by the remote foreign agent server for passing the remote mobile agent to its local machine.

Method *GetAgentLocationInfo()*

This method is used to ask the home agent server for the current location of mobile agent.

Method *UpdateAgentLocation()*

This method is used to send requests to inform the home agent server that the mobile agent has been moved to its local machine.

Method *init()*

This method is invoked by the init method of RequestHolder object to register the new PlaceHolder object with its local naming service.

A.3 Class RequestHolder

Method *init()*

This method is used to create a new placeholder object and bind it to its local naming service.

Method *doGet()*

This method is used to receive GET HTTP request from mobile and forward it to its local PlaceHolder object.

Method *doPost()*

This method is used to receive POST HTTP request, which is mainly for update requests, from mobile and forward it to its local PlaceHolder object.

A.4 Class Mobile

Method *startApp()*

This method is to start Mobile midlet application.

Method *startPage()*

This method is to show the first Welcome page.

Method *pauseApp()*

This method is inherited from midlet and do nothing.

Method *destropApp*()

This method is inherited from midlet and do nothing.

Method *showText*()

This method is used to show text that receives from foreign agent server.

Method *commandAction*()

This method is used to execute the command that user activate by invoking different method.

Method *handleConnectFAhost*()

This method sends connect command to the foreign agent server with HTTP request.

Method *openRequest*()

This method sends open command to the foreign agent server with HTTP request.

Method *closeRequest*()

This method sends close command to the foreign agent server with HTTP request.

Method *readfirstRequest*()

This method sends readfirst command to the foreign agent server with HTTP request.

Method *readnextRequest*()

This method sends readnext command to the foreign agent server with HTTP request.

Method *readprevRequest*()

This method sends readfirst command to the foreign agent server with HTTP request.

Method *readPage()*

This method sends HTTP GET request to the foreign agent server and receives response from the foreign agent server.

Method updateRequest()

This method sends HTTP POST request to the foreign agent server for updating its local buffer, and received updated contents from the foreign agent server.

B. Design Diagrams of Solution 1

1. Use Case Design

1.1 MOBILE DEVICES client Use Case Diagram

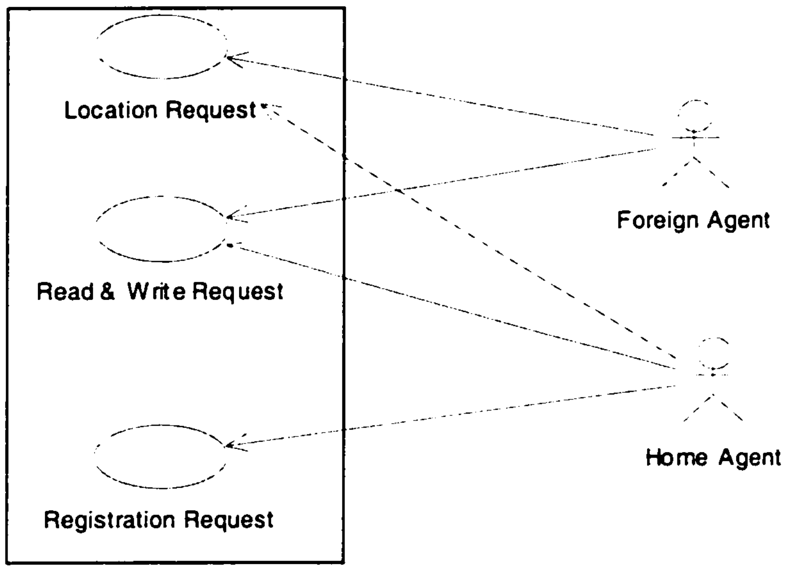


FIGURE B-1 MOBILE DEVICES CLIENT USE CASE DIAGRAM

1.2 Foreign Agent Use Case Diagram

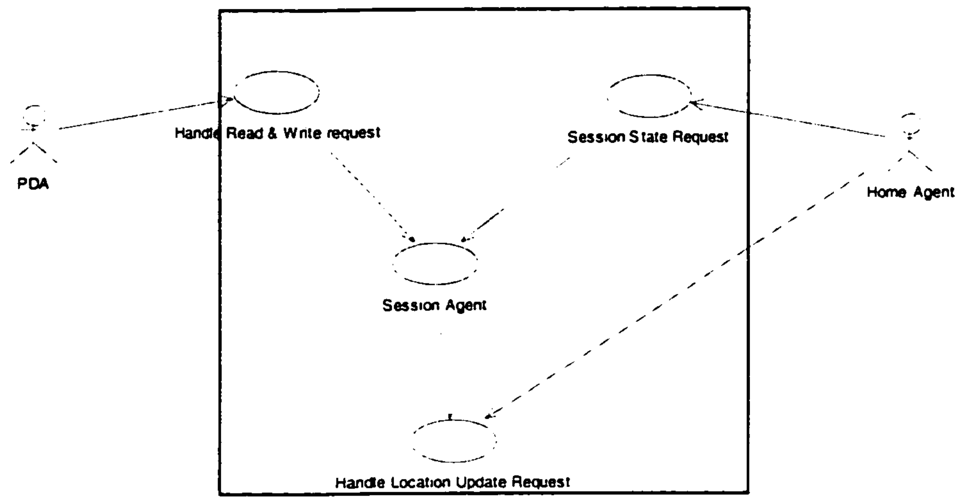


FIGURE B-2 FOREIGN AGENT USE CASE DIAGRAM

1.3 Home Agent Use Case Diagram

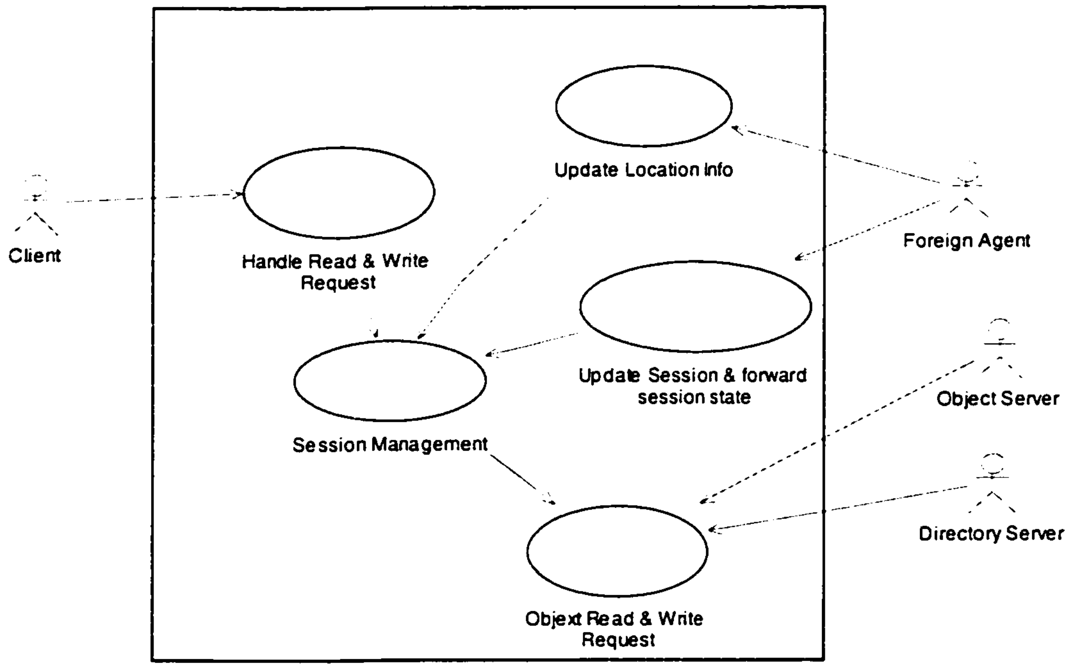

Client
Handle Read & Write Request
Update Location Info
Foreign Agent
Update Session & forward session state
Session Management
Object Server
Directory Server
Objext Read & Write Request

FIGURE B-3 HOME AGENT USE CASE DIAGRAM

1.4. Object Directory Server Use Case Diagram

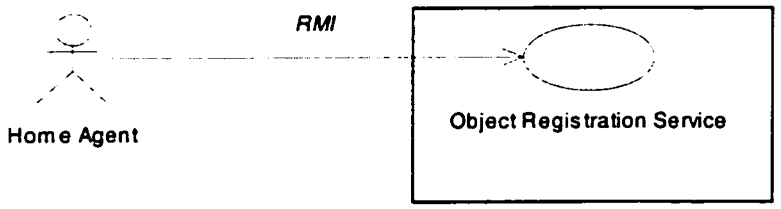


FIGURE B-4 OBJECT DIRECTORY SERVER USE CASE DIAGRAM

1.5 Object Server Use Case Diagram

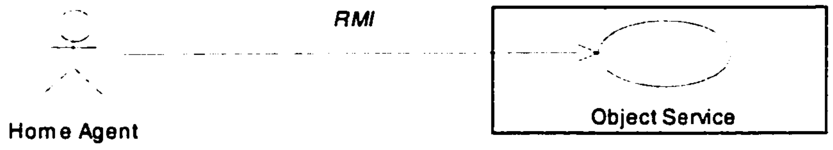


FIGURE B-5 OBJECT SERVER USE CASE DIAGRAM

2. Class Diagram Design

2.1 RegistryManager class diagram

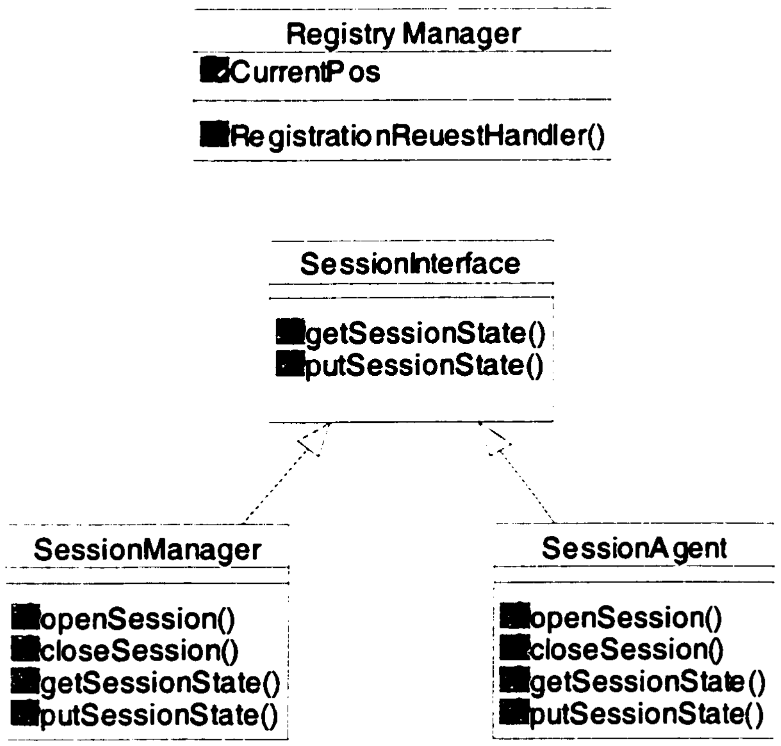
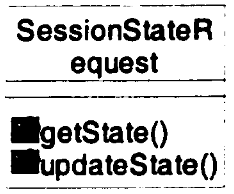


FIGURE B-6 REGISTRYMANAGER CLASS DIAGRAM



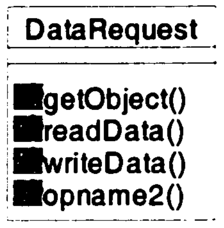
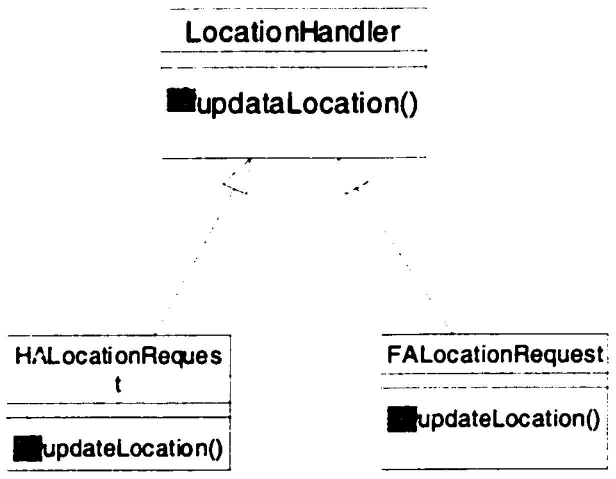


FIGURE B-7 SESSIONSATAEREQUEST & DATAREQUEST CLASS DIAGRAM



FIGUREB-8 LOCATIONHANDLER CLASS DIAGRAM

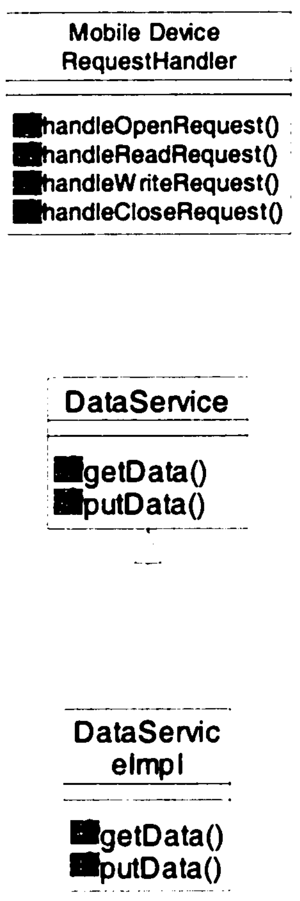


FIGURE B-9 MOBILEDEVICEREQUESTHANDLER CLASS DIAGRAM

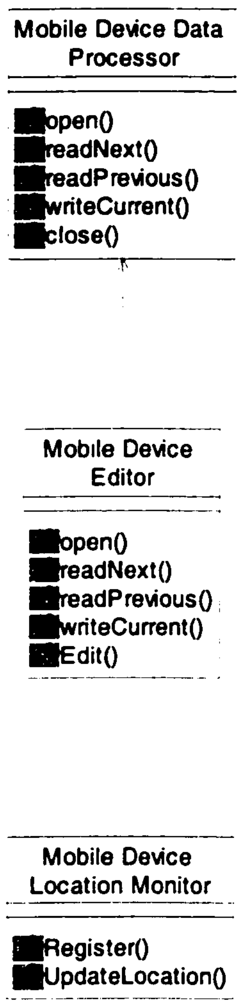


FIGURE B-10 MOBILEDEVICEDATAPROCESSOR CLASS DIAGRAM

3. Sequence diagram Design:

3.1 Session begin & end sequence diagram

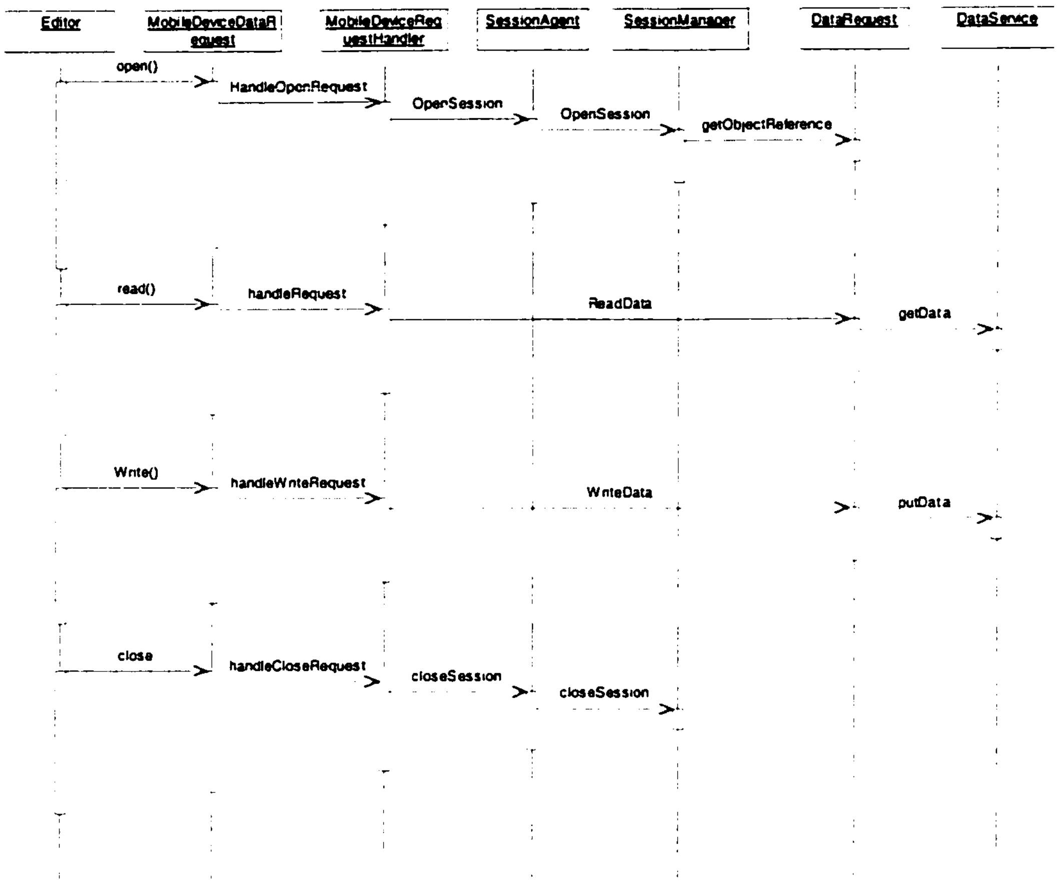


FIGURE B-11 SESSION BEGIN & END SEQUENCE DIAGRAM

3.2 Location & data sequence diagram

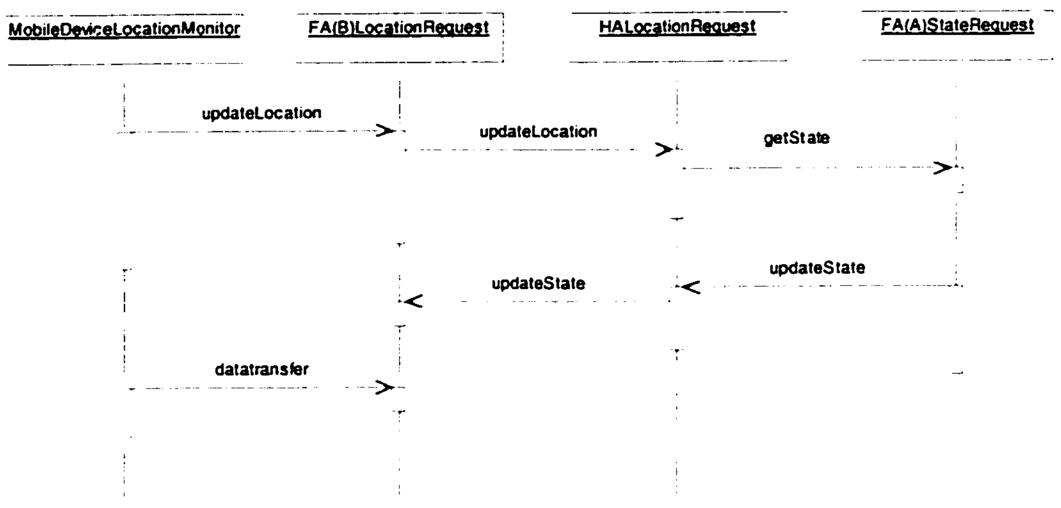


FIGURE B-12 LOCATION & DATA SEQUENCE DIAGRAM

3.3 HandleRegistryRequest sequence diagram

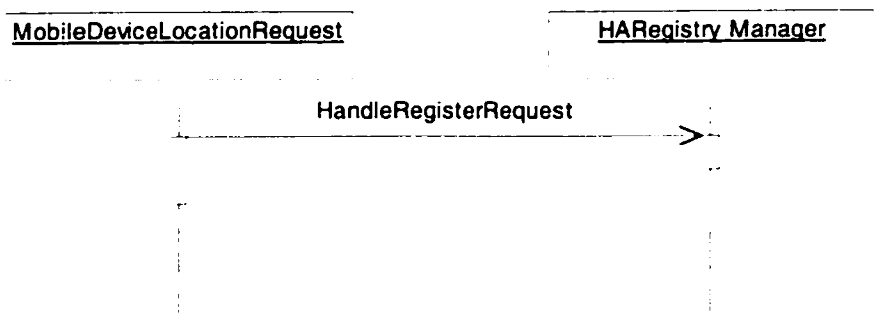


FIGURE B-13 HANDLEREGISTRYREQUEST SEQUENCE DIAGRAM