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Intelligent Agent-Based Predict System With Cloud Computing for Enterprise Service Platform in IoT Environment

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ABSTRACT If the product supply shortage occurs during the sales period, customers will turn to other companies, so the enterprise lose the sales opportunity. If the enterprise can predict product demands, and manages the product sales by using the supply chain management prediction system to improve the bottleneck of the inventory, the hot sales product can have more critical time utilization, and the inventory status can be reflected quickly by Internet of Things (IoT). To overcome the problem that the replenishment model cannot show the actual quantity of products on the store shelves, in the paper, we propose an intelligent agent-based prediction system, which serves as a framework to construct an integrated prediction system through the use of radio frequency identification (RFID) technology to design the intelligent product prediction shelf to extract product messages, and the service oriented architecture to develop prediction information to recommend products to the customer. The result of the paper proposes an agent-based cloud computing service platform in IoT and intelligent agents with SOA as backend cloud services. To build a prototype prediction system with performance analysis, it can be proved that the prediction system architecture for intelligent agent-based prediction system could improve operation performance and effectively enhance customer service quality for hot sale products.

INDEX TERMS Internet of Things (IoT), intelligent agent-based, predict system, cloud computing, enterprise service platform.

I. INTRODUCTION

With the changes in consumption patterns, product life cycle becoming shorter, and dramatic changes in the retail business, the vendors must timely provide diversified product contents with appropriate product promotion programs to meet consumers' one-stop shopping demand. According to the customer value, which states that the consumer makes a comprehensive assessment of product utilization based on the sense of both obtain and pay [1], hence ''customer value'' is his(her) final perception of whether his desire and demand are satisfied. The marketing planning must be consistent with the consumer's shopping expectation so as to create the maximum economic utilization [2]; therefore, the vendor must be discreet of the product portfolio strategy to promote the products, in accordance with the cyclical demand or news topics to attract the consumer's purchase intention and to satisfy customer's maximum value expectations.

However, the Customer Relation Management is mainly one-to-one, which is a great change when compared to the past database marketing which focuses on a specific customer segments for the promotion activities. As for the customer relation management, customer information in the customer database should include: (1) descriptive information, which records the basic attributes of the customers so as to facilitate segmentation and analysis purposes;

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(2) transaction history, which records complete customer purchase history and related details; (3) customer contact, which records customer contacts from a variety of channels or levels on a daily basis; (4) customer response: which means the immediate customer response to the marketing program [3]. If it analyze the current retail information system architecture, which is the relevant information at the point when the consumer checks out, including: descriptive information of product name and specifications, quantity purchased, amount and date, which will be used as the primary data for sales analysis, and, when combined with product barcode and warehouse management, used to control the inventory of the outlet. However, due to the fact that the POS information retrieval occurs at the checkout point, it cannot get real-time inventory info on the shelves, so a bottleneck which cannot afford to get timely information for the customer contact and customer response will occur.

After getting the product from the shelve and before checking out, the customer will usually go around or purchase other products, so the inventory information displayed in the POS will be inconsistent with the actual inventory on the shelves, which is the so-called ''information time gap'' and will cast adverse impact on the vendor and consumer. When customers are highly interested in the specific product and rush to buy it, such a product will become a hot sale product, and the hot-sale product is an important income source for the retail outlets. A hot-sale product will attract the consumer crowd and promote other products; therefore, under-stocked hot-sale products will result in the stagnant sale income; likewise, if the consumer wants to buy the hot-sale product but finds out that the hot-sale product is not on the shelf, (s)he will likely leave the store; however, a hot-sale product, characteristic of time utilization, has more intense demand for the timely information, so the traditional warehouse-centered replenishment architecture cannot provide the customer with direct perception for the product displayed on the shelf [4].

To upgrade the service industry to a new milestone, preliminary study on the sensing technology standards, application and overall development trend should be done earlier in response to the future evolution of Internet of Things and ensuing industrial change triggered by it. Four purposes of this study are shown below:

(1) Study on the critical applications of the Internet of Things is done, which focuses on the analysis of overall product sale and logistics architecture to identify the applicable critical technology and provide the relevant vendors with strategy advices.

(2) The active sensor devices and information system mechanisms are employed to monitor the product inventory status in the store in order to effectively obtain the sale information of hot-sale product so as to eliminate the bottleneck resulting from the information time lag.

(3) The intelligent agent is combined with an interactive interface to provide the product consultation or promotion advertising so as to promote consumer demand for specific product.

(4) With the help of Web services mechanism, the cross-platform software components are deployed to construct an integrated product sale service management platform so as to meet the front-end object identification.

The intelligent system integration technology platform as follows: It is a network composed of identifiable objects with which users can communicate through the intelligent operation interface and users can also perceptively connect with surrounding environment [5]. Weber pointed out that this platform is an intelligent communication service (whether between human being and object or between objects) which should be immediately and safely used anytime and anywhere, and this platform is also an infrastructure that integrates information and communication technology [6]. That by embedding short-distance sensing transceivers into commonly seen objects in our daily lives, the interconnection will be feasible anytime and anywhere [7]. From the definitions of the intelligent sensing system shown above, it is known that this system is mainly based on the sensing technology, which, through the data mining and communication technology, links physical objects and virtual objects, and which also integrates existing network mechanisms and other applications so as to provide object identification, sensing and connectivity, and other specific applications and services. From the studies discussed above, the intelligent system based on identification components such as RFID will include the following six layers: identification media layer, sensor linking layer, data communication layer, data middleware layer, computing storage layer and application service layer.

To meet the real-time demand for the hot-sale product while improving the operation bottleneck of the information time gap, this study ''intelligent sales service platform'' is divided into four scopes. First, the critical standards for the wireless sensor network (WSN) technology are explored, and the application development of cloud service is also scrutinized; second, the software agent architecture is used as the basis to build the entire system platform, and the RFID technology is also employed to develop the intelligent product shelf, which uses the RFID tag as the product-level sensing component to transfer the real-time shelve status to the back-end system and to assist people in the outlet to get the inventory and out-of-stock status for the hot-sale products so as to help the warehouse center make instant replenishment to meet consumer's demand; third, an interactive product information platform is to be constructed to provide an autonomous advice environment for the consumer so as to improve the customer satisfaction; finally, the hardware and software platform will be integrated for analysis.

II. RELATED WORKS

A. REAL-TIME FEEDBACK INFORMATION SYSTEM

The bullwhip effect describes the end-customer demand, in which through the transmission between the members of the supply chain, that is, from retailers to wholesalers and then to dealers, and transmission to manufacturers, its variation is gradually increased [8]. The bullwhip effect occurs

in almost all consumer-related places, and this effect is more obvious for the industry with shorter product life cycle, more product variety, and greater demand fluctuation. What is more, the hot-sale product has much shorter life cycle, and it requires the real-time information transmission and feedback.

Due to difficult information feedback and lead time delay existing in various sections in the supply chain, the decision-maker in each sector may make repetitive orders and order cancellation, thus resulting in demand amplification; demand uncertainty is the most direct factor influencing the bullwhip effect [7], which will make various sectors of the supply chain increase the inventory just for the sake of avoiding out-of-stock. If this is the case, it will cause chaos in manager's expected inventory decision-making, but in fact the actual demand is not so much as the expected demand, therefore demand amplification occurs. In the case of lot ordering [9], the lot size cannot correctly reflect the end-demand, and if the managers in the same section of the supply chain place orders from the supplier, it will cause demand surge and the bullwhip effect occurs; as for the price fluctuation [10], [35], [36], the consumer's expectation will have purchase/storage advance or purchase slowdown behavior; in the same manner, managers in each sector of the supply chain will do so, which will cause a backlog of inventory and demand amplification; moreover, each sector of the supply chain employs the data coming from the previous sector to forecast, but the data in these sectors is erroneous and inconsistent, coupled with inconsistent forecast methods, the forecast will be incorrect and the equilibrium in production and demand will be infeasible. Therefore, decreasing the number of sectors of the supply chain is the most effective method to eliminate the bullwhip effect [11]. Obtaining the sales information of the end-customer and even exploring the ordering behavior will be able to accurately estimate a consumer's order frequency, order quantity, to find the optimal combination of parameters to set safety stock, and to change the decision-making mechanism among sectors of the supply chain so as to reduce the bullwhip effect.

Using the information exchange mechanism of an automated system allows each sector able to get the end-customer sales; in such manner, the actual order quantity and redundant quantity in an order will be known so that the upstream and downstream sectors can use the same sales data to do forecast, and, with the POS, EDI and VMI, small-lot-size ordering or CRP (Continuous Replenishment Planning) becomes possible. At the same time, the past order information is used to do a proportional quota, and the inventory information sharing is also used to solve issues such as demand forecast, lot ordering, price fluctuation and out-of-stock order [12]. Lack of real-time feedback mechanism for product sales information will result in the information asymmetry [13]; with e-commerce booming in recent years, the manufacturers can directly contact with the end consumer and skip the wholesalers and retailers. There will be no inventory problem for the outlet and the shopping and browsing history are recorded so that more effective forecast for the consumer demand will be feasible; therefore, theoretically the bullwhip effect is unlikely to occur in the virtual e-commerce shopping environment [1]. Therefore, if the product status on the shelf or off the shelf in the brick-and-mortar outlet model, just like the consumer browsing and click behavior in the virtual shopping environment, can be effectively recorded and analyzed, it will help to reduce the inventory and distribution cost for the retailer in the physical channel.

B. INTERACTIVE SYSTEM ENVIRONMENT BASED ON THE SOFTWARE AGENT

One-way-communication advertising in recent years has gradually faded, and a two-way communication medium has been a trend. In the contemporary digital century, the ''interaction'' is the implicit nature of digital media. The Interactive Advertising itself uses media such as Internet, interactive television, mobile device, Kiosk, etc. to promote products so as to attract consumers in a direct and personalized way [14], enabling consumers to easily perceive and interact, which will make consumers willing to enter the interactive field and involved in it, and, at the same time, affect their potential purchase decision [15]. It is known from the experiment result that the interactive marketing can significantly grasp customer demand and attract customer's attention, which is currently the most dominant focus in the field of marketing [16]. Therefore, in order to set up an active communication channel with the customer and to enhance the customer's purchase desire and loyalty with a live conversation so the outlet can be more active to sell products to existing customers, the software agent mechanism is introduced, which will be able to avoid dull interaction with the customer and provide the customer with new shopping experience via a new rendering interface [37]–[39].

The software agent employs the artificial intelligence and network technology and is a program able to fulfill the mission delegated by the user [17]. Its functionality feature and operation will vary depending on the mission contents; according to the classification proposed by the scholars [18], the critical attributes of the software agent are shown in Table 1:

The consumer can obtain more market information and product contents by surfing the Internet to make sure that the product shopping demands are met; however, the data volume is so huge that to address the dilemma of consumer overloaded with information and to help the customer effectively search for the products (s) he needs and further enhance his (her) shopping desire, the ''service agent'' has received attention [19]–[23].

The system architecture of product service agent is shown in Figure 1.

C. SENSOR SERVICE

From the definition and concept of the sensor service proposed by the scholars [24]–[26], its structure can be divided into three layers. One of them is the ''Sensor Component'', which is composed of a variety of information-retrieving

TABLE 1. The attributes of software agent.

Proper	Description
Autonomous	It can operate on its own without user instruction.
Learning	Has ability to respond of changes in external execution and user behaviors.
Cooperation	Could exchange information with different software agent.

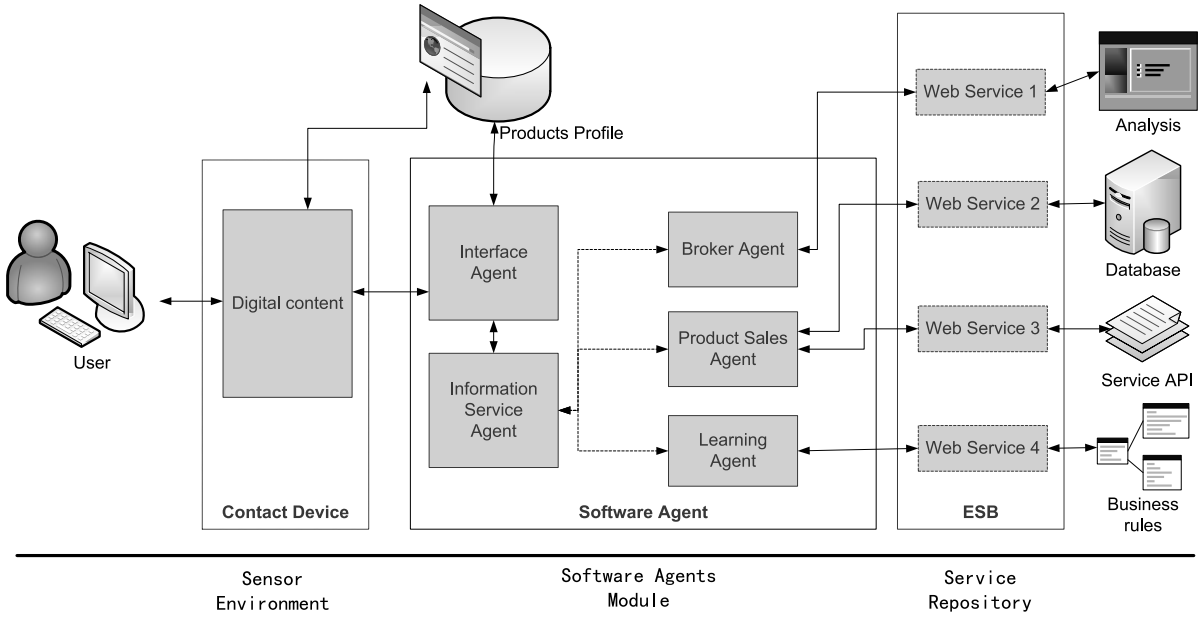

FIGURE 1. System architecture of product service agent.

and identifying components and is responsible for access to the behavior patterns of objects; the middle layer is the Middleware, which is composed of various types of wireless transmission technology and is responsible for the decoding, conversion and debugging of the data; the back-end is the ''Application Interface'', which is composed of a variety of applications and services based on the sensor components, such as environment checking and testing, traffic management and security [39], [40]. To make this system operate smoothly, there will exist an Enterprise Service Platform which is responsible for connecting various transmission networks and application services, as shown in Figure 2.

In order to create an information environment in which all devices can be interconnected and communicated anytime and anywhere, the object-sensing components and detection technology will play an important role [27], which will have a direct impact on the development of sensor service. The Wireless Sensor Networks (WSN) is the one composed of a number of distributed automatic devices; through the combination of sensors and wireless networks, these devices with sensing capability collaborate and monitor physical or environmental conditions in different locations, and they also provide various data in the surrounding environment so that the remote people can determine the status of the environment. In the sensor service environment, each object will own the ability to accept, transfer and process information, and the RFID application is a mature and feasible technology at present stage.

Moreover, the collections for RFID application of foreign retail industry are as below:

(1) Wal-Mart: Ever since the RFID project commencing in 2005, Wal-Mart kept asking the suppliers to adhere to its RFID applications; as of 2007 up to top 600 suppliers must adopt the RFID tags; in 2008, all 3C product suppliers were asked to adopt RFID tags on the product pallets and cartons [28].

(2) Metro: Metro began to use the RFID system in its retail stores beginning from the end of 2004; at the end of 2007 more than 100 retail malls and 10 distribution centers implemented the RFID mechanism, and up to top 150 suppliers were asked to adopt the RFID mechanism; as of 2008 the top 700 suppliers were asked to do so, and if the suppliers did not meet the requirements, each pallet will be charged for cargo handling costs [29].

(3) BestBuy: BestBuy, which got started with the RFID project beginning in 2006, had asked its top 100 suppliers to use the RFID tags on each single item, cartons and pallet [30].

D. RFID TECHNOLOGY

The Radio frequency identification (RFID) has the message read/write capability, it can be loaded with diversified product message contents [31]. The RFID, through the wireless

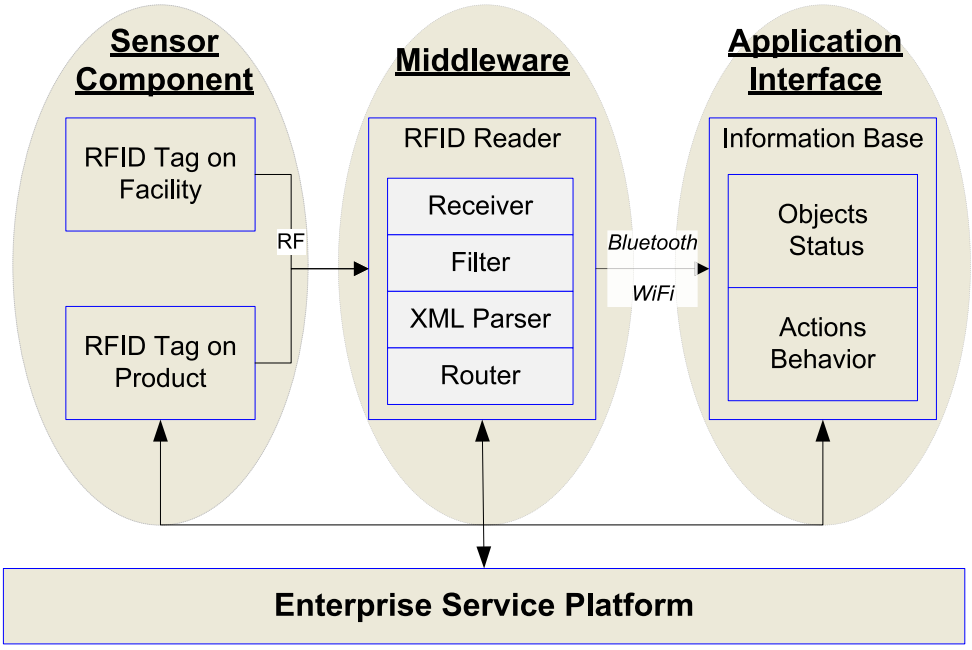

FIGURE 2. Architecture of the sensor service platform.

sensor technology, reads multiple tags automatically at a time, its applications will be broader and can realize the ubiquitous network environment. The RFID memory has larger capacity, can contain the identification numbers and attribute information of various kinds of products [41], [42], including: product title, expiry date, production history, circulation process, and price [43]. For those people involved in the warehousing management and operation. The framework will be conducive to the active message interaction in Figure 3.

Currently there are four primary aspects of RFID applications in the retail industry:

(1) RFID Intelligent Theft-Proof System: The RFID technology used in anti-theft door proceeds with the automatic identification only for a single item; when the customer tries to bring the unpaid products out of the outlet, the RFID intelligent anti-theft system will automatically alert and notify sales staff of which items have been illegally brought out of the outlet [44], [45].

(2) RFID Intelligent POS System: The RFID intelligent POS system can simultaneously support the RFID technology and traditional bar code to proceed with the quick checkout process, and accurately scan multiple items to significantly reduce customers' waiting time, which not only improves customer satisfaction but also avoids missing the sales opportunities during the peak shopping hours [46].

(3) RFID Stocktaking System: The RFID handheld device makes a quick scan on the product tag to enhance the stocktaking efficiency for the outlet; through the RFID handheld device, the outlet people can read the tag information on the product to retrieve the detailed product information (including: tile, specification, price, etc.), thus taking real-time control of the inventory status in the outlet [47].

(4) RFID Intelligent Fitting Room: The intelligent fitting room is a combination of RFID technology and user-friendly consumption environment. When the customer brings the clothes with the affixed RFID tag to the fitting room, the reader can automatically identify the RFID tag on the customer's clothes and the multimedia information about the clothes will be shown immediately on the terminal screen. When the customer needs the clothes of other sizes or colors, the terminal device will receive the customer's request, and the service people can provide the customer of what (s) he wants in no time [48].

To sales support used in the store outlets is not yet significant. This is mainly because the production cost of RFID tag is still too high and the implementation of RFID onto low-priced groceries, if the RFID tag is applied to high-priced brands or best sellers, and consumer acceptability will increase; therefore, the use of a popular brand as a research topic will be conducive to the feasibility of practical application.

E. SERVICE ORIENTED ARCHITECTURE

The service-oriented architecture, a system architecture, use software components focusing on the business demands, and typically includes three parts: software components, services, and workflow [49], [50]. If only a single service component in a business is used to do the information exchange, it will not meet all the demands for the business behavior automation; To be a complete business behavior automation, it often requires a set of service components provided by a number of different systems to provide services, and the business workflow arranges, integrates, and decided the use order of all service components.

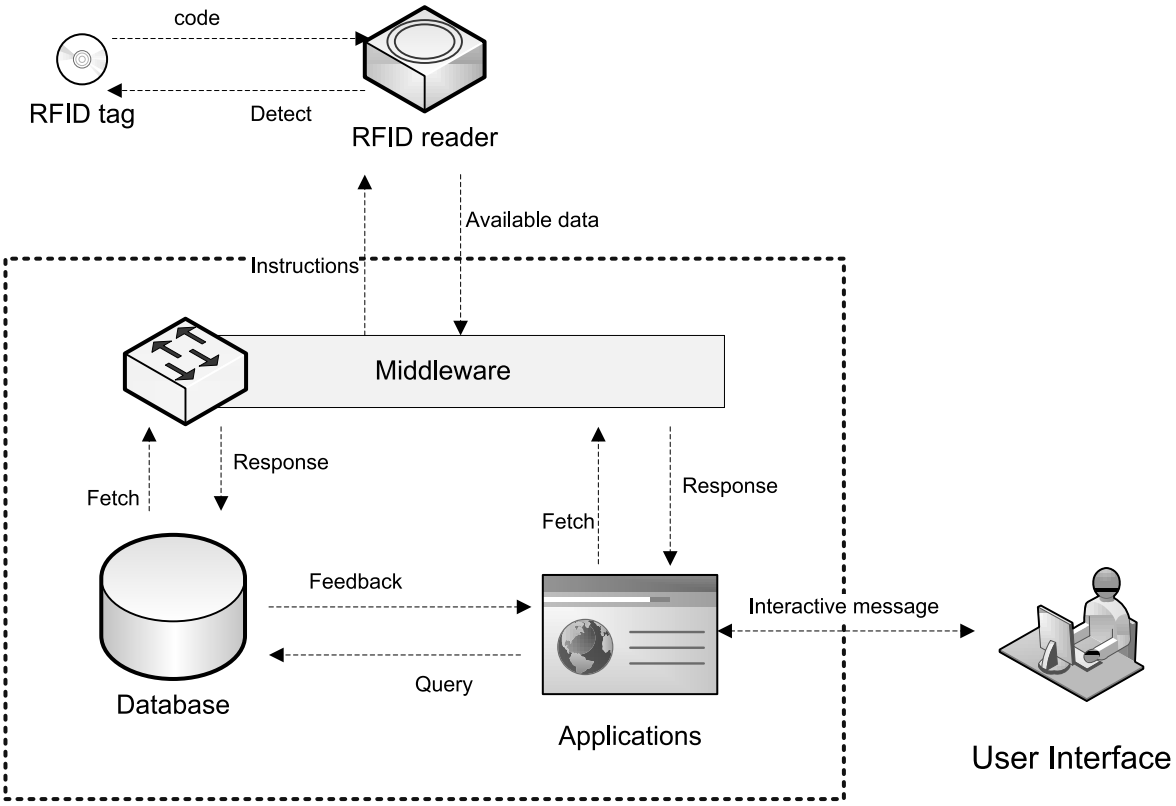

FIGURE 3. The RFID interactive mechanism.

The SOA technology focuses on the information integration, and its goal is to eliminate information silos so as to realize the ubiquitous information environment [51], [52], the middleware technology will be the basic platform of the integrated application system [53]; each application or subsystem is viewed by the SOA as a separate, independent, built-in and well-defined service or component; and through assembly of these services and registration, other applications on the network can find, invoke and query related services so as to realize system integration or construct new applications. Specifically, through the standard interface provided by the SOA, the hardware function will be converted to hardware-independent software service, will serve as the basis for this study to realize the following objectives:

(1) Seamless integration of the application system, information equipment and sensor devices.

(2) An interface among a variety of communication equipment is created to form a universal data exchange standard.

(3) This system serves as a middleware platform, providing support for many applications.

Therefore, the operation concept behind the past intelligent service mechanism emphasizes artificial intelligence, self-learning capabilities, etc., whereas service environment created through SOA will enhance the existing intelligent application, link the user experience, and increases the utilization of the existing intelligent network applications so as to better meet the personalized demand. For example, after scanning the product barcode with the cell phone or other sensor devices to identify the product, the user, in addition to being informed of the detailed information about the production history and promotion activity, can also use the community service to get suggestions and evaluation given by other users to make the final purchase decision that meets his (her) demand; SOA is also applicable in the retail field. For example, the advertisement on the electronic billboard at each store can be improved, and the community service such as user discussion can be added so as to improve the product sales.

F. CLOUD SERVICE

The cloud computing service provides an enormous amount of computing and storage capacity over the network to the users, and the key system architecture is the virtualization and component service so as to provide the consumer with elastic subscription or provide the enterprise with what is required; according the definition [32]–[34], [55] by the NIST (National Institute of Standards and Technology), there are three service models. The Infrastructure as a Service (IaaS) user can set up the virtual operating computing environment (CPU, Storage) and pay the bill according to quantity used; the Platform as a Service (PaaS) provides APIs to the user for software development, and the Software as a Service (SaaS) rounds up all software in the central database, provides the network access service, and charge according to the

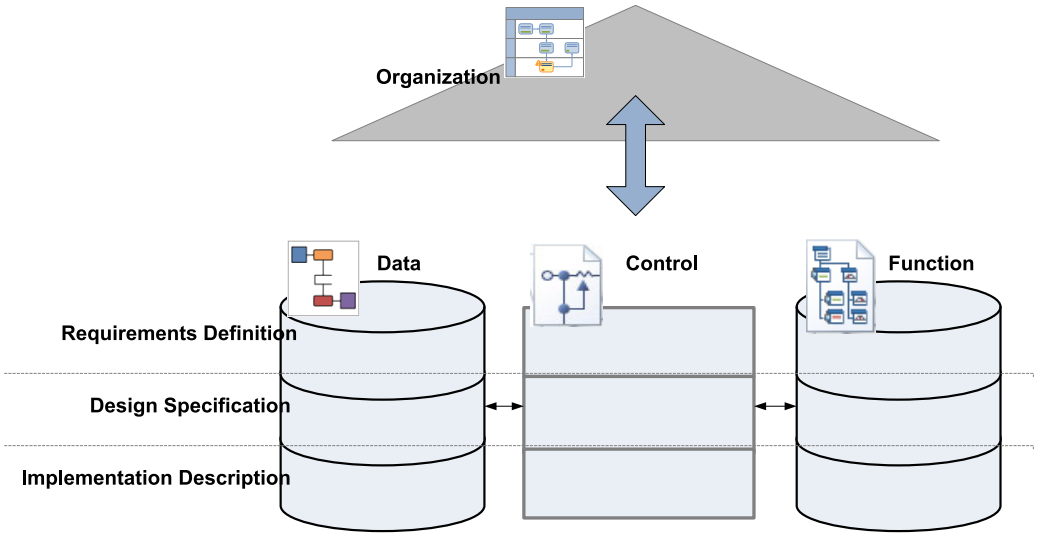

FIGURE 4. Research method.

subscription or pay-per-access. In addition, the cloud computing deployment model can be divided into the Public, Private and Hybrid. For the retail business, not all commercial operating system or services can use the public cloud services; for example, for the sake of trade secrets and other security considerations, certain services cannot use the public cloud (which will result in the trust doubts), and therefore through the virtualization mechanism, the cloud computing platform (that is, private cloud computing services) is deployed in the intranet, which will be able to meet the actual requests for the enterprises. Therefore, the private cloud setup can not only provide more security control, but also the utilization of IT resources, whether in view of performance management, demand expansion, access control or cost control, will be more efficient and flexible.

The SaaS and SOA concept are closely related. This study employs the web services to link the back-end private cloud information resources of the enterprise, including a wide range of equipment resources, virtual machines, storage devices and other related infrastructure to provide the user with a variety of cloud services through a variety of end devices and software technology, combined with the man-machine interface of the terminal device, middleware and application services, which will also go beyond the storage and computing capacity constraints of the handheld mobile devices. The back-end cloud services can support the front-end data-accessing services. For example, the RFID technology can be served as a front-end data retrieval component, the sales platform can interact with the consumer, and at the same time the cloud application services can change based on the user's individual requests or user behavior. Therefore, the system architecture of cloud service application will include: the computing and delivery of large amount of data, storage space of flexible service, the information centralization and integration, and the collection and analysis of user behavior [54], [56].

III. REQUIREMENTS ANALYSIS AND RESEARCH METHODOLOGY

A. RESEARCH METHOD

In this architecture, the enterprise as a whole is the main consideration; the internal organization of enterprises, operation workflow, operating procedures and enterprise resources are analyzed and designed; organization, data, control and function are four views, with each view being divided into requirement definition, design specifications and system construction so as to further convert the requirement definition into system specifications and implementation. As shown in Figure 4, mechanisms such as the RFID event-driven and information feedback are incorporated, the front-end service in the cloud system architecture is constructed, as well as the warehouse management & customer analysis modules are integrated so as to construct the back-end requirement in the cloud system architecture.

B. REQUIREMENTS ANALYSIS

1) CASE STUDY

According to statistics, online shopping accounts for only about 9 percent of U.S. retail sales and its annual growth rate is only about 10% [56]; What actually grows is the multi-channel expansion by the physical retailers, so the brick-and-mortar stores will still be the main point of contact for vendors and customers. Therefore, the new presentation type and store experience in the outlet will have the opportunity to provide customers with more convenient shopping type.

According to the analysis of operation mode of the existing retail outlets, as shown in Figure 5, it can be seen that from the factory product design, manufacturing workflow, and the sales information fed back from the outlet POS system is also used to proceed with the replenishment and transfer of products. The operation mode of traditional information system cannot provide more immediate response mechanism for the distribution channel and sales outlet in view of workflows

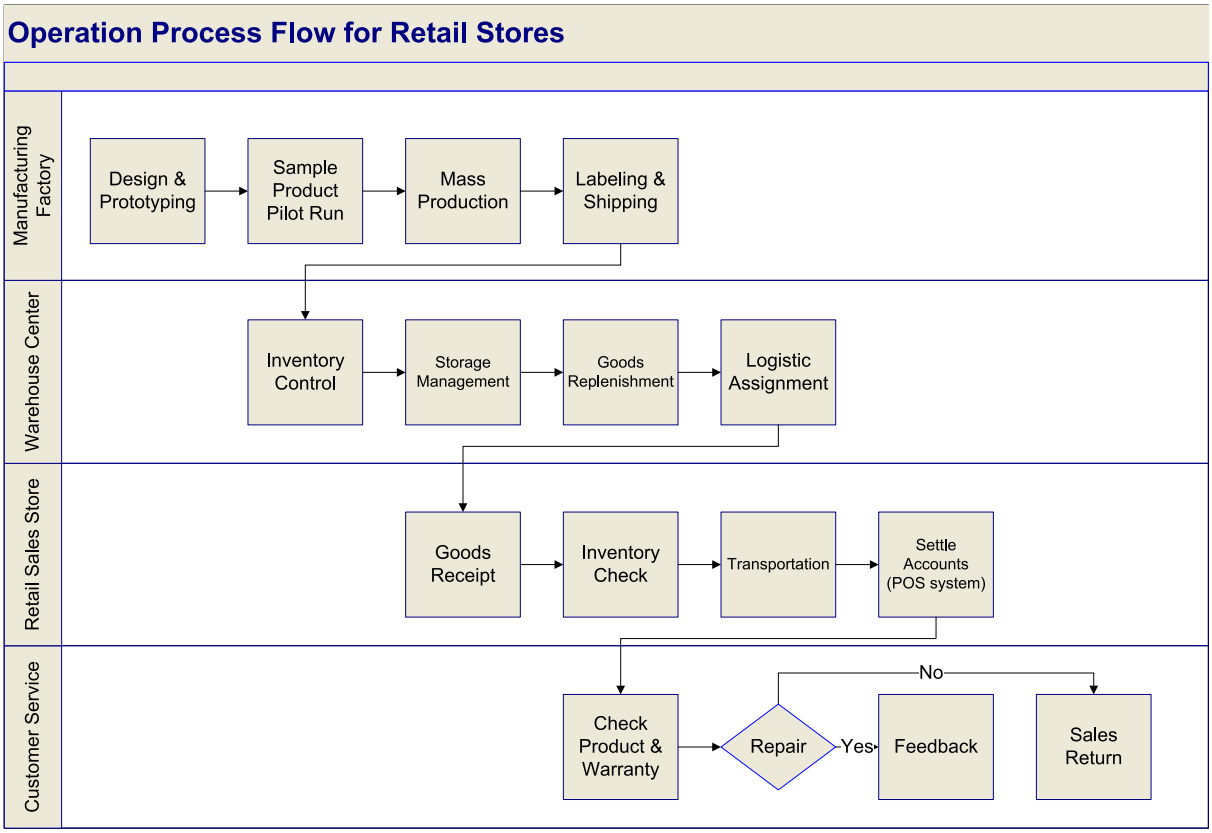

FIGURE 5. The primary service model for retail stores.

such as the product replenishment and putting products onto the shelves.

In addition, although the original logistics management mode and logistics workflow can support the sales checkout and warehouse management, but they still need to rely on the ''push'' marketing manners to directly face the final consumers in the outlets, which means that many sales persons will make face-to-face contacts with the customers on the spot; however, in addition to the increase of personnel costs, this approach will also potentially increase the psychological pressure for the customers.

2) PROBLEM STATEMENTS

Further analysis will also show the following four layers of bottlenecks confronted by the retail outlets:

(1) Operation efficiency of product replenishment: The inventory quantity of products is confirmed through the use of artificial periodic validation and barcode scanning, the logistics center is notified of the replenishment demand and the central warehouse proceeds with the replenishment; however, the bar codes must be scanned one by one, and the operating efficiency will cast impact on the time required for the warehouse process and putting products onto the shelves. Moreover, the life cycle of the hot-sale product is much shorter, and therefore the use of sensor components can immediately show the sales opportunities in the promotion period and the dynamic demands coming from the consumers.

(2) Management efficiency of products on the shelves: Time and quantity of product replenishment for the retail outlets can be supported by the supply chain management system and sales automation; however, the shelf space at the outlet is limited, so its utilization is very critical for the operating performance. It often occurs that there are products in the warehouse, but they are not in time replenished on the shelves, causing the distress of consumers when purchasing the products; on the other hand, placing products without any attraction on the shelves will result in low utilization of store space. Therefore, the information feedback on the shelf will be able to improve the utilization of shelves for the retail outlets.

(3) Service support for the product purchase: Analysis of the consumer behavior characteristics shows that in the interactive sales process the consumer often wants to have pressure-free shopping, and if (s)he wants to have assistance from the outlet clerk, (s)he queries the current inventory status of specific products in most cases. The sales people also query the inventory status of products from the inventory management system through the identification fields such as the product ID; therefore, building an interactive predict system can help customer proceed with the autonomous inventory query, act as a personalized product promotion platform.

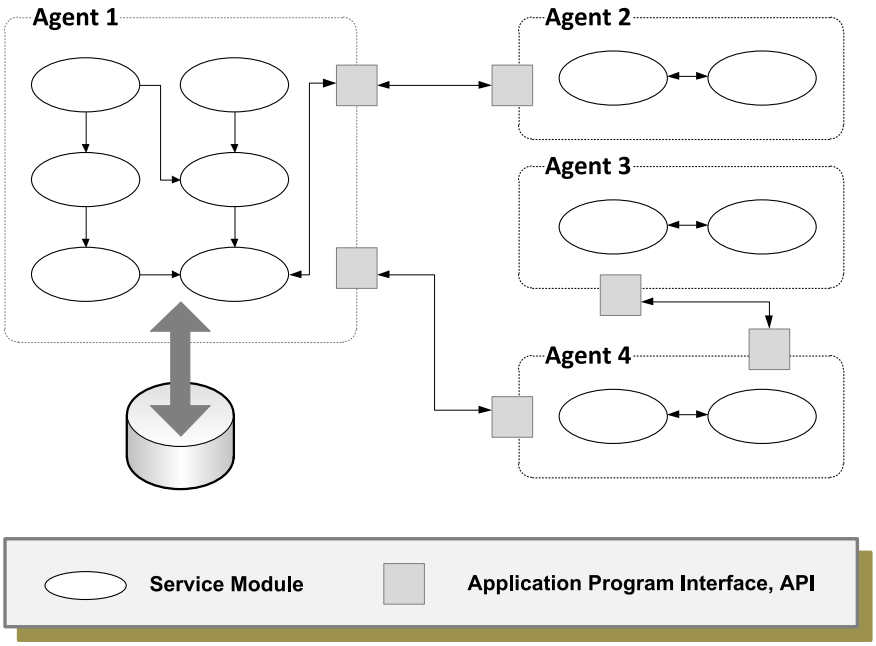

FIGURE 6. Service interface architecture of the information agent.

(4) Value-added application of the sales information: At present, all information about products sold at checkout is extracted through the POS system to proceed with the sales statistics and serves as reference samples for consumer behavior analysis; however, the information about product taken off from the shelf, returning back to the shelf and comparison cannot be recorded. If the behavior characteristics of consumer's product preferences can be instantly saved into the database systems and subsequently used in the data mining technique, it will be conducive for the product design to more cater to the customer demand.

The product on shelves present direct impression with consumer, but if the system architecture fails to provide the real-time information service, the loss of customers due to out-of-stock status on the shelves will reach 34%, according to the statistics; that is, if there are not enough stocks on shelves to meet consumer demand, will affect their shopping satisfaction, which may even make customers directly resort to competitors' products; vendors must have solutions and supporting measures to improve the customer service. Therefore, for the problems encountered in the outlets, First use the RFID tag management mechanism as the trigger control point for the active information in order to enhance the customer-end value-added service and business operation, and, through the integration of multi-agent architecture and enterprise information system, to extract customer/product information so as to better utilize the product purchase information and to enhance the overall performance of the supply chain management; finally, the construction of the system implementation of the interactive service platform will provide consumer with an interactive and autonomous way to obtain the required information, and then improve the operation efficiency of the outlet with an innovative business mode.

C. RESEARCH METHODOLOGY

The retail-outlet-focused model drives the integration process mainly in response to consumer's service demand, and it encapsulates the service interface of the information agent according to three resources modes: service request/response, event processing/control and content access/analysis. As shown in Figure 6, the software agent gets the service name from the service interface to identify the information service requested from the external system, and then responds to the service request so as to cater to changes in the business logic for the retail outlets and customer's dynamic consumption request.

For the application demand of the retail outlets, there are three layers according to the service requests: The bottom is RFID sensor; the middle is agent layer, software agent provide shopping recommendation, product query, and operation management to provide the corresponding information services so as to realize the overall system operation. At the same time, in response to the front-end and back-end service mechanism, the system architecture is divided into two modules, one of which is to support the front-end service consumer demand, and the other of which is to support the operation demand for the back-end managers. The overall system architecture model is shown in Figure 7.

1) FRONTEND AGENTS FRAMEWORK

In the process of interaction between consumers and products, the E-commerce agent system often requires

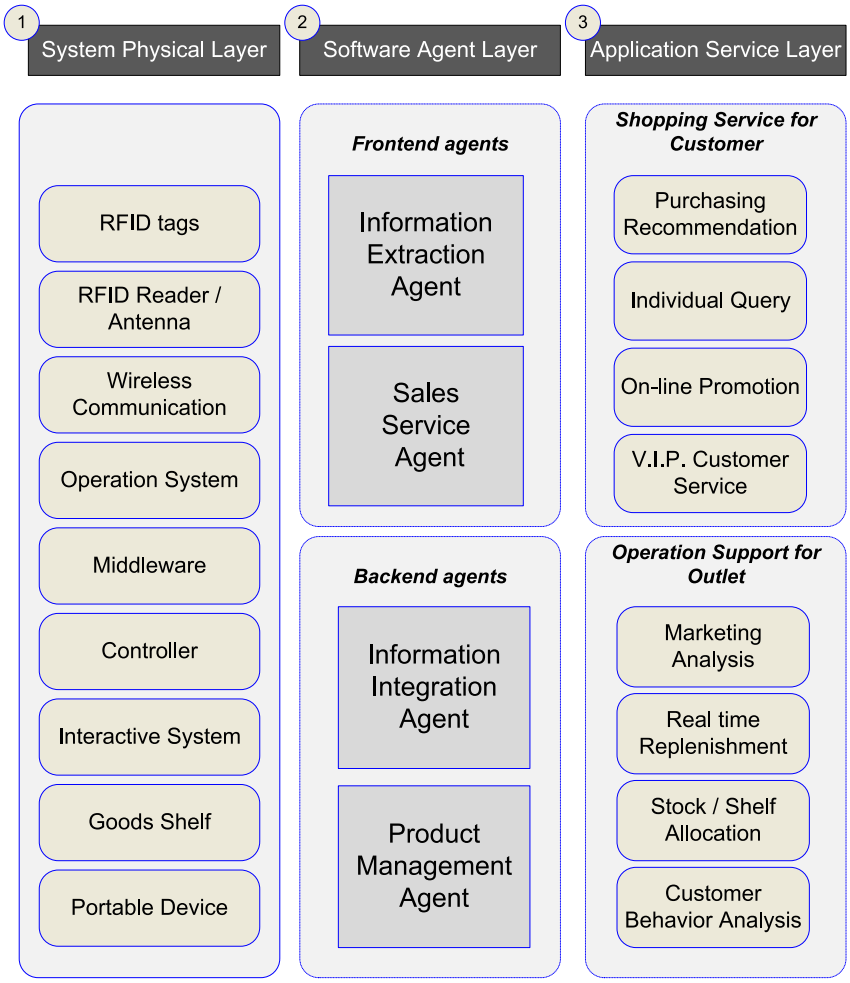

FIGURE 7. The proposed system architecture for retail stores.

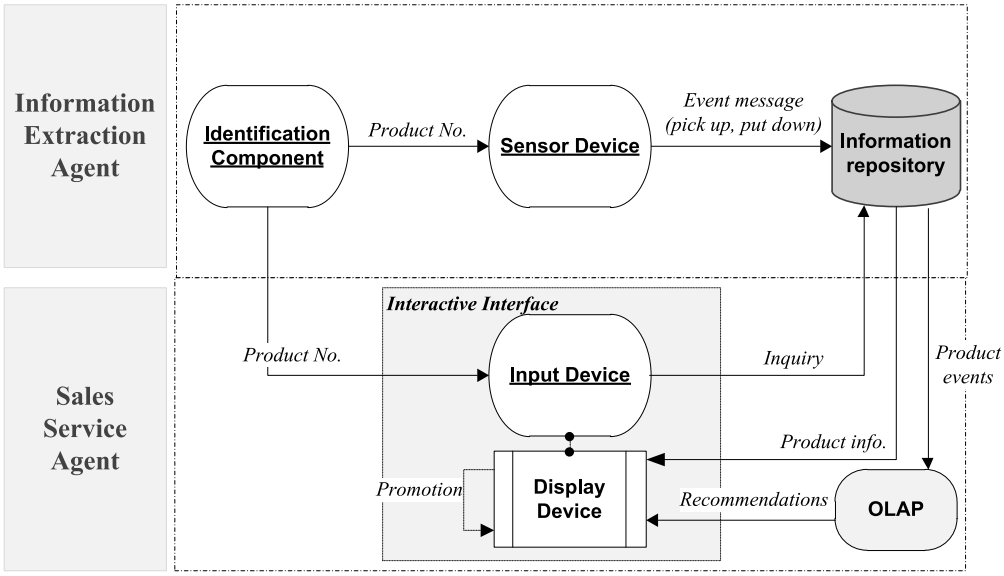

FIGURE 8. The software agents for customer services.

complicated operation steps, resulting in customers unable to effectively find the information (s)he needs in the outlet environment; therefore, two kinds of agents for the customer service are designed, as shown in Figure 8, in which the

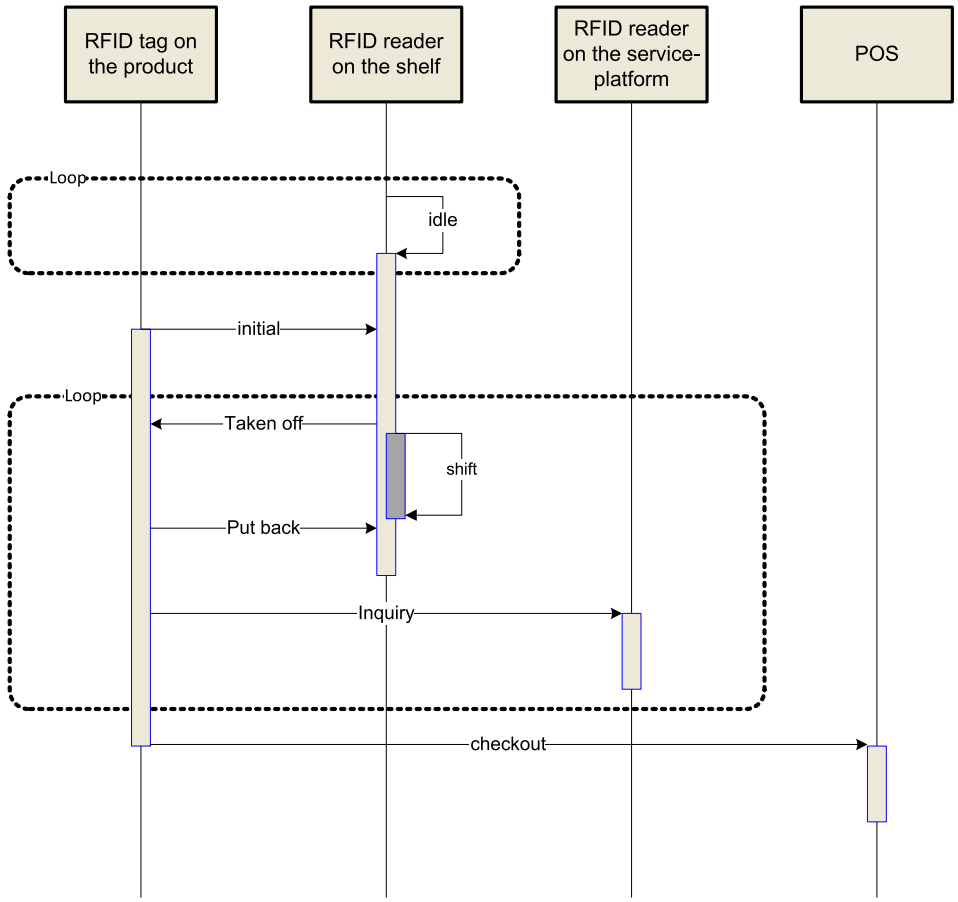

FIGURE 9. Event flows on intelligent shelf.

request number and response number are related together through the design of message number so as to meet the asynchronous request and response and at the same time to provide consumers with personalized counseling, purchasing recommendation, online promotion and VIP customer service.

(1) Information extraction agent: the interaction between the consumer and product function of the product, the consumer may put it back onto the shelf or check out. The sensor device responds to the consumer behavior through the message response, and events triggered are shown in Table 2. With the help of active trigger mechanism, the information extraction agent records the customer behaviors information in background so as to reduce user's burden and distress and immediately return back the shelf information as a reference for product replenishment or transfer; its message request/response patterns are shown in Figure 9.

(2) Sales service agent: When the consumer turns to sales service agent, the agent references the conditions given to filter the related product information and display the result, and it also provides the consumer with shopping advice and promotion program, interacting with the consumer just like a counter sales representative. The events triggered by the sales service agent are shown in Table 3.

2) BACKEND AGENTS FRAMEWORK

The real-time product record obtained by the front-end information extraction agent via the active trigger mechanism should be sent to the back end for information analysis so as to feedback the valid information to ensure the correct information; therefore, for the predict making application, the information integration agent and goods management agent are constructed, as shown in Figure 10. With the design of source ID and destination ID, each system module can get the message belonging to it so as to fulfill those functions such as market predict analysis, shelf planning and consumer behavior analysis recommendations.

(1) Information integration agent: The information applications of corporate headquarter includes warehouse management, product predict sales, financial predict planning, transport, and so on. To make the back-end system platform and front-end outlet application share the real-time information, the agent concerned here will make the product name, and features of product interconnected, enhance the operating of stocking efficiently. The information integration mode of RFID application in the retail logistics is shown in Figure 11.

(2) Goods management agent: This agent gathers the shopping information on the POS checkout system for grasp the relative sales, proceeds with the statistics for the info on the

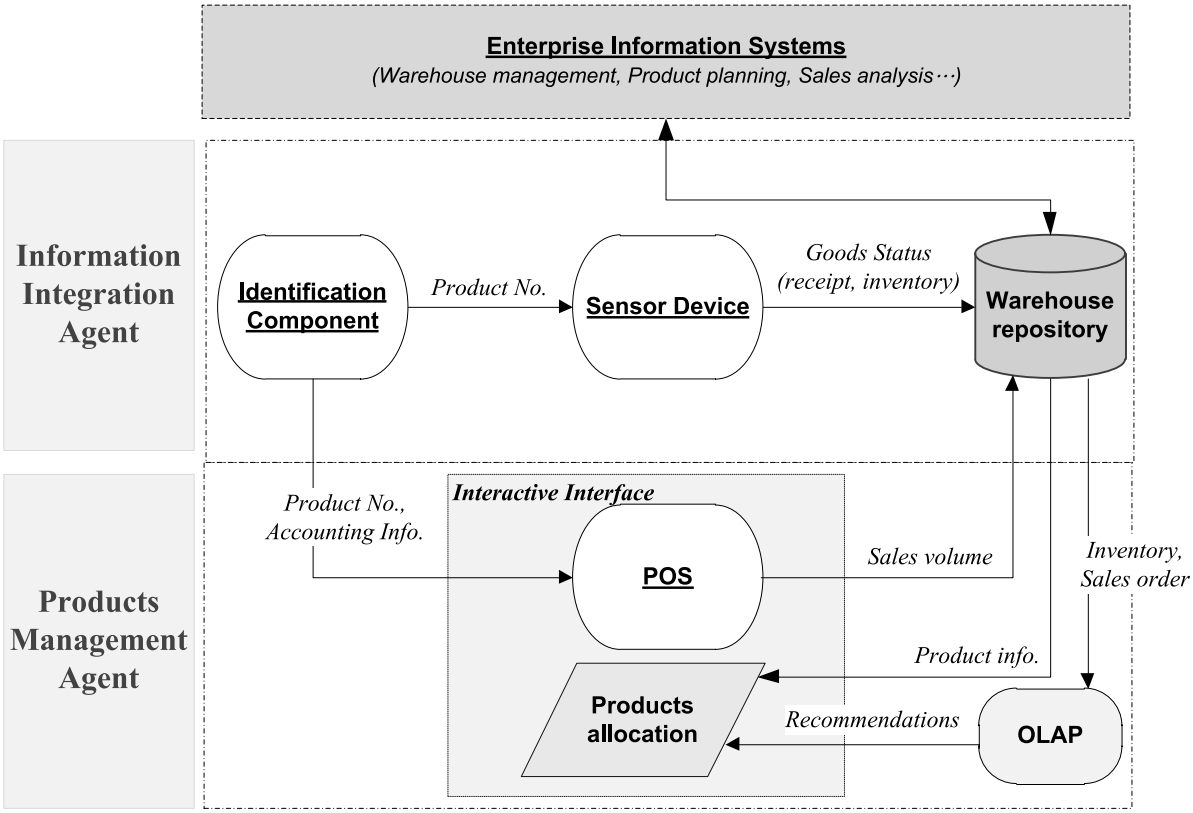

FIGURE 10. The software agents for management support.

TABLE 2. System events of the information extraction agent.

Code	Event	Description
A00	Idle	The product is not yet put onto the shelf.
A11	put on the shelf	The product number is recorded onto the shelf (Occurred when the product is carried to the shelf from the warehouse.)
A21	Taken off from the shelf	The product is taken off form the shelf. (If the product is not sensed by another hand-held reader within 5 seconds, then this event is deemed as being triggered by the customer.)
A22	Inventory check	The product is taken off from the shelf and the inventory is confirmed (If the product is sensed by the hand-held reader within 5 seconds, then this event is deemed as being triggered by the clerk.)
A31	Put back to the shelf	The product is taken down from the shelf and then put back to its original position.
A32	Shifted to another location	The product is taken down from the shelf and then placed at a different location.
A51	Checkout	The product is taken down from the shelf and the customer goes through the POS system for checkout.

shelves extracted by the information extraction agent, and also judges the product popularity on the shelf and customer's interest by using the data mining mechanism so as to provide the manager with suggestions about product replenishment or shelf layout.

3) APPLICATION MODELS

The intelligent agent-based predict system, through multiple software agents as the core of information service, links the information contents that the RFID tag carries and responses the service request on the

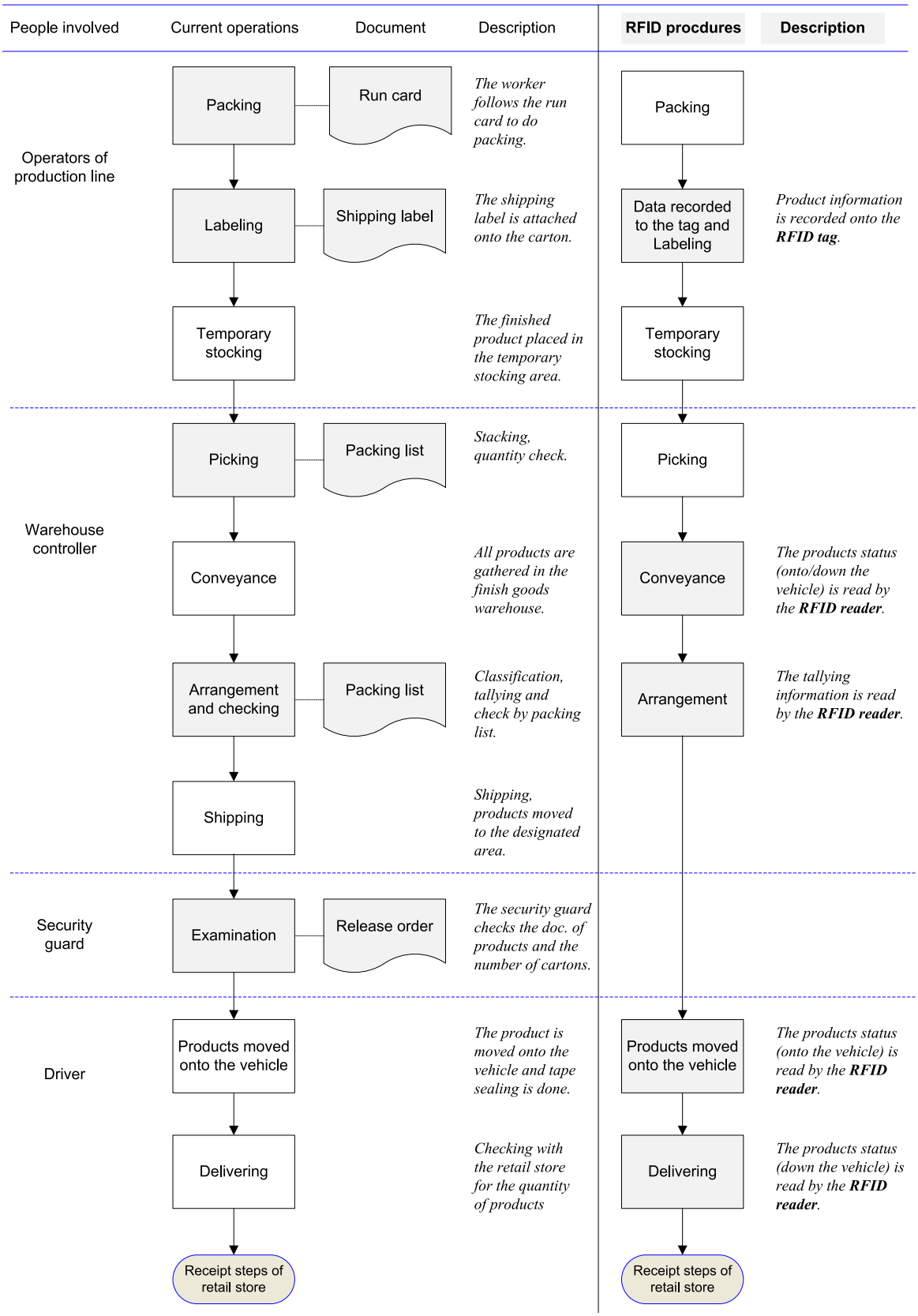

FIGURE 11. Information integration mode of RFID application in the retail logistics.

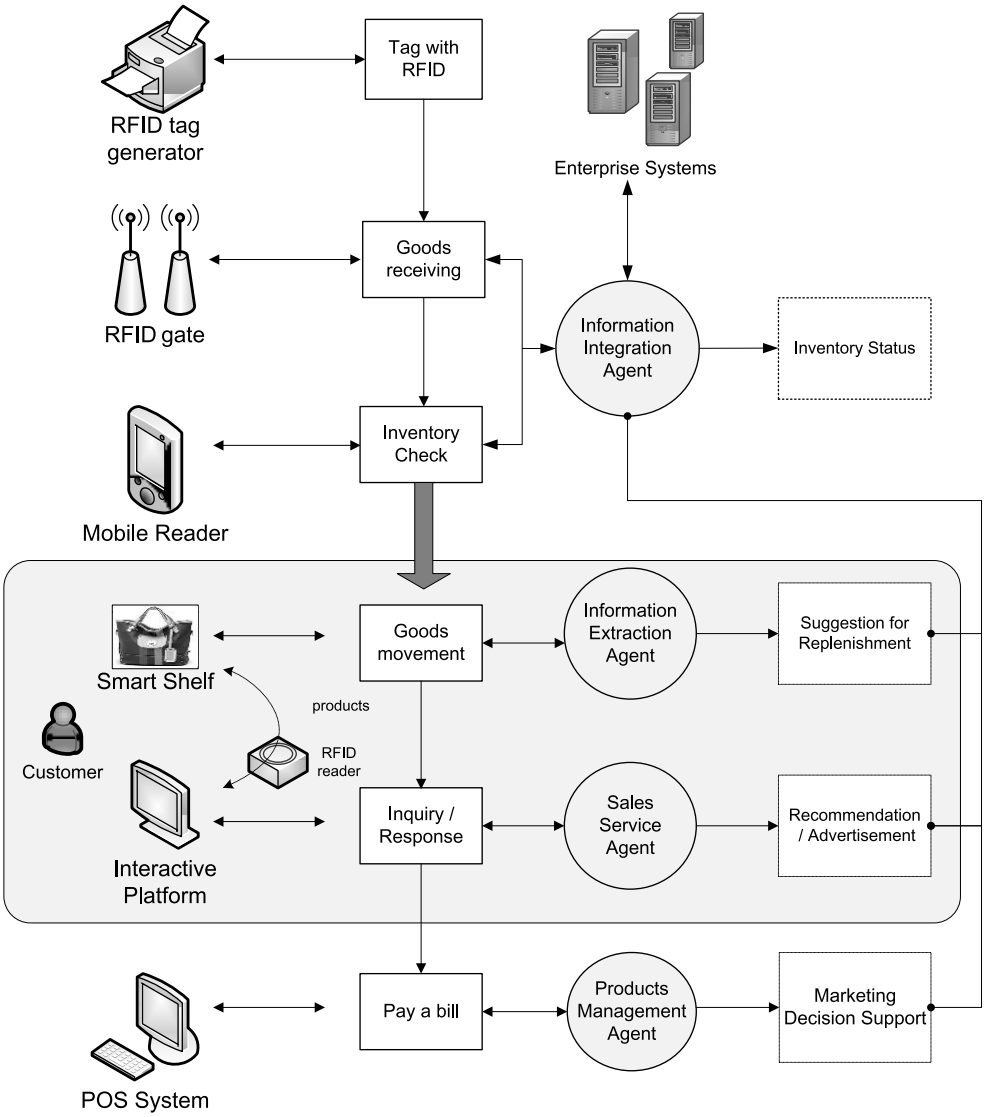

FIGURE 12. The architecture of intelligent service-integrated platform.

TABLE 3. System events of the sales service agent.

Code	Event	Description
B00	Idle	No event occurs.
B11	Advertising	No client service event occurs. The system sends out the promotion info on its own.
B21	Consulting	The identification component of the product is sensed, and the product description is sent back.
B22	Inventory	The inventory check is triggered, and the related inventory information is sent back.
B23	Recommendation	The product recommendation message is sent to the customer based on the product correlation analysis.

applications layer. The system components are described below:

(1) RFID tag generator: It mainly generates the RFID tag and uses the RFID reader module (which is integrated with

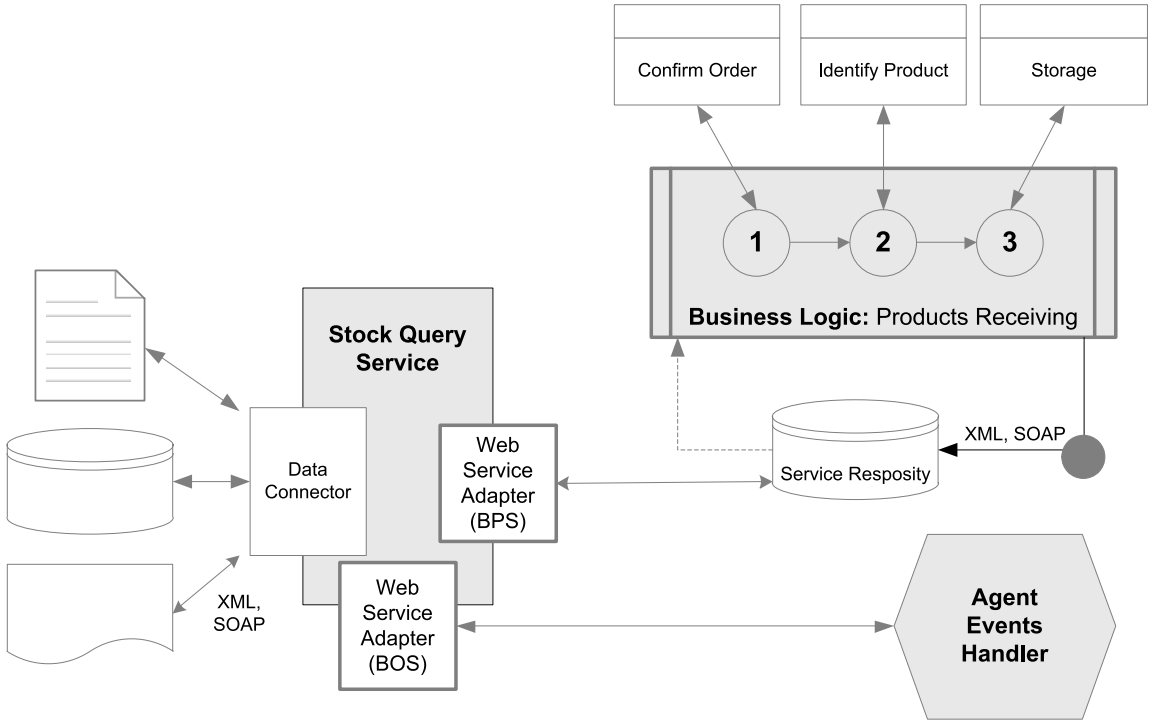

FIGURE 13. Service component architecture.

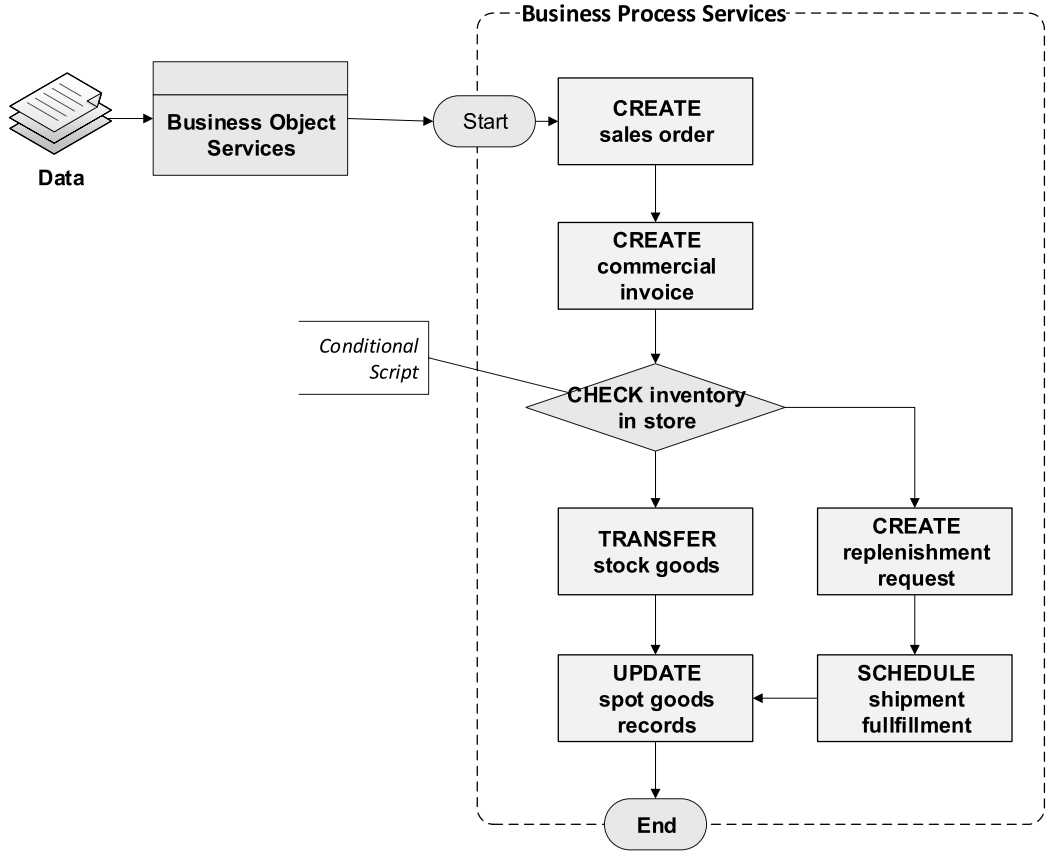

FIGURE 14. Diagram of business object service and business process service.

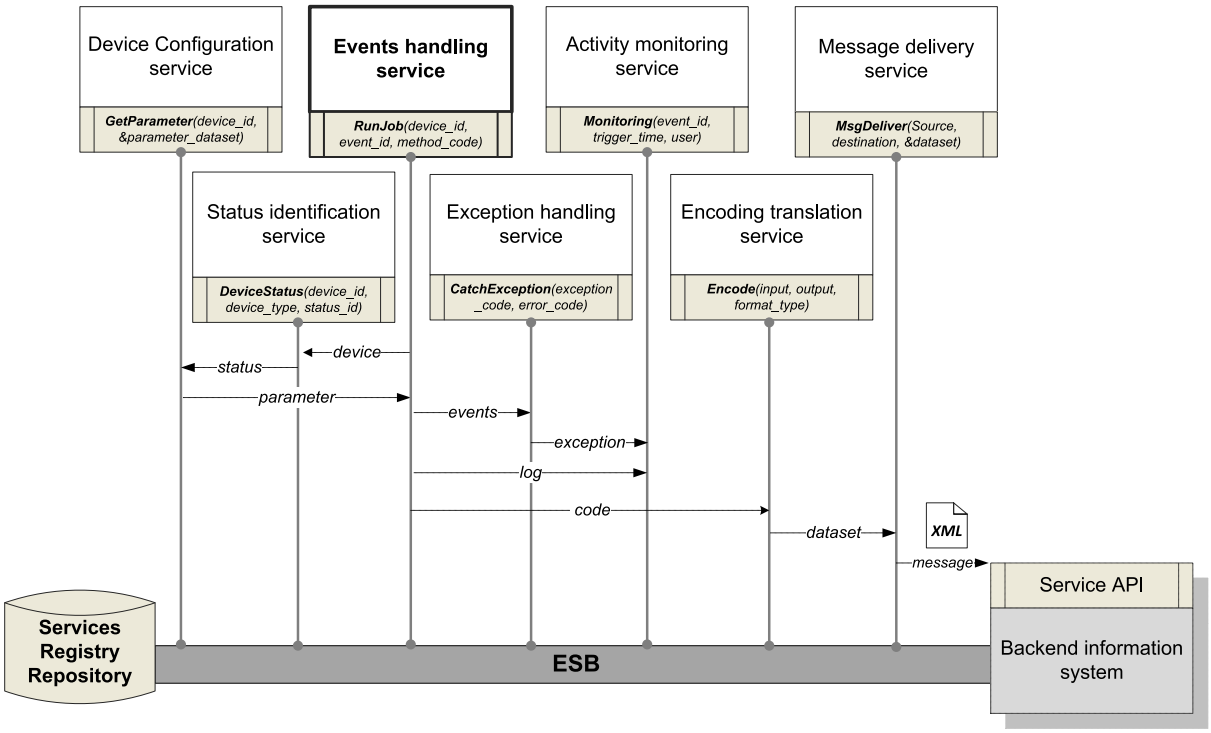

FIGURE 15. Service architecture of the information extraction agent.

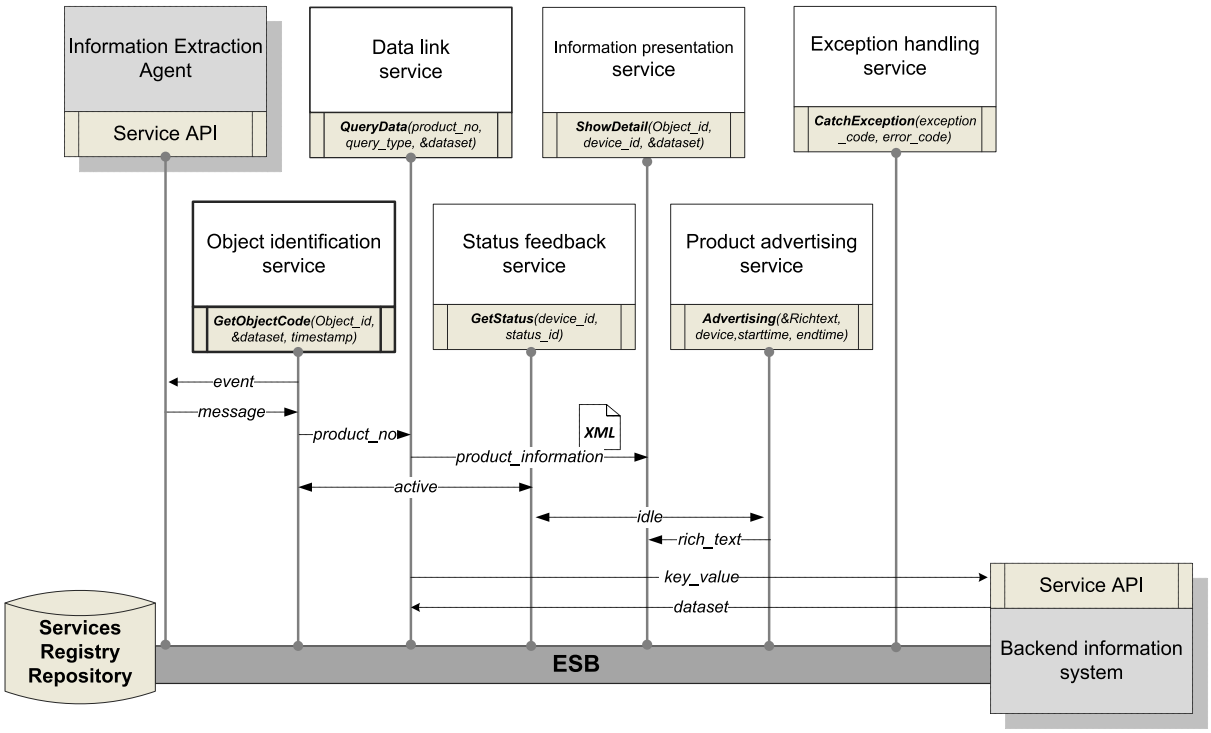

FIGURE 16. Service framework of the sales service agent.

the tag writing system) to read and write the basic data of the product synchronously to simplify the RFID identification and data read operations; the contents that the tag carries include the product name, production history, and so on,

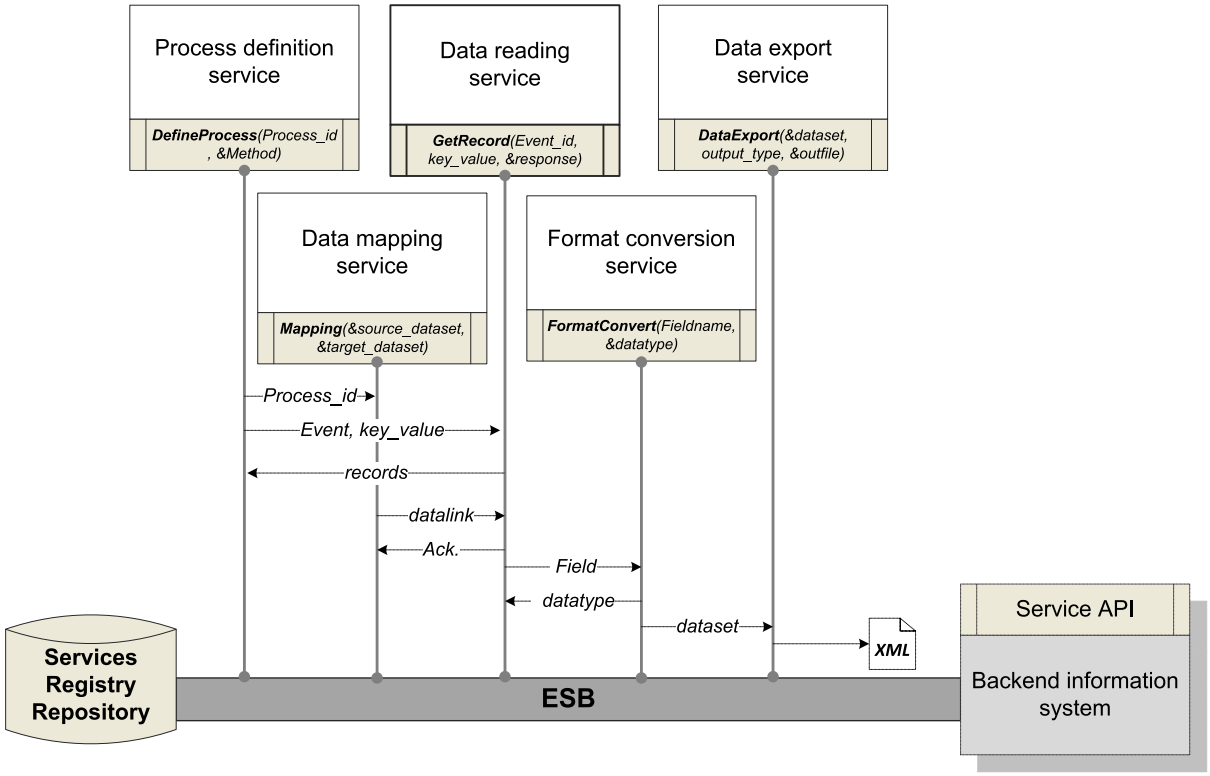

FIGURE 17. Service framework of the information integration agent.

which can be used by the smart product shelf, customer interaction application platform and service agent software.

(2) Fixed gate for incoming/outgoing products: The sensor device provides the user with the ability to set the purchase mode or shipping mode, in which the user can start to read the product data on the carton or pallet after entering the order or shipping order data; if the fixed reader device fails to receive complete data, the operating people can use the handheld readers to confirm the unread items.

(3) Handheld inventory reader: The outlet people use RFID reader to do the mobile product confirmation and upload the read information, with the help of storage management function in the warehouse management system, the storage information and the RFID tag are linked together so as to facilitate the users to quickly query the current inventory, storage location, and so on at the outlet.

(4) Intelligent product shelf: The miniaturized RFID tag/ antenna and distributed RFID communication control/sensor components are combined together to construct the multi-functional intelligent shelf; it can serve as the main device for information trigger and contents extraction done by the information extraction agent.

(5) Customer interaction application platform: The consumer can use the RFID reader device to sense the product in order to facilitate the product info query; multimedia can render the value-added services provided by the sales service agent, such as product promotion and shopping recommendation service; in the absence of consumers using the system, this application platform can also keep playing the corporate image and promotion advertisement.

As Figure 12 the RFID tag generator generates the product label while the product is still in the factory; when the product is sent to the reader do the quick receiving and storage space allocation and the information integration agent and back-end system are linked; when customer takes down product from smart shelf, the information extraction agent will be triggered, and agents will respond consequently; after customer check out, the agent will predict various kinds of decision information.

IV. SYSTEM ARCHITECTURE DESIGN

A. SYSTEM CONCEPT AND CHARACTERS

The Information integration service platform is composed of three major elements, including: process, service and software components. The process component defines the processing steps requested by the store, and the software agent mechanism constructs the system framework; the software component is a program responsible for execution the job and the service component contains all program components for specific processing steps. For example, when the outlet faces the product query by the consumer, the process defines the processing steps for data query, the service includes product identification, inventory query, product recommendations, etc., and then the component is a program which truly fulfills product identification, inventory queries, etc.; the service component architecture is shown Figure 13.

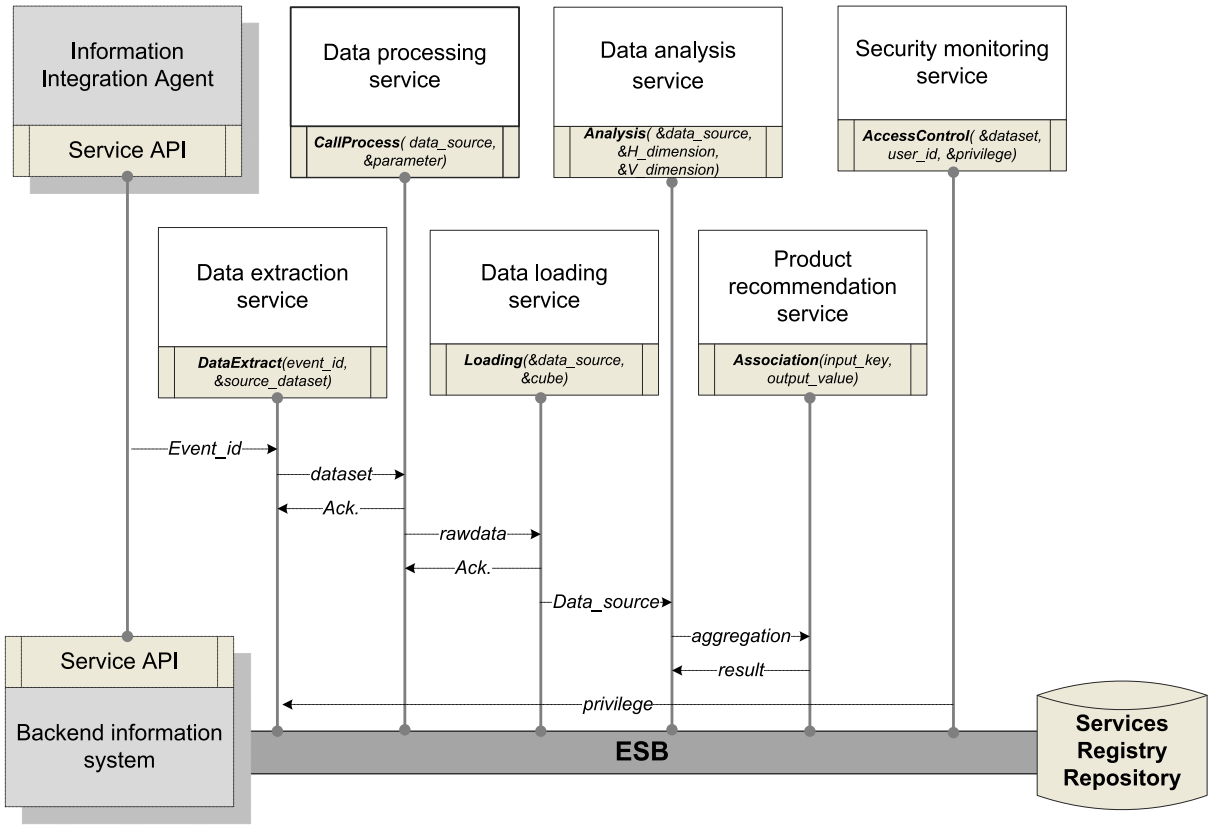

FIGURE 18. Service framework of the product management agent.

The overall service component architecture includes the following four elements:

(1) Data packet: It contains a record with the header and detail information to be processed.

(2) Service type repository: The Business Component Service (BOS) class library contains all Business Process Services (BPSs). All services must be registered here.

(3) Business process database: It records the definition of business processes.

(4) Web service adapter: In the business logic processing, through the Business Object Service, the application dispatches the process code and data packets of business process to the related Business Process Service for execution; based on the process code of the business process, the BPS starts the business process component to handle the data packet to complete the business process transaction. The relationship between Business Object Services and Business Process Services is as shown in Figure 14. All business processing services, with consistent design, are stored into the service class repository in order to facilitate the plug and play.''

B. SERVICES FOR SOFTWARE AGENTS

1) BUSINESS OBJECT SERVICES FOR INFORMATION EXTRACTION

To meet the sensing demand in the external environment, the system platform designs common information services to facilitate the front-end message extraction of RFID tag as well as back-end application for the integrated information. The service architecture of information extraction API is shown in Figure 15, including: (1) Configuration service: It provides the global static parameters and configuration settings for the front-end system devices and service components. (2) Status identification service: It identifies the read/write status of RFID tag or read/idle status of RFID reader so as to perform specific functions according to different states. (3) Event handling service: The RFID reading device extracts the recorded message to confirm the validity and integrity of the message according to the contents and cycles of the instruction or event. (4) Exception handling service: When the exception status, such as incomplete or erroneous-format information record, occurs, the system program will recover or redirect to another service so as to ensure that the program can operate successfully. (5) Activity monitoring service: The record contents read will be globally rendered, and the specific markup methods are used to distinguish the event types; it provides the information subscription mechanism, and through the active warning-sending mechanism, it reminds managers of a particular status or event so that they can respond immediately. (6) Encoding translation service: A level is translated to another level within a single schema. For example, the binary byte array (the format stored in the entity markup) is converted to the pure identification URI (used by high-level application programs which don't require all information in the entity markup). (7) Message

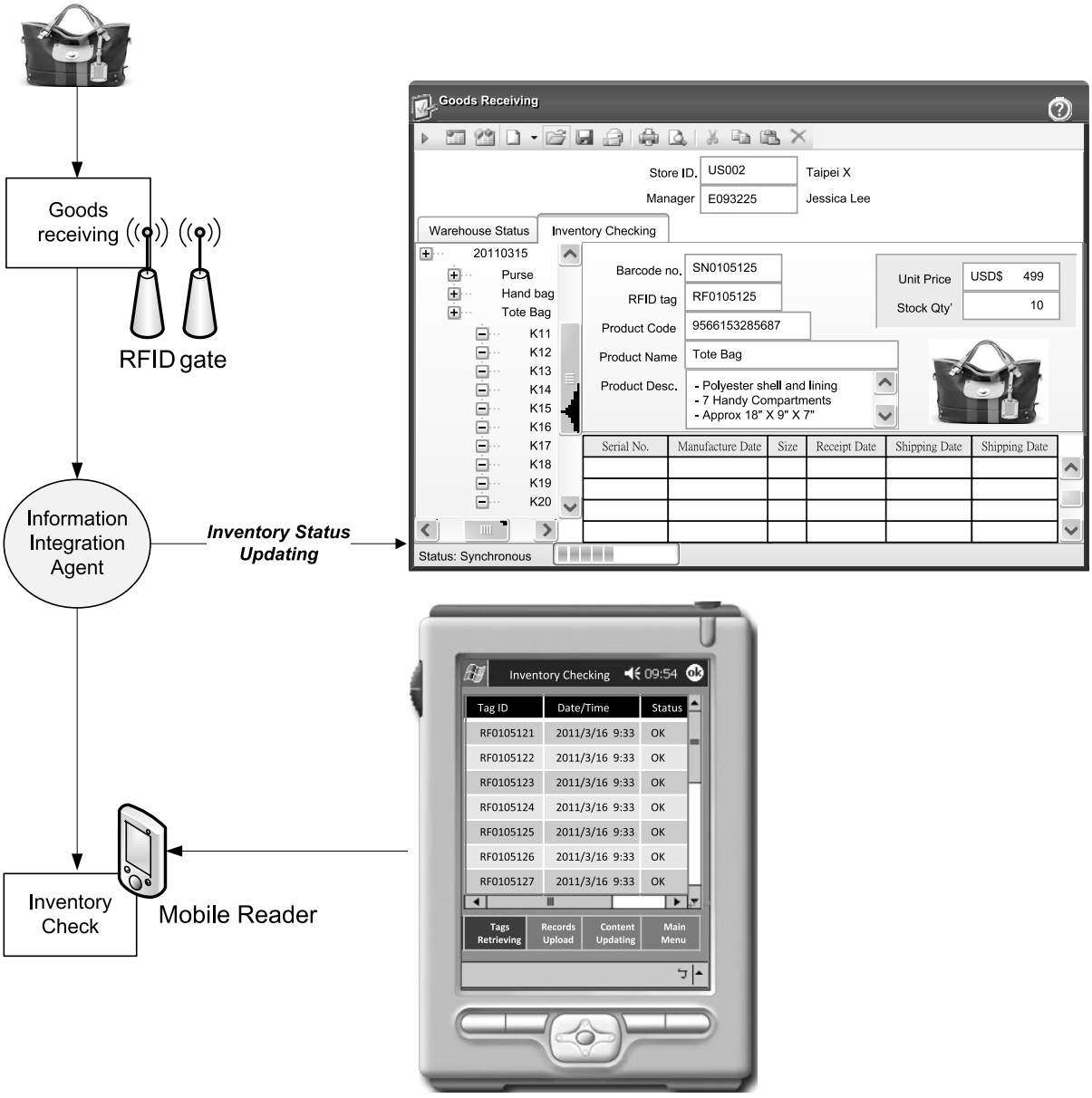

FIGURE 19. The system architecture of information integration agent.

delivery service: The decoded contents of a particular object are delivered to a specific device or back-end information system.

2) BUSINESS OBJECT SERVICES FOR SALES SERVICE

To integrate the information extraction agent, the sales service provides a self-service object identification and data query mechanism so as to facilitate the customer to search the information contents of interest on his own; it can also present product promotion and product recommendation messages. The sales service API mechanism is shown in Figure 16, including: (1) Object identification service: It confirms the corresponding contents of data input or embedded tag. Identifying the product number is an example. (2) Data linking service: It links to the table or view of related database according to the items entered or authorized contents to extract the required information records. The product specifications, inventory quantity and price discount are examples. (3) Information presentation service: It proceeds with the real-time response for the data items entered and presents it on a specific output interface to meet the info extraction expectation for the user; or, it proceeds with correlation link for a specific product to present the recommended products to the consumer. (4) Product advertising service: During a specific event or period, if there is any related product sales program, then the system will on its own send messages to the

Product events on the intelligent shelf

Source ID.	Date & Time	E_id	Event
POS 2	2011/3/19 11:26:14	A51	pay a bill
Reader 1	2011/3/19 11:14:39	A21	down
Reader 1	2011/3/19 10:28:13	A31	return
Reader 1	2011/3/19 10:25:44	A21	down
Reader 1	2011/3/18 19:54:18	A11	Initial

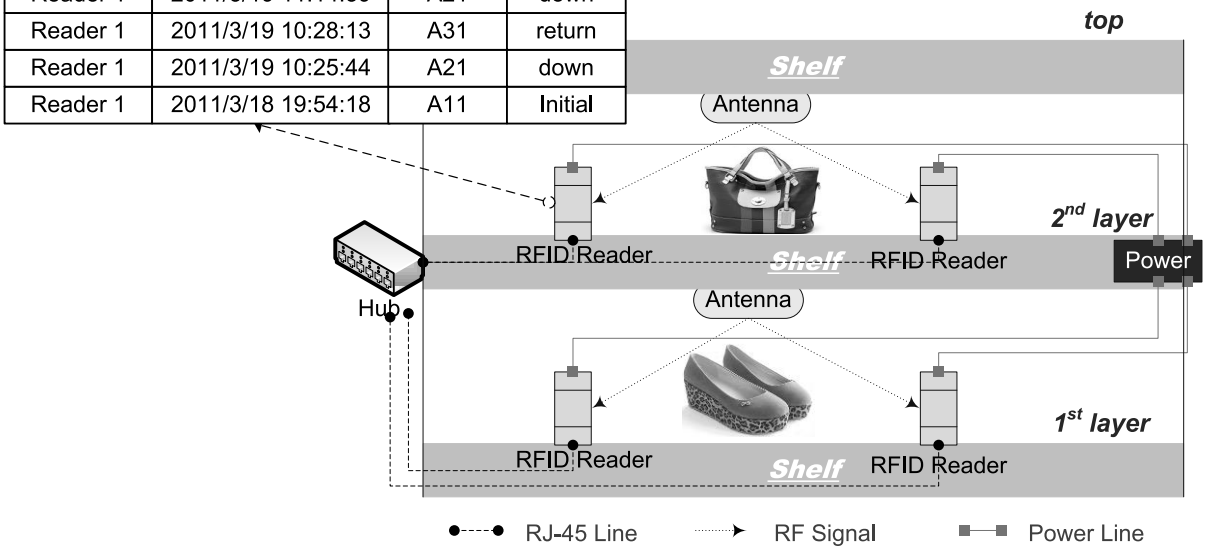

FIGURE 20. The prototype architecture of Intelligent Shelf.

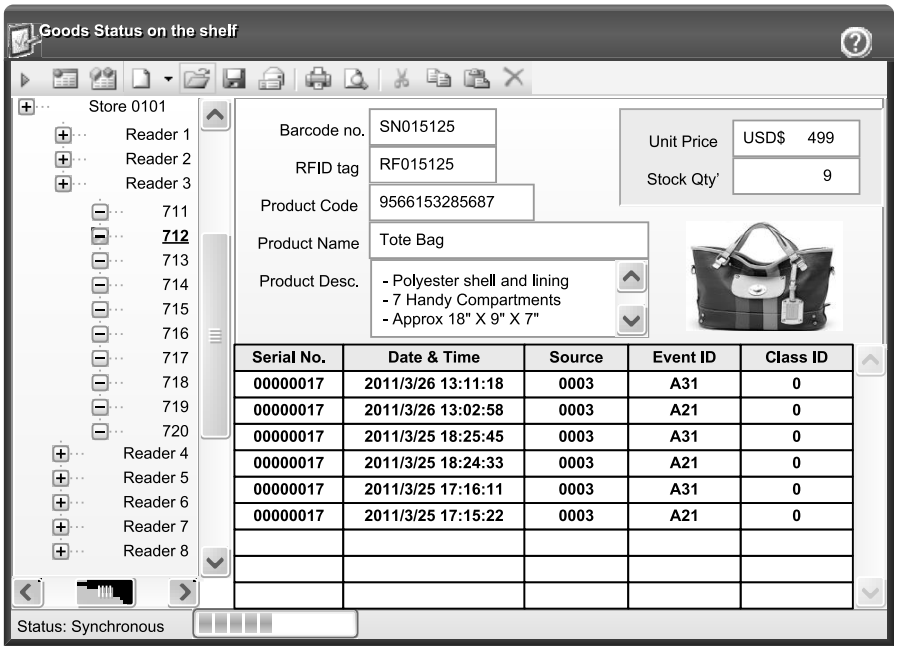

FIGURE 21. The system of information extraction agent.

consumer. (5) Status feedback service: It identifies the system device and check whether its status is idle or active in order to facilitate a specific event handling and information response. (6) Exception handling service: It checks whether there is any query object which cannot be effectively identified and, if yes, the program provides specific exception handlers to avoid the system execution error.

3) BUSINESS OBJECT SERVICES FOR INFORMATION INTEGRATION

Through the data integration interface, data records collected by the front-end devices can be linked with the existing backend information system architecture, thus realizing the business processes. The APIs of the information integration service mechanism are shown in Figure 17, including:

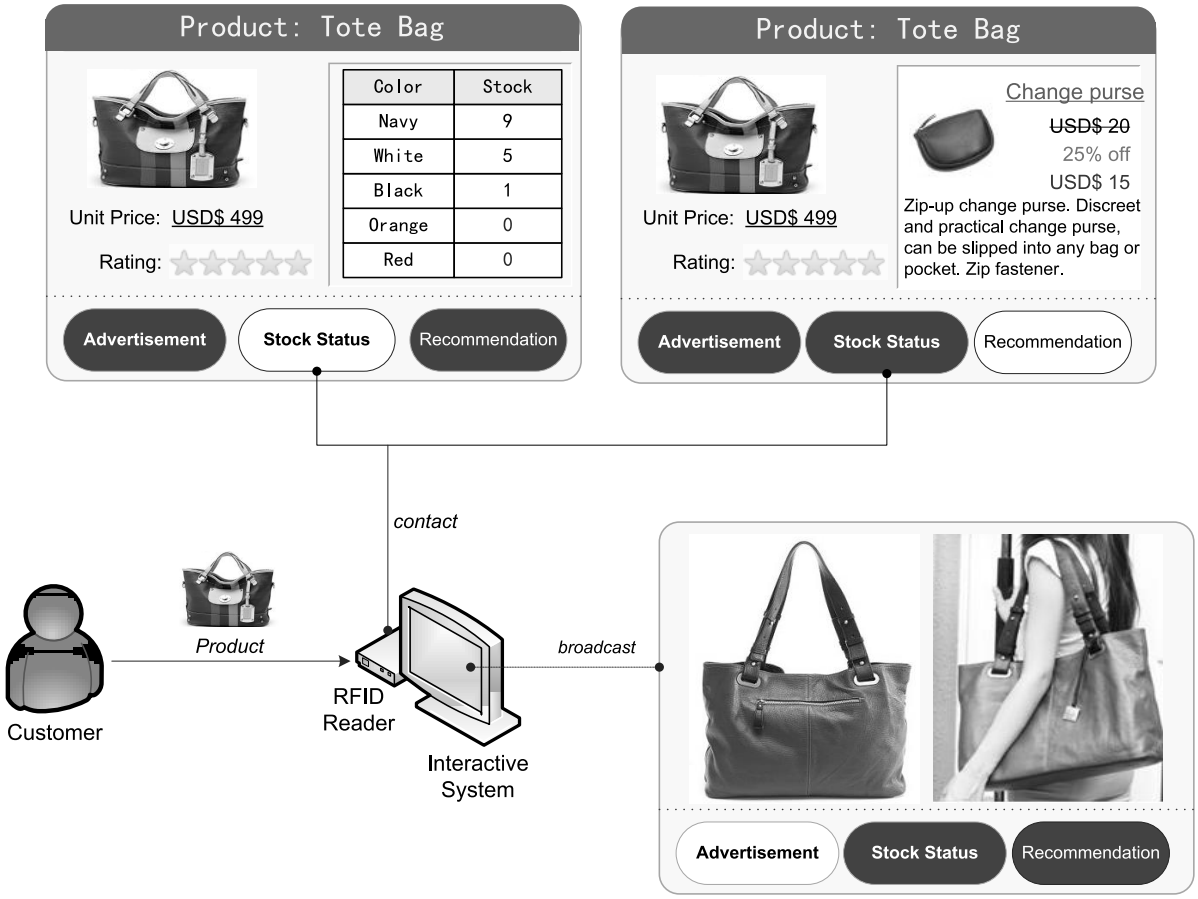

FIGURE 22. The system of sales service agent.

(1) Process definition service: According to the workflow of the system activity and the posting defined by the business operating procedures, the data interface and triggered job contents for each process are set up. (2) Data mapping service: The manager can establish data mapping for specific users and set up the basic structure for data import/export, allowing users to access or reference specific data columns and data types in the data source and primary contents server. (3) Data reading service: A batch data transfer is done according to a specific trigger event or occasion; or through the association of data key value, it links and responds to the contents of a specific data record. (4) Format conversion service: The data format change is done during the data import so as to comply with the consistent data integration requirement. (5) Data export service: It tries to connect to the target database, proceeds with the format conversion according to the data mapping service, retrieves the contents of the data source, and writes data to the specified destination according to the service request.

4) BUSINESS OBJECT SERVICES FOR PRODUCTS MANAGEMENT

In response to huge amount of data query requirements for product analysis and recommendation service, data sources from the existing system are extracted and the contents clean-up and summarization are proceeded so that the data items within the data model has the consistent definitions and formats. The APIs for product management service mechanism are shown in Figure 18, including: (1) Data extraction service: It combines the data mapping service mechanism of data integration agent and connects to a specific data source to extract a large number of data records. (2) Data processing service: The data items collected are combined with the format conversion service mechanism of the data integration agent to proceed with the data contents and format clean-up in order to facilitate the consistent format requirements for further data analysis. (3) Data loading service: The summarized and processed data contents are loaded into the data warehouse in batches in order to facilitate further multi-dimensional data analysis service. (4) Data analysis service: The product correlation analysis is done based on the product attributes, such as brand, price, and season. (5) Product recommendation service: The correlation analysis algorithm is used based on the actual sales history to find the products that may affect consumers' purchasing intention to proceed with the recommendation activity. (6) Security monitoring service: The data access privileges and priorities are managed, the update status of multiple data

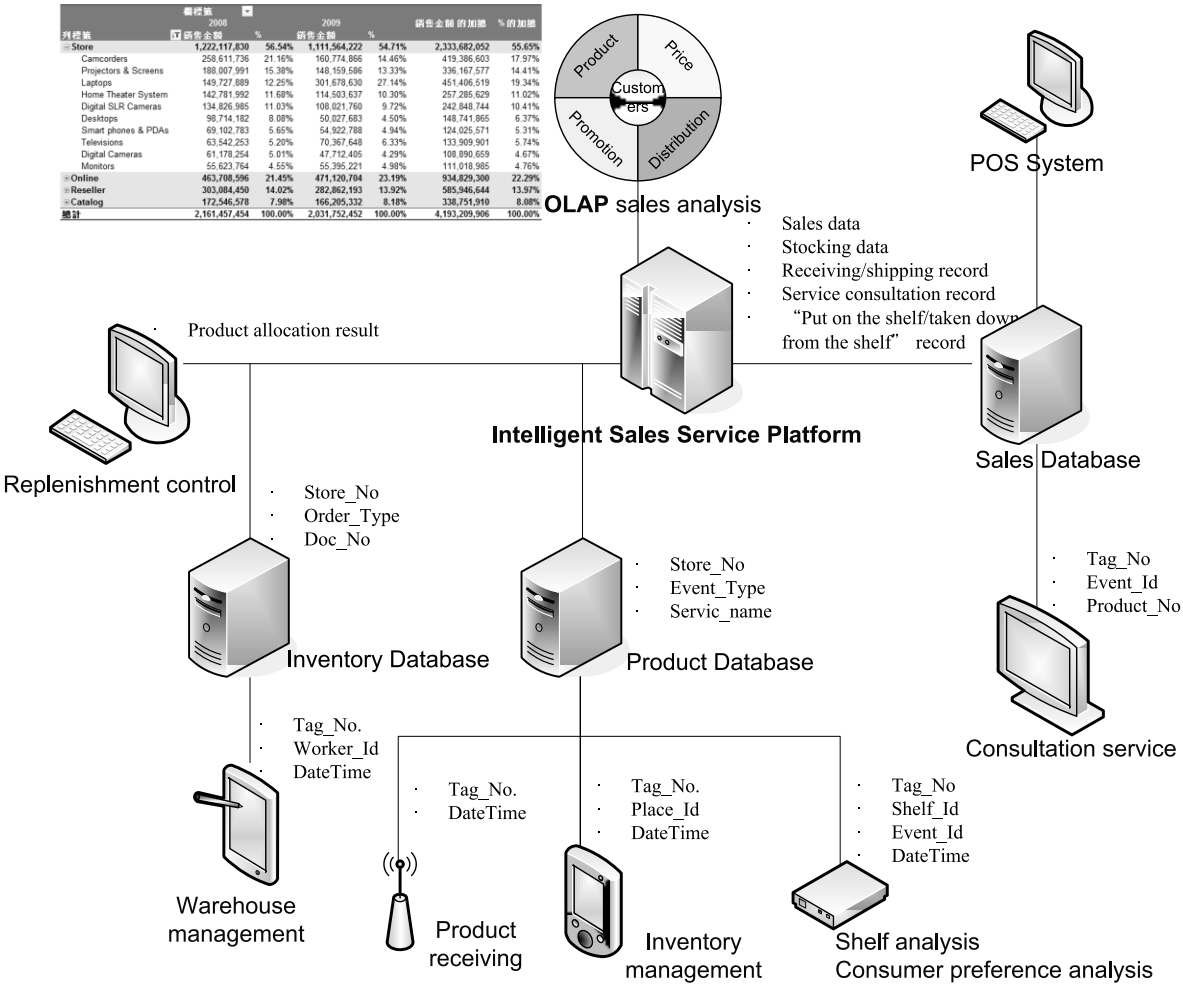

FIGURE 23. The system of product management agent.

sources is monitored, and the resources utilization is also managed.

V. IMPLEMENTATION PROTOTYPING SYSTEM

A. PROTOTYPE SYSTEM ARCHITECTURE

The RFID communication frequency used bandwidth is 875 ∼ 945 MHz. The specifications of major equipment for agents are shown in Table 4:

B. BUILDING PROTOTYPE SYSTEM

In order to delete information gap from product moving onto shelf to final checkout process and to improve the operation efficiency of product moving onto the shelf while enhancing the customer's satisfaction for shopping. The prototype architecture of the overall system is as follows:

(1) The information identification object is embedded into the individual product: The life cycle of a product in the outlet is from receiving into the warehouse to the checkout. The RFID tag generator makes the product label and attaches it onto the product or carton when shipping; at the same item the product information with XML format is written onto the RFID tag, in order to facilitate the product identification automation in the outlet.

(2) Extraction and reuse of the product information: Before the products are moved into the outlet warehouse in batches, they will first go through the fixed RFID gate to obtain the related product information records, and the information integration agent service mechanism, will confirm the purchase items, specifications, quantity and unit price; if it is necessary to do the inventory for products stored in the warehouse storage, the handheld reader to confirm stock status on the spot, and the service mechanism of information integration agent passes product information to the back-end information system via the mobile device so as to facilitate the management to plan the product replenishment request and shelf configuration, as shown in Figure 19.

(3) Dynamic access consumer behavior: take real-time control consumer behavior and shelf status, the basic/promotional/popular/limited product demands are taken into considerations to plan the intelligent shelves, the UHF RFID

FIGURE 24. Reports of improving effect.

reader is used as a medium, and a group of antennas are installed on the smart shelves, as shown in Figure 20, information extraction agent to collect info records for products placed onto or taken down the intelligent shelves as the information basis to analyze product status on the shelves in Figure 21, to take control of the storage status and replenishment demand.

(4) Customer service information access and feedback: when the consumer submits the product embedded with the identification object, through the information integration agent, pass data to the back-end product management agent as the information content for shopping analysis; the sales service agent will process it and then feedback the messages about product inventory status and shopping recommendations to the customer, as shown in Figure 22.

The Apriori algorithm of the SQL Server relational analysis is applied to the shopping recommendation system model, which compares the products purchased by each end customer with the recommended products for all association rules and excludes those products already purchased by the consumers.

$$\text{Confidence}(A \rightarrow B) = P(B|A)$$

TABLE 4. Specifications of equipment.

Equipment	Specification
Database	Microsoft SQL Server 2008
Middleware	Microsoft BizTalk 2009
Fixed gate	Antennas: 4 TNC duplex antenna ports, communication interface: 10/100 Base-T Ethernet RJ45Connector
Handheld reading device	antennas: communication interface: Wi-Fi 802.11 b / g
Intelligent shelf	RFID middleware: compliant with EPCglobal C1 G2 standard
Customer service application interface	Kiosk with 14-inch touch screen, 2.4GHz CPU, 1GB DDR3 memory

$$= P(A \cap B)/P(A) \quad (1)$$

$$\text{Support}(A \rightarrow B) = P(A \cap B) \quad (2)$$

The association rules helps the retailers and department stores do shopping basket analysis to find out the mutual relationship existing among products; the SSIS integration services is employed to create a project which designs a data flow and returns back the product association rule result to the Recommendation Products table as the reference source of product recommended list.

(5) Sales management decision support for the outlet: The product management agent analyzes events/processes, such as the product taken down from the shelf, product sensed in Figure 23, to confirm the product utilization and consumer behavior as a reference for real-time replenishment or promotional planning.

The ''conversion rate'' is used to analyze the consumer behavior between the products being on the shelf to the checkout.

$$\text{Conversion rate} = \text{times of checkout/times of taking down} \quad (3)$$

The times of checkout is the number in the Event code ''A51'' of the information extraction agent, meaning the times that the products have passed the POS system in the checkout area; the times of taking down is the number in the Event code ''A21'', meaning the times that the products have been taken down from the shelves. The more the conversion rate of product A, it means the more product A is potentially purchased by the consumers, the more the total checkout monetary amount, and also the more the expected contribution, and this will serve as the planning reference for the ensuing product replenishment.

The inquiry rate is used to analyze the consumer submitting the products to the sales service agent for product advice.

$$\text{Inquiry rate} = \text{times of submissions/times of taking down} \quad (4)$$

The times of submissions is the number in the Event code ''B21'' of the sales service agent, meaning the times that the products have been submitted to the customer service application platform; the times of taking down is the number in the Event code ''A21'' of the information extraction agent, meaning the products being taken down from the shelves. The more the inquiry rate of product A, it means the more the related information about product A is inquired by the consumers, the more the total checkout monetary amount, and also the more influence on the total sales, and this will serve as the planning reference for the ensuing product promotion.

To attract the consumer's attention and then surf on the website for browsing and shopping, the interface design of the Internet retail store will produce several consumer behaviors: (1) Leaving immediately: When the consumer visits a shopping site but the display contents of the product pages do not meet the customer's demand, (s)he will leave without hesitation. (2) Browsing: The consumer is interested the product, but the only browses the website and does not immediately purchase. (3) Browsing and checkout: When browsing the online store, the products stimulate the consumer's some kind of demand and the corresponding purchase behavior occurs.

As opposed to the traditional outlet stores which can only employ the product display shelves to display the products and attract consumers to purchase, the integrated mechanism of the intelligent shelf and software agent can effectively record the comprehensive shopping behavior for customer groups for specific products, and the constructed prototype system is then combined with the product marketing program in order to enhance the circulation rate of products on the shelves. For example, table 5 (a) has 44% conversion rate, while table 5 (b) when combined with the promotion program has the 86% conversion rate. In the future, the product display on the shelves can be also adjusted based on the response of customer groups. Therefore, for the physical store, the consumer behavior analysis mechanism provided

TABLE 5. Conversion rate for customer shopping behavior.

Table (a) : general sales programs

Code	Event	Times
A00	idle	16
A11	put on	16
A21	**taken off**	**36**
A22	inventory	1
A31	put back	20
A32	shift	1
A51	**checkout**	**16**

Conversion rate : **44.4%**

Table (b): combined with promotion

Code	Event	Times
A00	idle	16
A11	put on	16
A21	**taken off**	**28**
A22	inventory	1
A31	put back	20
A32	shift	1
A51	**checkout**	**24**

Conversion rate : **85.7%**

TABLE 6. Key performance indexes for evaluation.

Indexes	Description
product conversion rate	times of checkout / times of taking down
product inquiry rate	times of submissions to the sales service platform/ times of taking down
product shortage rate on the shelves	times of product shortage on the shelves / times of stock checks on the shelves
monetary consumption amount per consumer	monetary amount of product sales / times of consumption
staff productivity	total sales / personnel cost
customer satisfaction	satisfaction shown on the customer questionnaire
inventory average	(beginning stocking + closing stocking) / 2
product query time	average time for inventory query
operating time for receiving/shipping	operating time average of goods receiving/shipping

by the intelligent shelf can be used as the basis for product portfolio, shelf display and marketing plan.

C. EVALUATION

The intelligent sales service platform responses to the information requests of the retailers. It focuses on the customer behavior on the shelves in the outlet and interaction mode with the customer, and it uses the RFID technology combined with software agents to construct the front-end intelligent service application mechanism to enhance the information retrieval efficiency and customer service quality in the sales process for the outlet; the SOA is used to integrate the back-end system to provide back-end system management interface, and the instant RFID message feedback will reduce the time lag of information utilization. To quantify the evaluation result of system benefit, the sales data in December 2019 of the case company serves as the sample range in which the product records on the intelligent RFID shelves in outlet are retrieved as the experimental group, amounting to 1,100 product sales records in total. The experimental group is compared with the control group (whose product records are retrieved from the products on the traditional shelves and showcases in

TABLE 7. Comparison of traditional system and proposed intelligent agent-based predict system.

1. Frontend customer support

	Traditional system	Intelligent agent-based predict system
Shelf monitoring	Belong to Off-line system	On-line system; RFID detect
Product promotion	human made	Real-time response
Customer services	Passive	interactive
Purchase recommend	e salesmen's experience	Evaluate and response by system information

2. Backend management support

	Traditional system	Intelligent agent-based predict system
Product promotion	market forecast	Real time based on data-mining
Goods picking	human	Retrieved by RFID
Replenishment support	salesman	Automatic electronic system
Inventory control	by ERP system	Advanced analysis system

outlet B), and it can be found that the intelligent service integration platform (intelligent RFID shelf and agent system) has a performance improvement in Figure 24. The indexes of product management and consumer behavior analysis, the product conversion rate and product inquiry rate can be increased by 19% and 22% respectively; for customer service support indexes is reduced 90%; consumption amount 12%; employee productivity 15% and customer satisfaction are increased 9%; for predict decision support indexes, the average stock, product query time and the receiving/shipping time are also improved by 23%, 31% and 39% respectively. Some key performance indexes for evaluation are shown in Table 6.

In addition, the proposed intelligent agent-based predict system, compared with traditional system in table 7, management predict system, like shelf monitoring, customer service, purchasing recommendation, product promotion, and inventory control, it provides better information utilization and operating performance for the business outlets.

Therefore, from the actual verification, it obtains the following benefits:

(1) Constructing full-fledged service architecture: The software agent mechanism is used to design the cloud service platform architecture, and the RFID system mechanism is used to construct the front-end information service so as to provide immediate response to the dynamic requests of the customer; the back-end management mechanism is also deployed to provide the system integration interface and data analysis mechanisms to meet the product application requests of the retail industry.

(2) Improving product replenishment efficiency: information extraction agents and goods management agents developed can track history data from the products moved onto

the shelf till the checkout so that the shelf status and individual product identification can be actually controlled, it will provide real-time information about the product on the shelf, making the product transfer and replenishment more transparent while reducing out-of-stock items and theft proportion, which will help to improve overall logistics planning for the outlet and warehouse center.

(3) Reducing the inventory operation cost: In the case of void RFID system, all products must be scanned one by one by the barcode device when entering or out of the warehouse area and proceeding with the on-the-spot inventory, which will be time-consuming. However, mobile device can simultaneously read RFID tags, which will substantially reduce the operating costs of product confirmation and stocktaking.

(4) Enhancing the operation performance for the outlet: After the case company used with RFID intelligent system, it will be more convenient; agents also provide the consumer with the shopping guidelines and special offers, which will stimulate the customer's purchase intention and thus promote the performance and growth for the outlet.

(5) The infrastructure of the retail cloud: The retail cloud mechanism established in this study, through the SOA service creation and reuse, will eliminate the redundant system and reduce the maintenance costs; it is process-centric and, in the construction of the system, specific work processes requirements of the retail outlet will be considered to create the service interface and input/output data formats so that other developers can choose the right components based on the service interface to get the jobs done. Therefore, for the large retail vendors, their system resources are more abundant and can therefore directly refer to the prototype system architecture proposed in this study to deploy the intelligent shelf environment; for the SMEs, the system modules can be established step by step according to the requirements. In addition, the front-end RFID equipment can be established for each physical outlet store, while the back-end management mechanism can be used by the corporate partners based on their permissions and paid according to the system applications used.

VI. CONCLUSION

In this article, it focuses on the time utilization issue of hot-sale products for the outlet sales and warehouse management, as well as the combination of RFID technology and multi-agents, which provides static display model for the traditional product shelf, while using intelligent shelves serves as the ''last mile'' to narrow the gap between the consumer and product shelf so as to realize the convenient shelf management, real-time product information response, as well as the interactive product recommendation; so as to facilitate the dynamic response to market changes and customer demands; finally the RFID characteristics are also utilized so as to improve replenishment efficiency and reduce labor costs.

The research contributions are as follows:

(1) Being different from existing retailer who simply uses the concept of RFID applied to the intelligent shelf, which will practically solve the operation problems such as out-of-stock and replenishment for the business outlet, which provide the consumer with automatic, interactive and innovative customer shopping experience.

(2) Intelligent shelf and interactive customer predict system can supply real-time control of the consumer demand, and the integration with the enterprise information systems will help to improve the operational efficiency of supply chain.

(3) Intelligent agent and intelligent predict system will improve inventory on the shelves for the outlet, which will be conducive to the subsequent development and study of the consumers' behavior analysis.

(4) As the experiment shows, the use of RFID technology combined with agents and SOA mechanisms to construct the front-end/back-end applications of the cloud information services will increase the operating efficiency for the outlets by over 10%; the overall system architecture can also act as the reference model when deploying the intelligent product sales service platform.

With the trend in which the worldwide major retailers keep increasing the IoT investment to meet the consumers' requirements, vendors must take actions in advance. The prototype system architecture of the integrated product sales service platform proposed in this article can be up and running very fast when asked to implement the RFID system so as to meet the requirements coming from the consumers and outlet stores.

The future works are as follows:

The intelligent product sales service platform can take real-time and accurate control of the product status on the shelf; in the current cross-organizational information exchange mechanism, it can use the EPCglobal to integrate the RFID technology among partners. However, as for the products with shorter life cycle, how the upstream/downstream vendors use the product information on the shelf to develop the replenishment plan so as to shorten the replenishment lead time or how to integrate the RFID technology to the VMI so as to reduce the inventory levels will be a topic for the supply chain optimization in the future.

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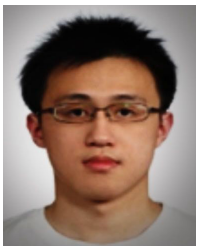

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