Constructing the Multi-Agents Communication Model to Implement Dynamic Intelligent System

[1]Steven K.C. Lo, [2]Jen-Chih Lin, [3]Huan-Chao Keh, [3]Yi-Hung Lin, and [4]Wan-Chih Wang[3]

[1] Department of Information Management,
Jin-Wen University of Science & Technology, Taiwan, R.O.C.
[2,4]Graduate School of Toy and Game Design,
National Taipei University of Education, Taiwan, R.O.C.
E-mail:[2]yachih@tea.ntue.edu.tw
[3]Department of CSIE, Tamkang University, Taiwan, R.O.C.

Abstract: The intelligent agent communication mechanism is designed to execute under background when the application drives an event trigger and the telephony technologies have been rapidly grown up and provide the multi-functions and good interactive user graphic interface (GUI). The hardware of cellular phone device also provides the light , small size with wide screen, more convenient, stable, flexible and available to easy obtain the information from internet world wide web (WWW). According to magazine reporting, most of people have an above 2G cellular phone at least in Taiwan and use the multi-function to retrieve data from internet. In this paper, it is implemented the intelligent communication agent [3, 6, 8, 12] mechanism characterizes and integrated the RFID mechanism to establish a communication channel to automatically transmit data packets from source site to destination site. Using the RFID mechanism to obtain the data from tags through the reader/interrogator is the RFID agent primary task.

Keywords: Intelligent Agent, cellular phone, RFID, Single-agent system, Multi-agent system

1. Introduction:

The mobile technology evolution is from the early 1G, 2G, 2.5G and now 3G. The G meaning is Generation and individual generation has different characterizes and functions such as max speed, system, signal type and its' support functions are as shown in table 1.

Table 1: Mobile evolution

Class / Item	1G	2G	2.5G	3G
Signal Type	Analog	Digital	Digital	Digital
Max. Speed	Not Available	14.4kbps	384kbps	2Mbps
System	AMPS	GSM CDMA	GPRS	WCDMA CDMA2000
Support Function	Voice	Voice SMS	Voice/ SMS Application	Voice/Video /MMS/SMS Application

According to Taiwan magazine reporting, most of people have an above 2G cellular phone at least and use the multi-function to retrieve data from internet, such as e-mails, news, games and so on. Now the handset design single is not a telephone, it is ingenious equipment that provides the powerful function interactive in real-time. In addition, the mobile system fundamental characterize is provided information at anytime and anywhere through the base stations for users to retrieve.

The primary of intelligent agent [7, 29, 30, 31] characterize is to establish a communication channel automatically transmit data packets from the source site to the destination site using the TCP[19] or UDP[20] communication protocol. In this paper, it uses embedded concepts to integrate the intelligent agent communication mechanism and retrieves the real time information from RFID middleware. The intelligent agent communication mechanism is designed for executing under background when the application drives an event trigger.

The rest of this paper is organized by five sections. Section 2 describes the intelligent agent. In this section, it demonstrates the intelligent agent classes, intelligent agent attributes, and intelligent agent synchronous/asynchronous and proposes the four kinds of intelligent agent communication behaviors models including cooperation behaviors model, coordination behaviors model, combination behaviors model and competition behaviors model. Section 3 describes the brief Radio Frequency Identification (RFID). Section 4 presents a case study: Intelligent Parking System to illustrate how the

Class / Attribute	Local	Networked	Central and Distributed	Fixed and Migrating
Agent Intelligence	□	□	□	□
Agent Continuity	□	□	□	□
Agent Communication		□	□	□
Agent Cooperation			□	□
Agent Mobility				□

	Single-Agent system (SAS)		Multi-Agent system (MAS)	
Class	Local	Networked	Central and Distributed	Fixed and Migrating
Application	Personnel assistants Meeting Schedulers	Personnel assistants Smart Mailboxes	Distributed Problem Solving	Telecomm-unication

intelligent agent mechanism is implemented and integrated the RFID mechanism. Eventually, section 5 summarizes the overall embedded the intelligent agent communication mechanism and integrate the RFID mechanism for the Intelligent System.

2. Intelligent Agent

The meaning of intelligent agent is proposed by [13, 14, 16], and the implementation of agent is diverse for many systems, such as communication systems, coordination systems, cooperation systems and so on. The purpose of intelligent agent is divided into two part systems: Single-agent system(SAS) and Multi-agent system(MAS) as shown in table 2[4].

Table 2: Agent System Classification

2.1 Intelligent Agent attributes

The Main attributes [17] of intelligent agent are Intelligence which describes vocabulary data, conditions, goals, and tasks, Continuity which an agent is a continuously running process, Communication which is an agent to communicate with other agents to achieve its goals, Cooperation which is an agent automatically customizes itself to its users' needs and Mobility which is an agent perform varies from remote execution. The agent attributes and classes' relationship are shown as table 3.

Table 3: Agent Attributes and Classes Relationship

2.2 Intelligent Agent Synchronous/Asynchronous

The Intelligent agent interaction behaviors [11, 23, 24] can be divided into two parts. One is Synchronous model and the other is Asynchronous model.

•**Synchronous:** Both of Agent A and Agent B send/receive the packets and parsing the packets in the same time as shown in Fig.1.

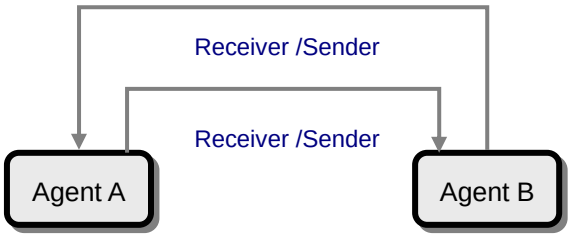

Fig. 1: Intelligent Agent Synchronous Model

•**Asynchronous:** Agent A sends packets to Agent B. After Agent B Received and parsed the packets, Agent B responses a message to Agent A as shown in Fig.2.

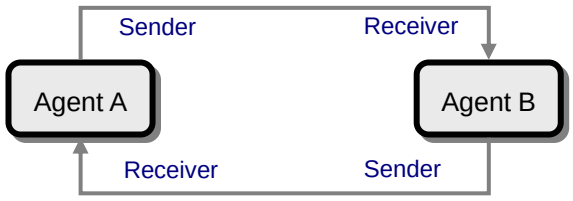

Fig. 2: Intelligent Agent Asynchronous Model

2.3 Intelligent Agent Communication behaviors Model

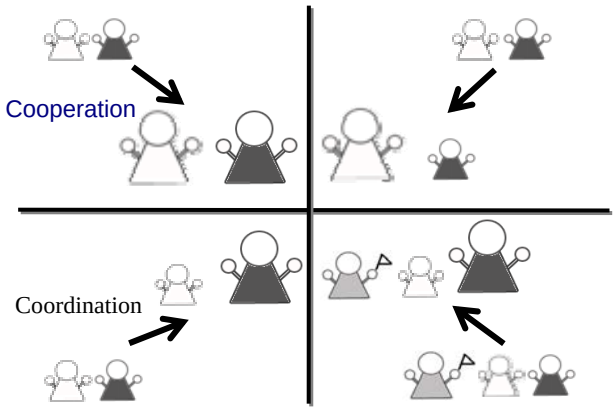

Fig. 3: Intelligent Agent Communication behaviors Model

In this study[9, 18], it proposes the intelligent agent communication behaviors model to demonstrate the agents' behaviors in detail. The intelligent agent communication behaviors model is comprised four models: Cooperation behaviors Model, Coordination behaviors Model Combination behaviors Model and Competition behaviors Model as shown in Fig.3.

•**Cooperation behaviors Model: [22, 23]** This cooperation behaviors model is demonstrated the intelligent agent cooperation behaviors as Fig.4. The intelligent agent is referenced to the definition of cooperation policies to assign the complexity tasks to the dependency agent. This model reduces the execution time and obtains the effective performance.

[Synchronous]

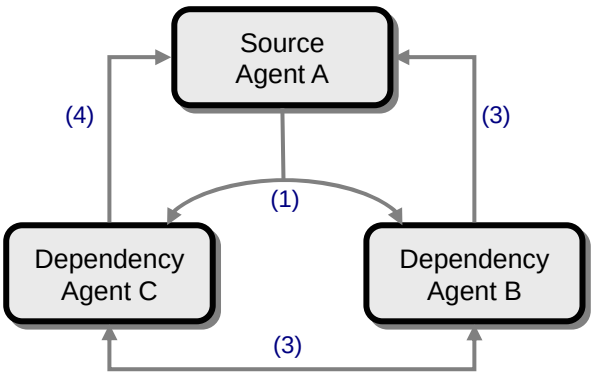

Fig. 4: Cooperation behaviors Model

Description:

(1)The source agent A is based on the definition policies to assign the tasks to the Dependency Agent C and the Dependency Agent B.

(2)The Dependency Agent B and the Dependency Agent C executes the tasks from the Source Agent A.

(3)When the Dependency Agent B is finished the tasks from the Source Agent A, the Dependency Agent B is response a message to the Source Agent A.

(4)After the Dependency Agent C finished the tasks from the Source Agent A, the Dependency Agent C is response a message to the Source Agent A.

•**Cooperation behaviors Model Algorithm**

```
SAA=new Agent; //Source Agent A
Result DABFunction(Agent Source)
{
DAB=new Agent;//Dependency Agent B
rst=DAB.ExecuteTask(Source);
Destroy(DAB);
Return(rst);
}
Result DACFunction(Agent Source)
{
DAC=new Agent;//Dependency Agent C
      rst=DAC.ExecuteTask(Source);
      Destroy (DAC);
      Return(rst);
}
while (IsTaskFlag ==OK)
{
      ResultB=DABFunction(SAA);
      ResultC=DACFunction(SAA);
      SAA.Restult=ResultB+ResultC;
}
Destroy (SAA);
```

Competition

Combination

•**Coordination behaviors Model:** This Coordination behaviors model is illustrated the intelligent agent coordination procedure as shown in Fig.5. This intelligent agent will establish a connection in the initial phase with other agents. Once the connection is connected, the Source agent interacts with the destination agent.

[Synchronous]

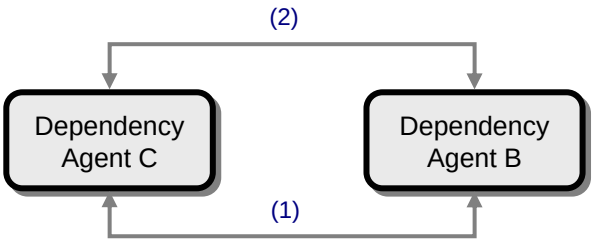

Fig. 5: Coordination behaviors Model

Description:

(1)The Dependency Agent A process the tasks and response packets to the Dependency Agent B when the Dependency Agent A is finished the specify tasks. The Dependency Agent B checks and confirms the result is valid or invalid.

(2)The Dependency Agent B process the tasks and response packets to the Dependency Agent A when the Dependency Agent B is finished the specify tasks. The Dependency Agent A checks and confirms the result is valid or invalid.

•**Coordination behaviors Model Algorithm**

```
SAA=new Agent;//Source Agent A
SAB=new Agent;//Source Agent B
```

```
Result DACFunction(Agent Source1,Agent
Source 2)
 {
 DAC=new Agent;//Dependency Agent C
 rst=DAC.ExecuteTask(Source1,Source2);
 Destroy(DAC);
 Return(rst);
 }
 while (IsTaskFlag ==OK)
 {
 if (SAA &&SAB is not NULL)
       Result=DACFunction(SAA,SAB);
 }
 Destroy (SAA);
 Destroy (SAB);
```

•**Combination behaviors Model:** This combination behaviors model is demonstrated the intelligent agent combination procedure as shown in Fig.6. This intelligent agent accomplishes the tasks by itself and transmits the result to specify intelligent agent. This specifies intelligent agent starts the coordination mechanism to integrate the result from source agents.

[Synchronous / Asynchronous]

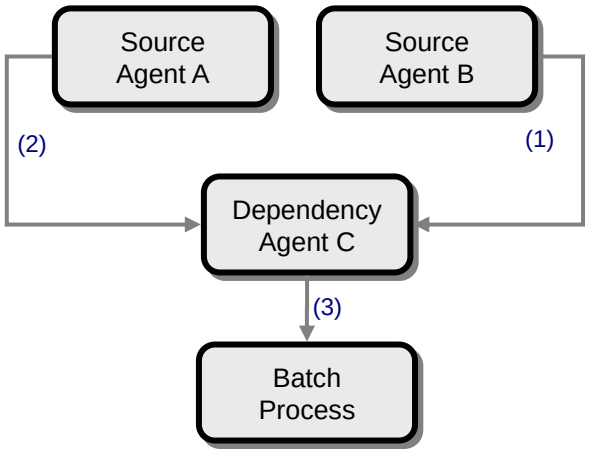

Fig. 6: Combination behaviors Model

Description:

(1)The Source Agent B is process its' tasks in first. After the Source Agent B finished its' tasks, the source agent B transmits the result to the Dependency Agent C.

(2)The Source Agent A is process its' tasks in first. After the Source Agent A finished its' tasks, source agent A transmits the result to the Dependency Agent C.

(3)The Dependency Agent C obtains the result from the Source Agent A and the Source Agent B. After the Dependency Agent C receives the result from the Source Agent A and the Source Agent B, the integration and batch process is triggered.

• **Combination behaviors Model Algorithm**

```
DAA=new Agent; //Dependency Agent A
DAB=new Agent; //Dependency Agent B
Result DAAFunction(Data Source)
{
      rst=DAA.Confirm(Source);
      Return(rst);
}
Result DABFunction(Data Source)
{
      rst=DAB.Confirm(Source);
      Return(rst);
}
while (IsTaskFlag ==OK)
{
      ResultA=DAAFunction(DAB.Data);
      ResultB=DABFunction(DAA.Data);
      if (ResultA && Result B)
            OK;
      else
            FAIL;
}
Destroy (SAA);
Destroy (SAB);
```

•**Competition behaviors Model:** This competition behaviors model is illustrated the agent competition procedure as shown in Fig.7. This intelligent agent occurs the competition when multi-agent is active. To avoid the collision situation, the intelligent agent shall obey the constraints of predefinition competition rules. The anti-collision mechanism is key success factor in this competition behaviors model.

[Synchronous]

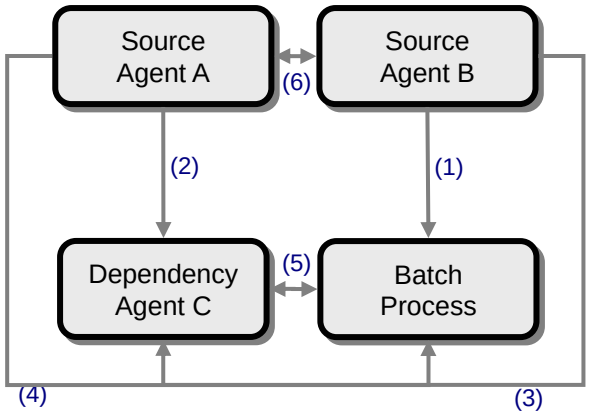

Fig. 7: Competition behaviors Model

Description:

(1)The Source Agent B is process its' tasks in first. After the Source Agent B accomplish its' task, the Source Agent B transmits the result to the Dependency Agent D.

(2)The Source Agent A is process its' tasks in first. After the Source Agent B accomplish its' task, the Source Agent A transmits the result to the Dependency Agent C.

(3)The Source Agent B is process its' tasks in first. After the Source Agent B accomplish its' task, the Source Agent B transmits the result to the Dependency Agent C.

(4)The Source Agent A is process its' tasks in first. After the Source Agent B accomplish its' task, the Source Agent A transmits the result to the Dependency Agent D.

(5)Both the Dependency Agent C and the Dependency Agent D receive the results from the Source Agent A and the Source B. The Dependency Agent C and the Dependency Agent D obey the constraints of predefinition competition rules to arrange the tasks priority.

(6)Both the Source Agent A and the Source Agent B transmit the result to the Dependency C or Dependency D. Before the transmission mechanism beginning, the Source Agent A and Source Agent B refer to the constraints of predefinition competition rules to arrange the tasks priority.

- **Competition behaviors Model Algorithm**

```
SAA=new Agent; //Source Agent A
SAB=new Agent; //Source Agent B
Result DACFunction(Agent Source1,Agent Source 2)
 {
 DAC=new Agent;//Dependency Agent C
 if (Source1.priority > Source2.priority)
 {
      rst=DAC.ExecuteTask(Source1);
      rst=DAC.ExecuteTask(Source2);
 }
 else
 {
      rst=DAC.ExecuteTask(Source2);
      rst=DAC.ExecuteTask(Source1);
 }
      Destroy(DAC);
      Return(rst);
 }
Result DADFunction(Agent Source1,Agent Source 2)
 {
 DAD=new Agent;//Dependency Agent D
 if (Source1.priority > Source2.priority)
 {
      rst=DAD.ExecuteTask(Source1);
      rst=DAD.ExecuteTask(Source2);
 }
 else
 {
      rst=DAD.ExecuteTask(Source2);
      rst=DAD.ExecuteTask(Source1);
 }
 Destroy (DAD);
      Return(rst);
 }
 while (IsTaskFlag ==OK)
 {
      if (SAA.priority >SAB.priority)
      {
      Result=DACFunction(SAA,SAB);
      Result=DADFunction(SAA,SAB);
      }
      else
      {
           Result=DACFunction(SAB,SAA)
      ;
           Result=DADFunction(SAB,SAA
      );
      }
 }
 Destroy (SAA);
 Destroy (SAB);
```

3. Radio Frequency Identification (RFID)

Table 4: RFID frequencies and characterizes

Radio frequency identification (RFID) [10] consists 3 part as tags, reader/interrogator and middleware[15][21] as shown in Fig.8. The tag is attached to objects and preserves critical information. The critical information is a model type, a product number, a product serial number, a location or any necessary data. There are 2 kind of tag be used in RFID system. One is Passive tag. Other is Active tag. The primary different of those tags are battery used. The passive tag's characterize is without requires a battery for RF transmission and the active tag does require a battery to transmit a signal to a reader antenna.

The tag has three attributes to identify the data can be read or written type.(Read-only, Write-once and Read-write) and the RFID technology is operating for the specify frequency(LF 125 KHz , HF 13.36 MHz, UHF 868-915 MHz, Microwave 2.45 GHz & 5.8 GHz) as shown in table 4. Both the tags and Reader/interrogators use the same frequency to transmit the information and using the anti-collision protocols to allow multiple tags to be read for one single reader/interrogator. This anti-collision protocol is designed for avoiding the interferer among the multiple tags.

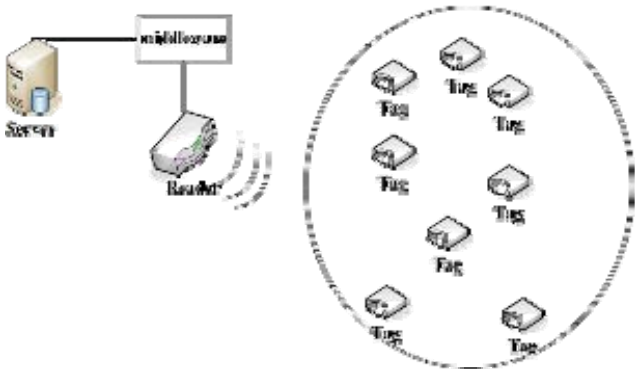

Fig. 8: RFID System Architecture

4. Using Multi-Agent [1][2][28] Communication Mechanism on Intelligent System[5] Implementation

In this paper, it implements the intelligent Parking system using the RFID mechanism and embedded the intelligent agent mechanism to explore the parking lots conveniently and automatically. User(s) can use the handset devices such as PDA phone and cellular phone to retrieve the authentication and services. Once the authentication is passed[25][26], user(s) can easy to search the parking lots close to him/her location as shown in Fig.9.

Frequency Range	LF 125 KHz	HF 13.56 MHz	UHF 868-915 MHz	Microwave 2.45 GHz & 5.8 GHz
Read Range	Up to 4-6 In	Up to 8 feet	10-20 feet	<3 feet
Data Rate	Slow	Slow	Fast	Fast
Passive Tag Size	Large	Large	Small	Small

The cellular phone or PDA phone is used the mobile system to automatically search the base station. Once the connecting with the base station, user can dial the number out or search Internet using the communication protocol. The cellular phone has a major characterize which is mobility and conveniently. Based on this primary characterize, user(s) can explore the information at anytime and anywhere. The system has to consider the limitation of handset device screen size and the specifications at system design beginning. Table 5 is shown the intelligent parking system (User's cellular phone application) configuration more detail.

Table 5: Intelligent Parking System Configuration

	Description	Remark
Software	1. Microsoft embedded Visual C++ 4.0[27] 2. Microsoft ActiveSync 3.Intelligent Parking system	1.Development tool 2.Gateway 3.Application
Hardware	Dopod 838Pro PDA phone with wireless Module	Detail Specification please refer to : http://www.dopodasia.com/Dopod/Australia/Products/PDAPhone/838Pro/spec.htm

Scenario: When John is driving a car to Shihlin district and he desires to know where the parking lot is close to him. He only brings the cellular phone and attends a very important conference with his boss. He does not want to waste the time to go around and search the empty parking lots.

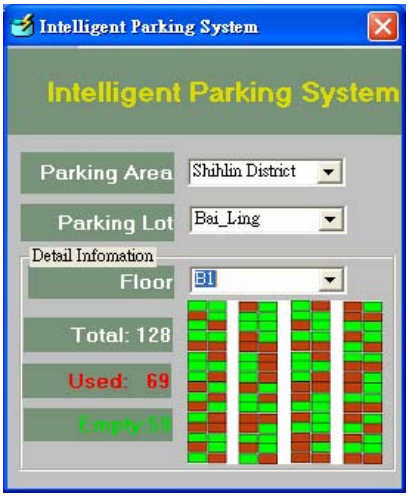

Fig 9: Intelligent Parking System

Solution: Suddenly, John remembers that he can use the intelligent parking system to help him to quickly search the close parking lot. He takes the cellular phone in first and double-clicks this application of intelligent parking system to start this authentication screen. After he passed the authentication, he saw the dialog as shown in Fig.9. In this dialog, he chooses the Parking Area (Shihlin District), Parking Lot (Bai_Ling) and Floor (B1). Then, he obtains the information in detail Information block. The left side of detail Information is capacity of Packing Lot and how many parking lots are used or empty. The Right side of detail Information is graphic user interface (GUI) to demonstrate the parking lot used or empty, the green color is empty and the red color is used.

Agent Activity: In this Intelligent Parking System architecture as shown in Fig. 10, it includes three agents (Authentication Agent, Service Agent and RFID Agent) to establish a communication channel and transmit the data stream. Those agents are belonged to communication behaviors model (See section 2.3) and the life cycle of agent is from event triggered beginning to the tasks has been done. The Authentication Agent process the LDAP protocol authentication when the user(s) use the mobile device to obtain this application. Service Agent processes the request from user(s) and communicates with RFID Agent. RFID Agent is obtained the data from RFID middleware and transmitted the data to Service Agent immediately.

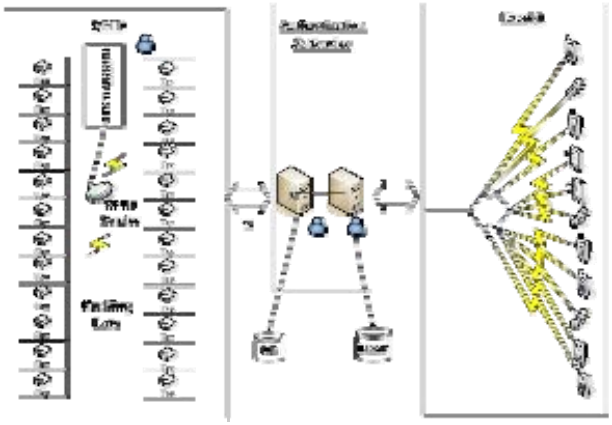
Fig 10: Intelligent Parking System Architecture

RFID: This Intelligent Parking System is applicable for the RFID characterize (See section 3). In each parking lot with install the tag to transmit the status to RFID reader. When the parking lot is occupied or empty, the RFID reader updates the status immediately and the RFID agent is triggered.

•Authentication Agent

In this study, it uses the Authentication agents to receive the requirements from end-users and communicate with the Service agent. The Authentication agent is created by itself when end-users send a request to Authentication site. After the Authentication agent has been created, the end-users authentication verifies with the LDAP Server. Authentication Agent is comprised 8 states to demonstrate the Authentication agent communication behavior as shown in Fig 11 and its functions. It includes Creating, Connecting, Communication, Response, Verify, Unavailable, Destroy and Service Agent.

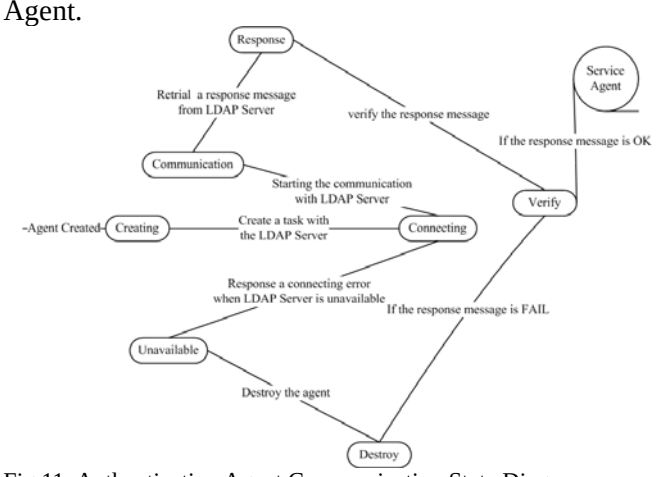

Fig 11: Authentication Agent Communication State Diagram

(1) Creating:

The agent is created by the system when end-users send a request to Authentication site and create a task with the LDAP Server.

(2) Connecting:
When the agent is created by the system, the agent states the Connecting state. System starts the communication with LDAP server to retrieve the Return Message. If the LDAP server is active, this system entry the Communicate state otherwise entry this state of Unavailable.

(3) Communication:
When the LDAP server returns an OK message, the system states the communication state and sends the username and password from end-user to LDAP server. The communication protocol is TCP in order to ensure the packet safely.

(4) Response:
After received the username and password form end-user, the system states the Response state. This state gets the response message from LDAP server.

(5) Verify:
The Verify state function is to check the response message. If the response message is FAIL, this system states the Destroy state, otherwise the system entry the Service Agent.

(6) Unavailable:
When the system gets a connecting error from LDAP server, the system states the Unavailable state. In this state, the LDAP server is not active.

(7) Destroy:
When the system getting a response message is FAIL or LDAP server is unavailable, this system states the Destroy state. In this state, this system terminates this agent activity.

(8) Service Agent:
If the system getting a response message is OK signal, system communicates with Service agent.

•Service Agent

In this study, it uses the Service agent to receive the events from Authentication Agent if system getting a response message is OK. This Service Agent checks the end-user ACL (Access Control List) to provide multi services. It is comprised 6 states to demonstrate the intelligent agent communication behavior as shown in Fig. 12 and its functions. It includes Creating, Service Request, ACL, Service Provided, Fail and Destroy.

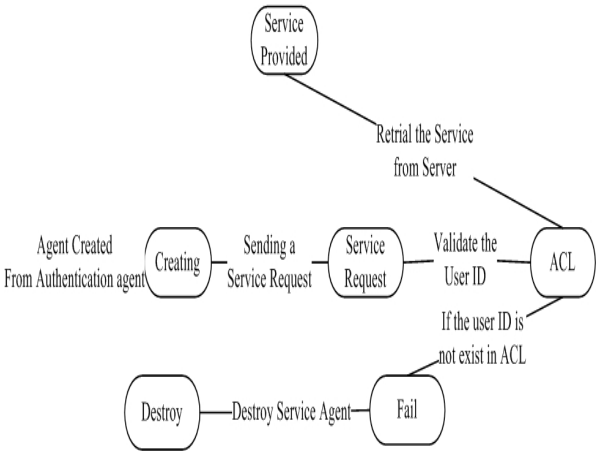

Fig 12: Service Agent Communication State Diagram

(1) Creating:
The agent is created by the system when an event triggers occurring from Authentication agent. After this state has been created, the system sends a Service Request.

(2) Service Request:
When the agent is created by the system, the agent sends a Service Request and entry in Service Request state.

(3) ACL(Access Control List):
When the system gets the Service Request, this system validates the username authorize list with the ACL. This ACL function is provided the authorize list by each end-user.

(4) Service Provided:
After Validated the User ID and the User is valid, the system entry the Service Provided state. This Service Provide state is retrieval the Service from Server.

(5) Fail:
When the user ID is not existed in ACL, the system enters the Fail state. The Fail state triggers the Destroy state immediately.

(6) Destroy:
In this state, this system terminates this agent activity.

•RFID Agent

In this study, it uses the RFID agent to receive the events from the RFID middleware. The RFID agent creates by itself when trigger occurred and send the data stream from RFID middleware to DB. It is comprised six states to demonstrate the RFID agent communication behavior as shown in Fig. 13 and its functions. It includes Creating, Connecting, Meta, Unavailable, Waiting and Retry.

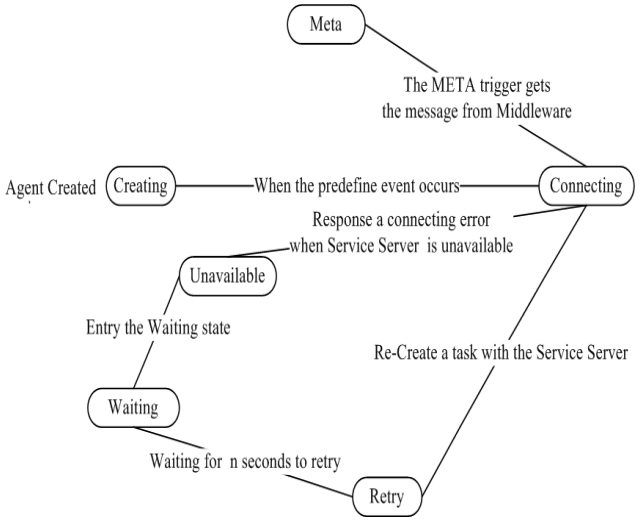

Fig 13: RFID Agent Communication State Diagram

(1) Creating:
The agent is created by the system when an event triggers occurring from RFID middleware. In this Creating state, the new agent is alive and beginning communicates with next state.

(2) Connecting:
When the agent is created by the system, the agent creates a process with the destination agent (DB). The communication protocol is TCP to ensure the packet safely.

(3) Meta:
After Connecting active is OK, the Meta trigger gets the message from Middleware. This Meat state updates the Parking lot status into DB immediately.

(4) Unavailable:
The Unavailable state is stand for the Service Server is not reachable.

(5) Waiting:
When the Unavailable state is occurred, system waits for n second to retry this communication.

(6) Retry:
The RFID agent re-Creates a task with the Service Server. If the re-Create action failure, the RFID agent enter the Unavailable state.

5. Conclusion

The RFID technology has been more mutual in recently and the telephony infrastructure has been established around the world. How to integrate these architecture and embedded the intelligent agent communication mechanism to provide the flexible, stable, available system is the most important key successful factor. Using the intelligent agent mechanism characterize and integrated the RFID mechanism can reduce the management cost and engineering cost. (Only need to install a tag and a RFID reader/ interrogator) The intelligent agent is executed under background automatically by system when the event is triggered. In this paper, it proposes four kinds of intelligent communication behaviors model to describe the intelligent agent cooperation behaviors model, coordination behaviors model, combination behaviors model and competition behaviors model and implement an intelligent parking system to demonstrate the intelligent agent mechanism and integrate the RFID mechanism.

Using the intelligent agent is to improve the procedure more smoothly and automatically. (The intelligent agent automatically establishes a communication channel and to transmit the data packets from source site to destination site.) Furthermore, how to reduce the management cost and enhance the efficiency is important factor for intelligent agent mechanism and how to establish a compatible communication channel to integrate many heterogeneity systems are future research directions.

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