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Integrated the Intelligent Agent Behavior Model and Billing Service into Communication System

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Abstract: The evolution of mobile communications has been rapidly popular in recent years. In Taiwan, mobile phones predominantly possess multiple functions. In other words, mobile phones are not only conventional phones but also smart computer systems embedding with intelligent agent mechanisms to integrate heterogeneous applications. In addition, the billing system (Customer DB, Tariff and Sharing Schemes, Rating and Bill Data) is the crucial part of the communication system. It is an independent system to calculate the fee of communication. There are a lot of applications embedded into the mobile device in the market; however, how to integrate the billing system with the applications is insufficient. This study uses the RFID characteristics and intelligent agent attributes to establish a communication channel in order to automatically transmit data packets from the source site to the destination site. It exploits the intelligent agents to combine the intelligent parking system and the billing system. In addition, it proposes four kinds of intelligent behavior models including the intelligent agent cooperation behavior model, communication behavior model, coordination behavior model and competition behavior model to improve the process more smoothly and automatically. Using the intelligent agent characteristics and integrating the RFID features with the billing system are the most significant key factors. The proposed method improves the process, reduces the management cost and provides more flexible, stable and available systems.

Key words: Intelligent system, radio frequency identification, agent, billing

INTRODUCTION

The developmental trend of mobile devices has been from simple functions to multi-interactive functions. Mobile devices (Ozen *et al*., 2004; O'Hare *et al*., 2006) are the human's best helper instead of earlier devices with simple functions. Meanwhile, it can be exploited to communication (Giancarlo *et al*., 2008) in day to day life. The added values of mobile devices are entirely used to deal with trace or warning events.

In recent year, the mobile technology has been rapidly grown up from simple functions to multiple functions. Meanwhile, the mobile technology evolution is from the early 1G, 2G and 2.5G to now 3G. The G stands for Generation and individual generation has different characterizes and functions such as max. Speed, signal type and signal type. Its' support functions are as shown in Table 1.

According to this trend of mobile system, it shows that the mobile phone is not only the dial out and pick up but also provides a lot of information via the internet. It also impacts human learning behavior from the stationary device to the mobile device. The objective of study is to integrate the agent mechanism upon the mobile device and demonstrate the agent behaviors and functions.

The primary feature of intelligent agent (Amy and Gian, 1999; Glitho *et al*., 2002; Wooldridge *et al*., 1996; Panait and Luke, 2005) is constructed a communication channel to transmit data packets from the source site to the destination site via the TCP/UDP communication protocol automatically. In this study, it integrates the billing system (Maria *et al*., 2007; Yu-Yi *et al*., 2005) with intelligent agent behaviors. Besides, using the RFID (Konstantinos *et al*., 2007; Li *et al*., 2004; Selwyn, 2007) characteristics and intelligent agent attributes to combine the heterogeneity system and obtain the real time information from the RFID middleware (Floerkemeier and Lampe, 2005; Joseph and Thompson, 2006). The meaning of intelligent agent is proposed by Noureddine and Obaidat (2004) and implemented in numerous systems, such as the communication system, coordination system and cooperation system. The purpose of

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Table 1: Mobile evolution

	Class			
Item(s)	1 G	2 G	2.5 G	3 G
Signal type	Analog	Digital	Digital	Digital
Max. speed	Not available	14.4 kbps	384 kbps	2 Mbps
System	AMPS	GSM CDMA	GPRS	WCDMA CDMA2000
Support function	Voice	Voice SMS	Voice/SMS application	Voice/video/MMS/SMS application

Table 2: Agent system classification

Classification	Single-Agent system (SAS)	Classification	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	Communication

intelligent agent includes two aspects of systems: Single-Agent System (SAS) and Multi-Agent System (MAS) (Tweedale *et al*., 2007; Mehdi and Gomez-Sanz, 2005; Kotz and Robert Gray, 1999) as shown in Table 2. Meanwhile, the intelligent agent mechanism is designed to execute tasks under the background in terms of the application drives an event trigger.

INTELLIGENT AGENTS

In this study, it proposes the intelligent agent behavior models (Finin *et al*., 1998) to demonstrate the agents' behavior in detail. The intelligent agent behavior model is comprised of four models: (1) cooperation behavior model, (2) communication behavior model, (3) coordination behavior model and (4) competition behavior model as shown in Fig. 1.

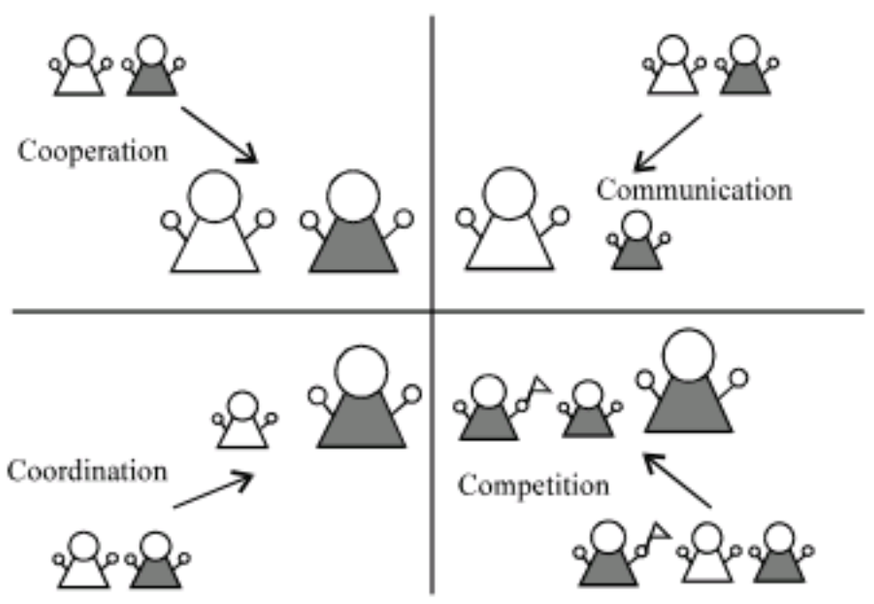

Fig. 1: Intelligent agent behavior model

Cooperation behavior model (Sarit, 1997; Liu and Yao, 2004): This cooperation behavior model is demonstrated the intelligent agent cooperation behavior as shown in Fig. 2. The intelligent agent is in terms of the definition of cooperation policies and assigned the complexity tasks to the dependency agent. The purpose of this model is to reduce the execution time and obtain the effective performance.

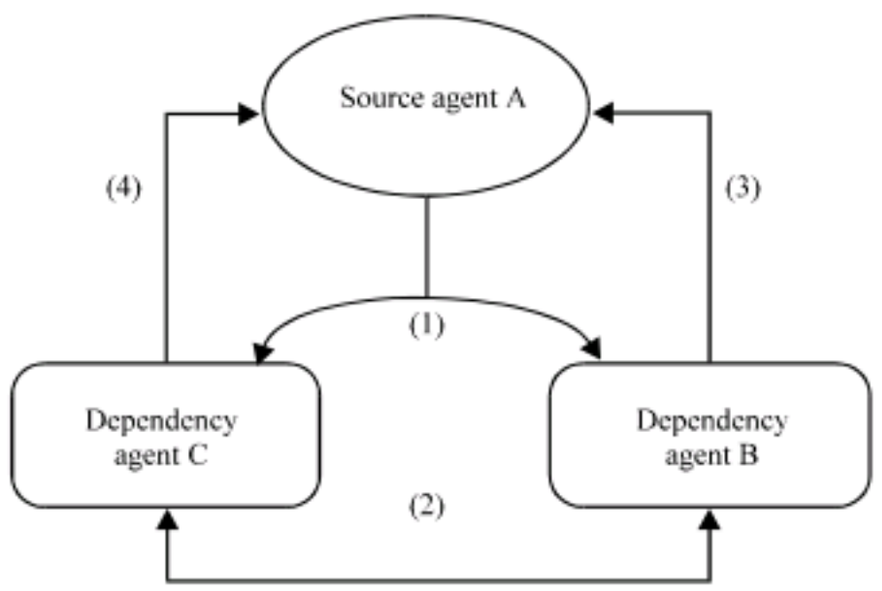

Fig. 2: Cooperation behavior model

Description:

- The source agent A is based on the definition policies to assign the tasks to the dependency agent C and the dependency agent B
- The dependency agent B and the dependency agent C execute the tasks from the source agent A
- The dependency agent B responses a message to the source agent A when the dependency agent B is finished the tasks from the source agent A
- The dependency agent C responses a message to the source agent A, after the dependency agent C is finished the tasks from the source agent A

Communication behavior model: This communication behavior model (Nicoletta *et al*., 2007) is illustrated the communication procedure of intelligent agent as shown in Fig. 3. The intelligent agent establishes a connection in the initial phase with other agents. Once the connection is connected, the Source agent interacts with the destination agent.

Description:

- The dependency agent A is to process the tasks and response packets to the dependency agent B when

the dependency agent A is finished the specific tasks. The dependency agent B checks and confirms whether the result is valid

- Likewise, the dependency agent B is to process the tasks and response packets to the dependency agent A when the dependency agent B is finished the specific tasks. The dependency agent A checks and confirms whether the result is valid

Coordination behavior model: This coordination behavior model is demonstrated the coordination procedure of intelligent agent as shown in Fig. 4. The intelligent agent accomplishes the tasks by itself and transmits the result to specify intelligent agent. This intelligent agent starts the coordination mechanism to integrate the result from source agents.

Description:

- The source agent B is to process its' tasks first. After the source agent B is finished, the source agent B transmits the result to the dependency agent C
- Similarly, the source agent A is to process its' tasks first. After the source agent A is finished, source agent A transmits the result to the dependency agent C

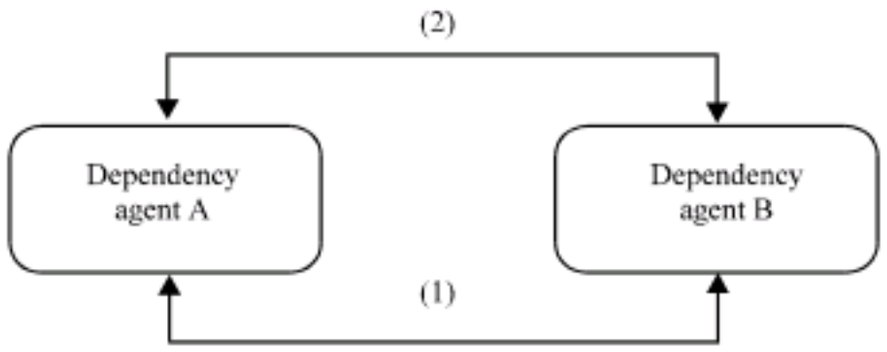

Fig. 3: Communication behavior model

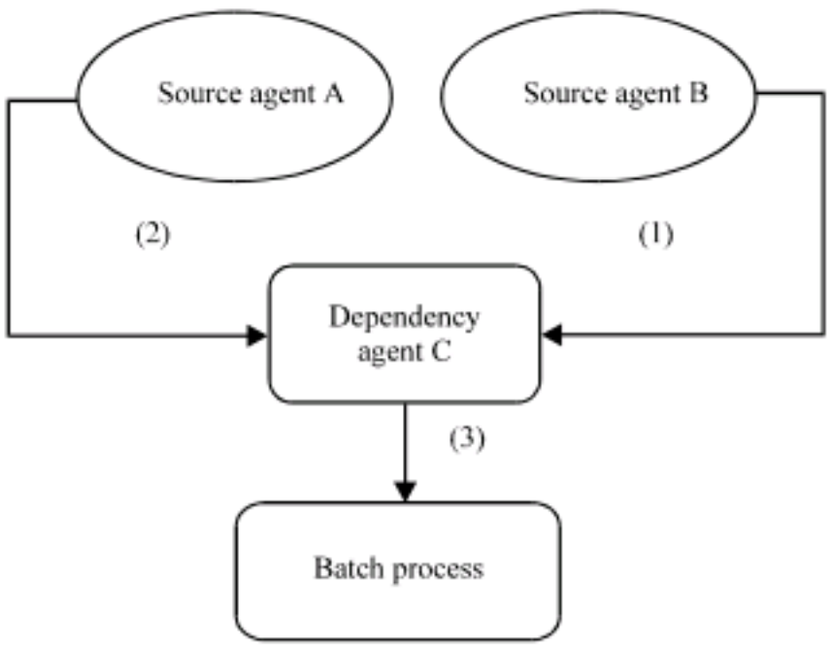

Fig. 4: Coordination behavior model

- 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 both the source agent A and the source agent B, the batch process is triggered

Competition behavior model: This competition behavior model is illustrated the agent competition procedure as shown in Fig. 5. The competition situation of the intelligent agent is existed for the multi-agent. In order to avoid the collision situation, the intelligent agent shall obey the constraints of predefinition competition rules. The anti-collision mechanism is the major success factor in this model.

Description:

- The source agent B is to process its' tasks first. After the source agent B accomplish its' task, the source agent B transmits the result to the dependency agent D
- The source agent A is to process its' tasks first. After the source agent B accomplishes its' task, the source agent A transmits the result to the dependency agent C
- The source agent B is to process its' tasks first. After the source agent B accomplishes its' task, the source agent B transmits the result to the dependency agent C
- The source agent A is to process its' tasks first. After the source agent B accomplishes its' task, the source agent A transmits the result to the dependency agent D
- Both the dependency agent C and the dependency agent D receive the results from the source agent A and the source agent B. The dependency agent C and the dependency agent D arrange the tasks priority according to the constraints of predefinition competition rules

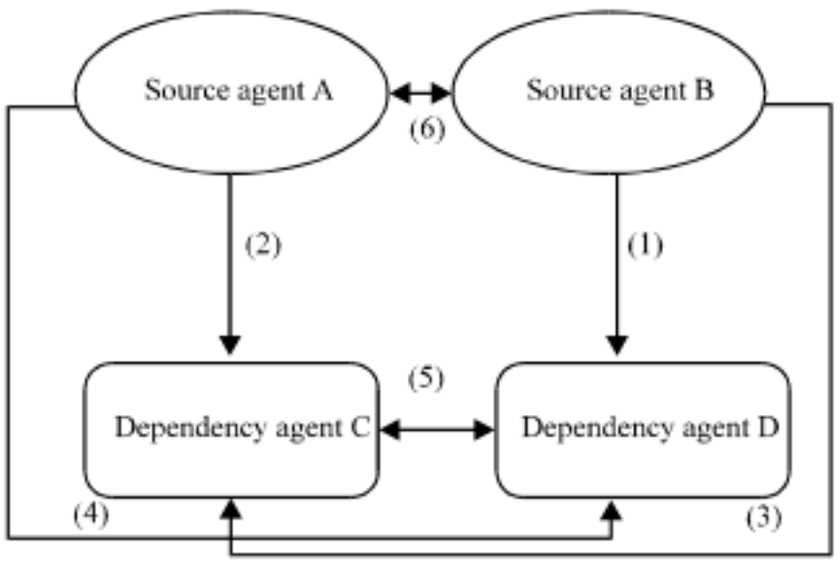

Fig. 5: Competition behavior model

- Both the source agent A and the source agent B transmit the result to either the dependency agent C or dependency agent D. However, before the transmission mechanism starts, the source agent A and source agent B according to the tasks priority based on the constraints of predefinition competition rules

RADIO FREQUENCY IDENTIFICATION

The Radio frequency identification (RFID) includes 3 aspects: tags, reader/interrogator (Selwyn, 2007) and middleware (Floerkemeier and Lampe, 2005; Joseph and Thompson, 2006) as shown in Fig. 6. The tag is attached to objects and preserves the critical information. Furthermore, the critical information can be a model type, a product number, a product serial number, a location or any necessary data. Two kinds of tags including passive tag and active tag are used in the RFID system (Konstantinos *et al*., 2007). The primary different of those tags are battery used. The passive tag's characteristic is without requiring a battery for RF transmission. However, the active tag is needed a battery to transmit a signal to a reader antenna.

Three attributes of tag containing Read-only, Write-once and Read-write is to identify the data whether it can be read or written. Meanwhile, the RFID technology is to operate for the specific frequency: LF 125 kHz, HF 13.36 MHz, UHF 868-915 MHz, Microwave 2.45 GHz and 5.8 GHz. Both the tags and Reader/interrogators use the same frequency to transmit the information and perform the anti-collision protocols in order to permit multiple tags to be read for one single reader/interrogator. This anti-collision protocol is designed for avoiding the interferer among the multiple tags.

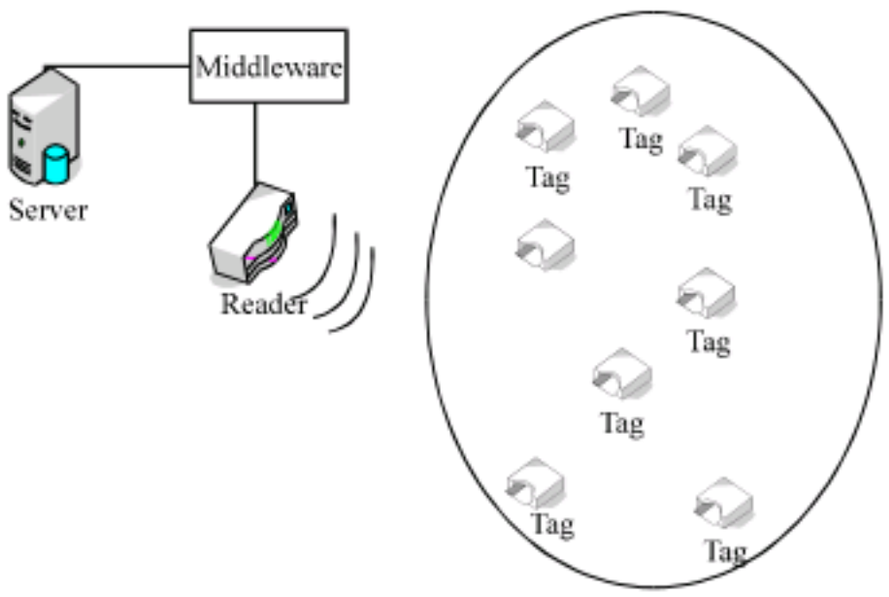

Fig. 6: RFID System architecture

IMPLEMENT THE INTELLIGENT SYSTEM

In this study, it implements the intelligent Parking system (Zili and Chengqi, 2007) by using the RFID mechanism and embedding the intelligent agent mechanism to explore the parking lots conveniently and automatically. The mobile devices such as PDA phone and cellular phone are used to retrieve the authentication and services. When the authentication is passed, the close parking lots can be detected (Barg and Wong, 2000; Martin *et al*., 1999; Stroulia and Hatch, 2003; Fianyo *et al*., 2001) as shown in Fig. 7.

Either the cellular phone or PDA phone is used at the mobile system (Ozen *et al*., 2004; O'Hare *et al*., 2006) to automatically search the base station. Once the connection is established the base station, dialing the number out or surfing the Internet can be utilized under the communication protocol. The cellular has a major characteristic which is mobility and conveniently. Based on this primary characteristic, it can be explored the information at anytime and anywhere. However, the system has to consider the limitation of handset devices screen size and the specifications at the system design beginning.

Scenario: When John is driving a car to Shihlin District and desires to know where the parking lot is close. 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.

Solution: Hastily, John remembers to use the intelligent parking system to promptly search the close parking lot. He takes the cellular phone first and double-clicks this application of intelligent parking system (Fig. 8) to start this authentication screen. After succeeding the authentication, he will see the dialog as shown in Fig. 8. In this dialog, the Parking Area (Shihlin District), Parking Lot (Bai_Ling) and Floor (B1) is selected. After that, the information in detail Information block is obtained. The left side of detail Information is capacity of packing lot and how many parking lots are occupied or empty. The right side of detail Information is Graphic User Interface (GUI) to demonstrate the parking lot occupied or empty, the green color is empty and the red color is occupied.

Radio Frequency Identification (RFID): This Intelligent Parking System is applicable for the RFID characteristic. In each parking lot, it is installed the tag to transmit the

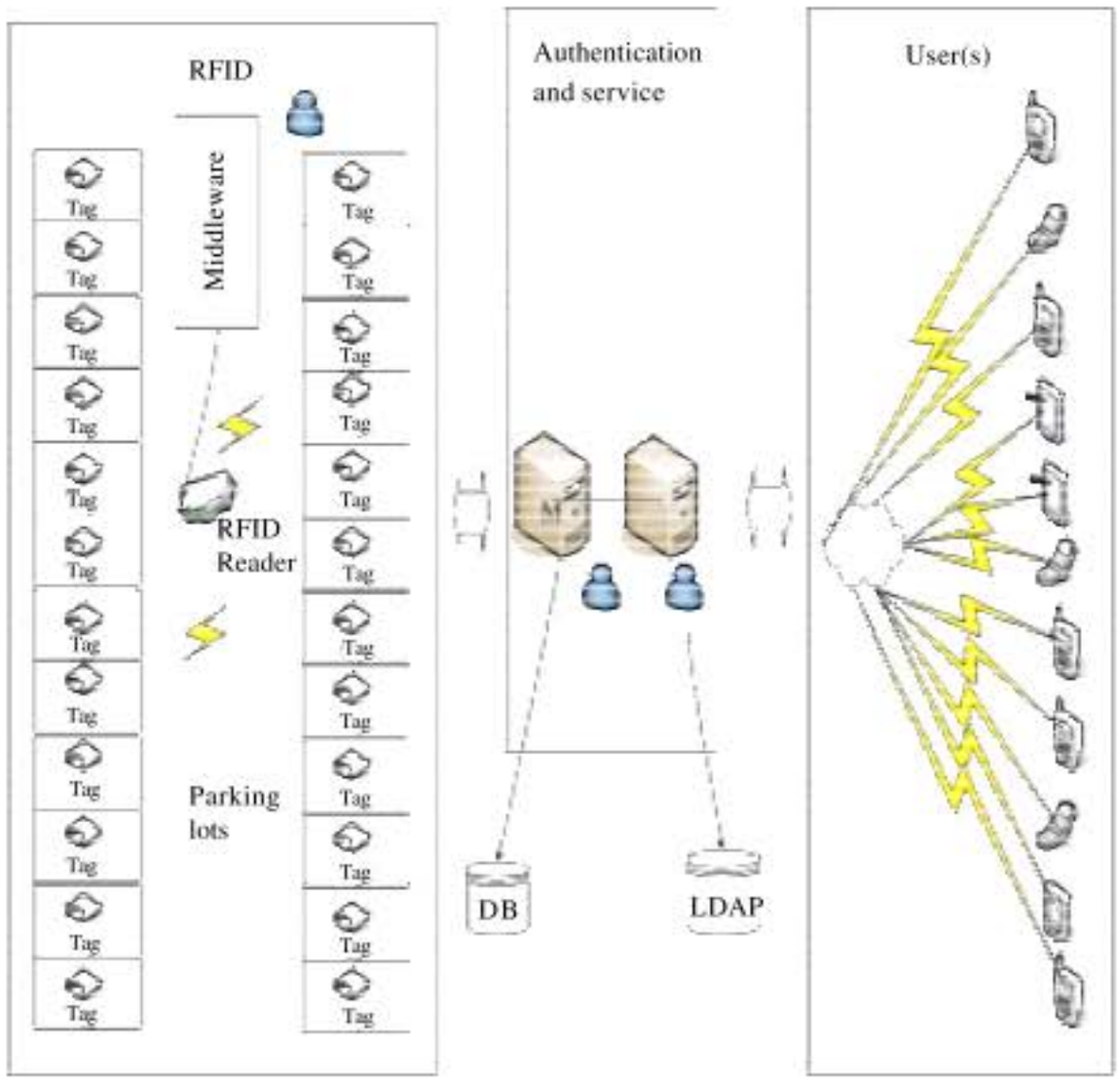

Fig. 7: Intelligent parking system architecture

Fig. 8: Intelligent parking system

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.

Agent activity: In this Intelligent Parking System architecture, it includes 3 agents (authentication agent, service agent and RFID agent, which are belonging to communication behavior model) to establish a communication channel and transmit the data stream. The authentication agent process the LDAP protocol authentication when the users use the handset device to gain this application. Service agent is to process the request from user and communicates with RFID agent. RFID agent obtains the data from RFID middleware and transmitted the data to Service agent immediately.

Authentication agent: In this study, it exploits the authentication agent 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 the authentication site. After the authentication agent has been created, the end-users authentication is verified with the LDAP Server. Authentication agent is comprised 8 states to demonstrate the authentication agent communication behavior as Fig. 9 and its functions. It includes creating, connecting, communication, response, verify, unavailable, destroy and service agent.

- **Creating:** The agent is created by the system when end-users send a request to the authentication site and create a task with the LDAP server
- **Connecting:** When the agent is created by the system, the agent states connecting state. The

system starts the communication with LDAP server to retrieve the return message

- **Communication:** When the LDAP server returns an OK message, the system enters the communication state and sends the username and password from end-users to LDAP server. The communication protocol is TCP in order to ensure the packet securely
- **Response:** After received the username and password from end-users, the system states response state. This state gains the response message from LDAP server
- **Verify:** The verify state function is to check the response message. If the response message is FAIL, this system states the destroy state
- **Unavailable:** When the system gets a connecting error from the LDAP server, the system states this unavailable state. In this state, the LDAP server is not active
- **Destroy:** When the system obtains a response message is either FAIL or LDAP server is unavailable, this system states this destroy state. In this state, this system terminates this agent activity
- **Service agent:** If the system getting a response message is OK signal, the system will communicate with service agent

Service agent: In this study, it uses the Service agent to receive the events from the Authentication Agent if system getting a response message is OK signal. This service agent checks the end-users ACL (access control list) to provide multiple services. It comprises 6 states to demonstrate the intelligent agent communication behavior as Fig. 10 and its functions. It includes creating, service request, ACL, service provided, fail and destroy.

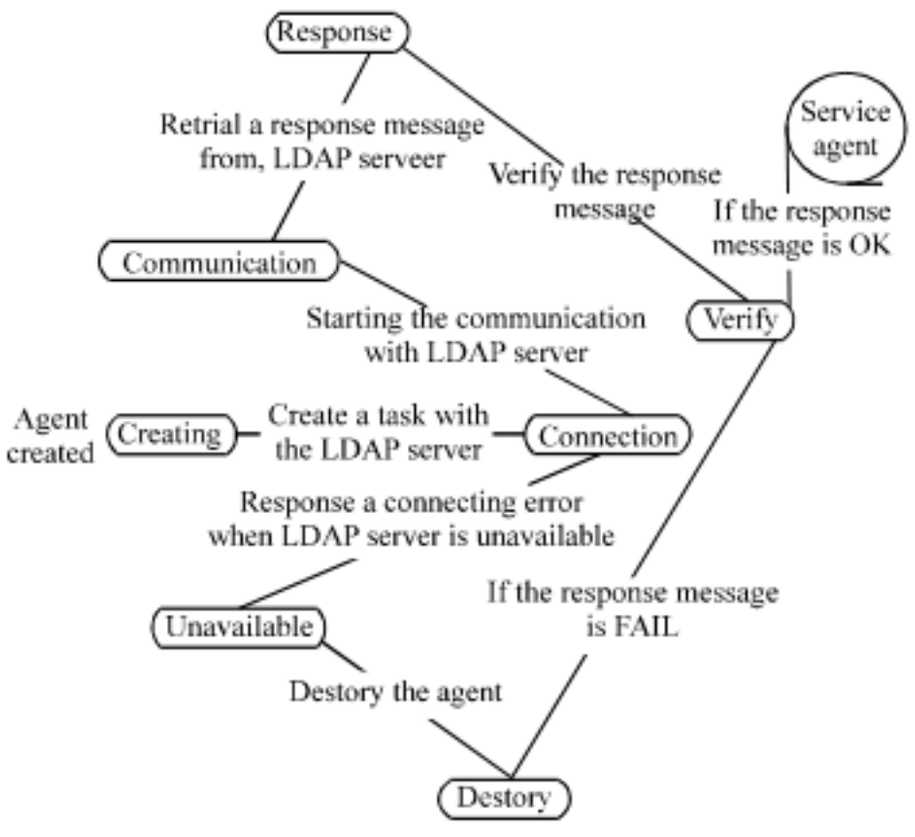

Fig. 9: Authentication agent communication state diagram

- **Creating:** The agent is created by the system in terms of an event which is from the authentication agent. After this state has been created, the system sends a service request
- **Service request:** When the agent is created by the system, the agent sends a service request and enters in service request state
- **ACL (Access Control List):** When the system receives the service request, this system validates the username authorization list with the ACL. This ACL function is to provide the authorization list for each end-user
- **Service provided:** After validating the username, if the user is legal, the system enters the service provided state. This service provided state is to retrieve the service from the server
- **Fail:** When the username does not exist in ACL, the system enters the fail state. The fail state triggers the destroy state immediately
- **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 the RFID middleware to database. It comprises 6 states to demonstrate the RFID agent communication behavior as Fig. 11 and its functions. It includes creating, connecting, meta, unavailable, waiting and retry:

- **Creating:** The agent is created by the system when an event triggers occurring from the RFID middleware. In this creating state, the new agent is alive and starts to communicate with the next state

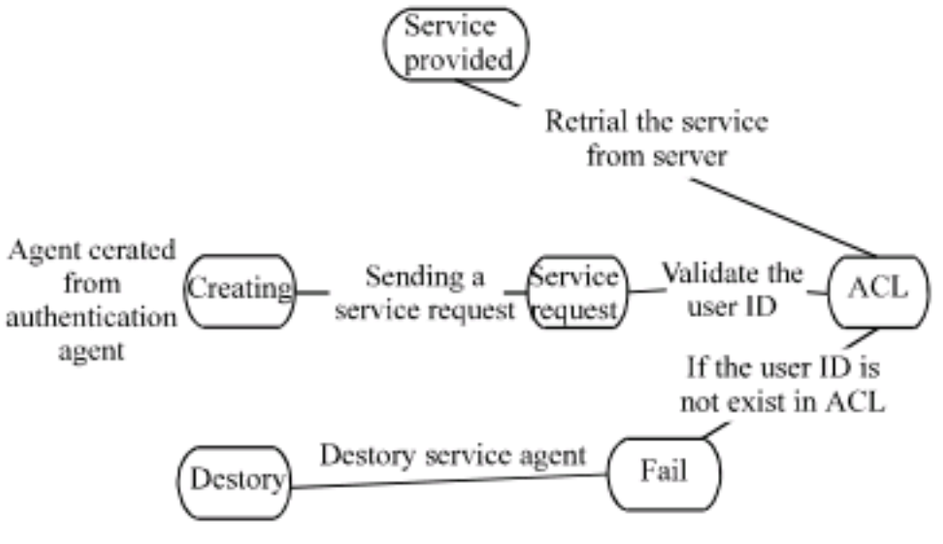

Fig. 10: Service agent communication state diagram

- **Connecting:** When the agent is created by the system, the agent creates a process with the destination agent. The communication protocol is TCP in order to ensure the packet securely
- **Meta:** After connecting active is OK, the meta trigger receives the message from the middleware. This meta state updates the parking lot status into database immediately
- **Unavailable:** The unavailable state stands for the service server not reachable
- **Waiting:** When the unavailable state occurs, the system waits for n second and then retries this communication

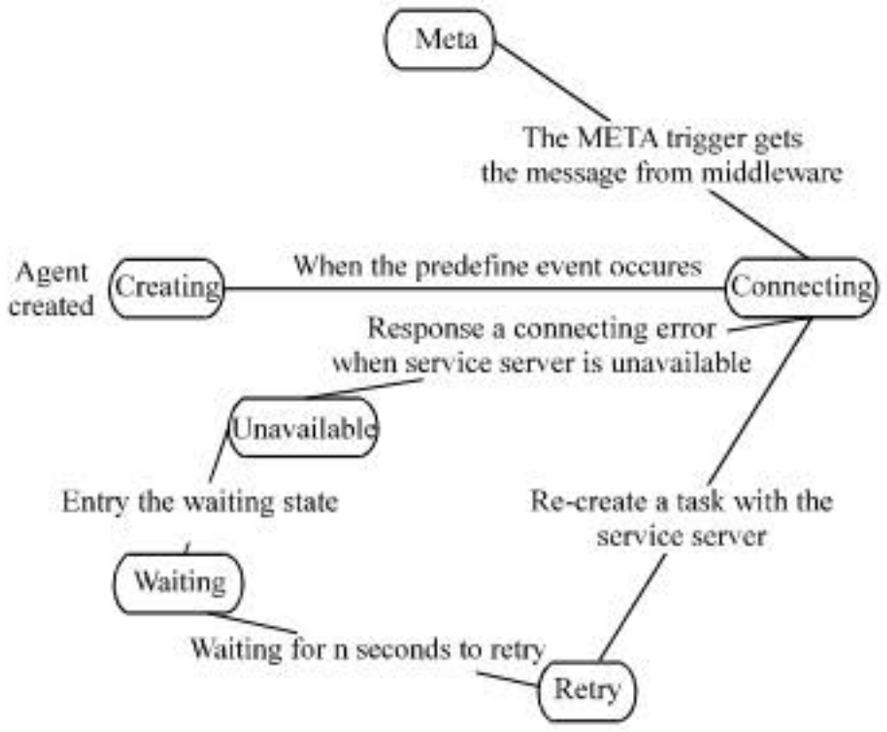

Fig. 11: RFID agent communication state diagram

- **Retry:** The RFID agent re-creates a task with the service server. If the re-create action is failure, the RFID agent enters the unavailable state

BILLING

The billing system architecture is shown as Fig. 12. In this billing system (Maria *et al*., 2007), it divides two aspects to demonstrate the procedure between the telecom billing (Yu-Yi *et al*., 2005) and parking billing. The end-user uses the handset device to obtain the intelligent parking system and the system logs with the duration usages. The billing of parking is according to user information (Tariff and Sharing Schemes, Rating data and Event Mediation) to calculate the current fee and pass this data to telecom, which is via agent interface. This agent communicates states the procedure as shown in Fig. 13.

The telecom bill production is based on the customer Database, Tariff and Sharing Schemes, Rating and Bill Data to produce both the payment checking and Bill Printing. This is because the events trigger the billing system. It is also called Event Detail Record (EDR) and should be included the follow parameters/attributes (Päivi *et al*., 2004):

- The source mobile phone and user profile (For instance ID, etc.)
- The parking area and profile (For instance ID, etc.)
- The Quality of Service (QoS) (Guerin *et al*., 1998)

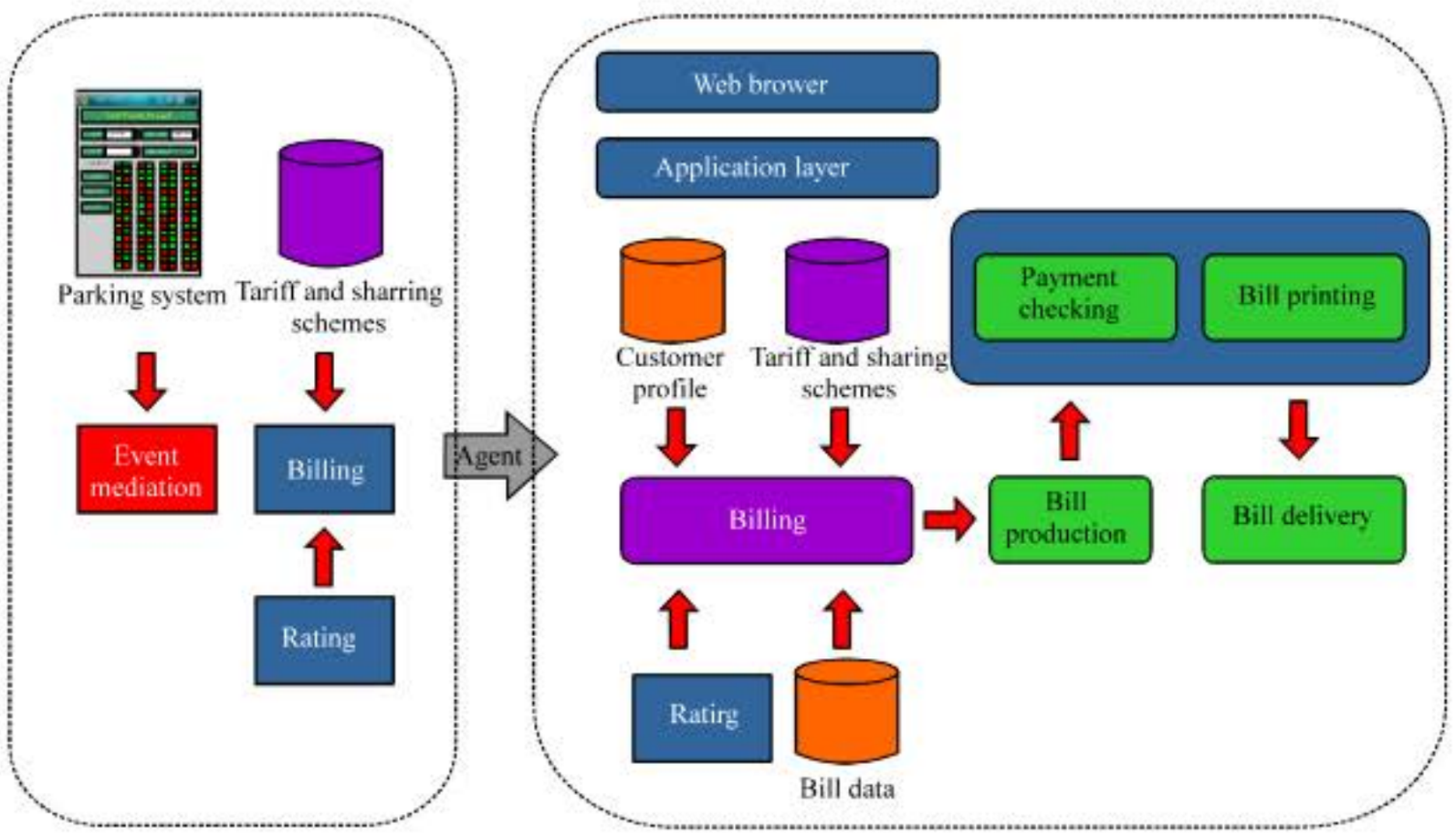

Fig. 12: Billing system architecture

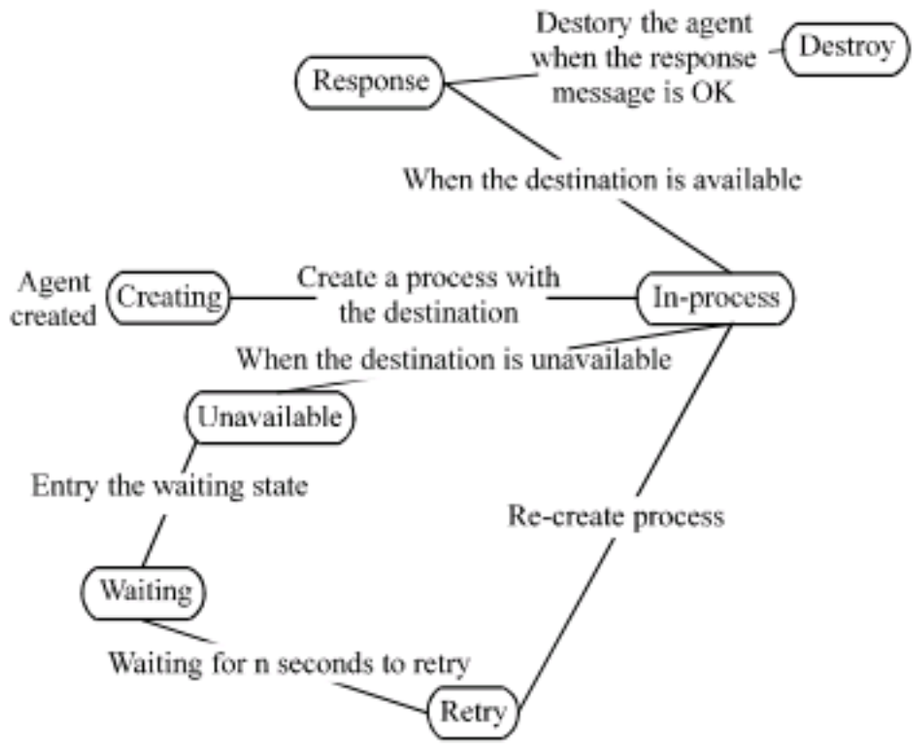

Fig. 13: Billing agent communication state diagram

The billing is to calculate the communication fees according to the user profile (User ID, telephone, address, etc.), Rating Plan, Tariff and Sharing Schemes and Bill data. After the bill production finished the whole process, the communication bill list is produced. Meanwhile, the Bill Printing prints the bill list by the bill cycle and sends the bill list to users via either mail or e-mail. Besides, user can access the web site to know the information of bill further.

In this study, it uses the intelligent billing agent to receive the events from the event mediation (Parking) and communicate with the event interface. The intelligent billing agent creates by itself when trigger occurred and sends the data stream to the billing procedure. It comprises 7 states to demonstrate the intelligent billing agent behavior and its functions. It includes creating, in process, response, destroy, unavailable, waiting and retry.

- **Creating:** The agent is created by the system when an event triggers occurring from the event mediation (Parking). In this creating state, the new agent is alive and starts to communicate with the next state
- **In-Process:** When the agent is created by the system, the agent creates a process with the destination agent. The communication protocol is TCP in order to ensure the packet securely
- **Response:** When the destination is available, the system enters the response state. In this state, the billing data processes and responses a message to the next state
- **Destroy:** After the system receiving the message is OK, the system enters the destroy state. In this state, this system terminates this agent activity
- **Unavailable:** The unavailable state stands for the service server not reachable
- **Waiting:** When the unavailable state occurs, the system waits for n second and then retries this communication
- **Retry:** The billing agent re-creates a process with the destination agent. If the re-create action is failure, the billing agent enters the unavailable state

DISCUSSION

We have demonstrated the intelligent agent behavior models including cooperation behavior model, communication behavior model, coordination behavior model and competition behavior model to exploit existing RFID techniques and integrate the billing system. Firstly, it uses the intelligent agent characteristics to propose four kinds of behavior models and illustrates each of behavior model procedure and interoperability. Secondly, it exploits existing techniques RFID features to implement the intelligent parking system and embedding the intelligent agent behavior models to automatically transmit data packets from the source site to the destination site under the background. It also uses an example to illustrate the agent communication state including the authentication agent, service agent and RFID agent. Finally, a billing system is most crucial part to integrate the heterogeneity existing telecommunication system, which using the billing agent communication mechanism. In this study, it integrates three knowledge areas, intelligent agent characteristics, RFID features and Billing, which is differ from previously study in:

- **More practical:** Since the existing heterogeneity system communication between each other through the intelligent agent becomes more flexible middleware, which are also discussed by Stroulia and Hatch (2003). The interoperability through agents are executed under the software layering (Giancarlo *et al*., 2008) that possess the mobility characteristic is more practical. In this study, it uses the agent characteristic to integrate the existing heterogeneity system to provide the flexible services
- **More convenient:** Since the information becomes real time and therefore the operation method is more simple. The users are only use the mobile device to retrieve the information through the wireless network. Ozen *et al*. (2004) was proposed Highly Personalized Information Delivery to Mobile Clients in 2004 and demonstrated the mobile device becomes more convenient for human life

- **Modular:** It proposes four kinds of intelligent behavior models (cooperation behavior model, communication behavior model, coordination behavior model and competition behavior model) to demonstrate the intelligent agent interactive activities.
- **Reduce cost:** It implements the integrated intelligent system to reduce management cost (process automatically) under the intelligent agent characteristics. The traditional individual applications such as Parking system (Teodorovic and Lucic, 2006) is designed for stand alone system and need manpower to process the billing procedure . In this study, it uses the agent behavior models to process the multiple procedures, which is from query parking lots through the RFID existing technology to billing system through the existing telecommunication billing system (Maria *et al*., 2007; Yu-Yi *et al*., 2005)

From this study result, it improves the traditional individual systems weakness (communication with heterogeneity system) and integrates the existing RFID techniques and heterogeneity telecommunication billing system under the intelligent agent behavior models to process from system initial phase to billing payment phase automatically. Furthermore, it integrates the intelligent agent behavior model and billing service into communication system and also provides the more convenient to know where the parking lot is available in real time.

CONCLUSIONS

The RFID characteristic is provided the communication between the source site and the destination site in short distance and it only needs to install a tag and a RFID reader/interrogator. In this study, it uses the intelligent agent to transmit the real parking lot status immediately and integrate the billing system to achieve the automatically query parking lot status and payment throughout the communication system. Using the intelligent agent in RFID system can accomplish the real time data immediately and provide the mediation of billing to reduce the management cost. How to integrate these heterogeneity architectures and embedding the intelligent agent mechanism to provide the more flexible, stable, available system is the most significant Key Successful Factor (KSF).

It proposes four kinds of intelligent behavior models including the intelligent agent cooperation behavior model, communication behavior model, coordination behavior model and competition behavior model. In addition, it implements an intelligent parking system (Using the three agent: authentication agent, service agent and RFID agent which belong to communication behavior model) to demonstrate the intelligent agent mechanism and integrates the RFID mechanism and the billing system (Using only one billing agent which belongs to communication behavior model) to calculate the payment automatically. Using the intelligent agent characteristic improves the procedure more smoothly and automatically. Furthermore, how to integrate multitudinous heterogeneity billing systems and existed applications are future research directions.

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