Intelligent service-integrated platform based on the RFID technology and software agent system

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ABSTRACT

The mobility of the popular goods on the shelves will have a crucial impact on the store sales. For retailers, the seasonal or news-induced demand for commodity will have the flocking effect or business opportunity lasting for some time; if the product shortage occurs, consumers will immediately turn to other stores, and the sale opportunity will be missed.

Traditionally, to confirm the demand for commodity, the stores primarily employ the point-of-sale (POS) system to monitor the inventory of goods, but the turnover rate of popular goods is very demanding. The inventory information supplied by the POS system is that generated after the ledger-closing stage, and it cannot precisely match the actual quantity of goods on the shelves. Therefore, in order to prevent the monetary loss due to the information gap, we propose the "intelligent service-integrated platform", which employs the software agent as the framework to construct the integrated information system mechanism. We also employ the radio frequency identification (RFID) technology to realize the smart shelf as the trigger point for the retrieval of commodity message. At the same time, we develop the interactive information platform to provide the consultation and promotion service of goods. The overall framework will help enhance the performance of the sales outlets and improve the customer service, while addressing the time effect issue of the popular commodity.

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1. Introduction

With the shift of life style and consumption trend, the operation of retail industry has dramatically changed; diversified products and timely product promotion activities must be provided to meet the demand for one-stop shopping from the customers. However, marketing planning must match the shopping expectations of the consumers to create the most cost-effective result (Achrol & Kotler, 1999); therefore, retailers must deliberately determine their strategy for the product portfolio, which means that they follow the seasonal demand or news to release the commodity, such as: air-conditioners in the summer time or Olympic-related souvenirs, to attract the consumers.

When observing the status of the information structure of the retail industry, it can be found that whether through the data mining technology to analyze the consumer behavior or through the customer relationship management (CRM) system to plan the product promotion, all the original information retrieved is from the point-of-sale management (POS). When the customer checks out, the product-related information, including product item,

quantity, price and shopping date, will be retained to serve as the main basis for sales analysis, and, at the same time, combined with the warehousing management system and the bar code, to confirm the inventory of commodity. However, the POS system retrieves the information at the ledger-closing point, so it does not reflect the actual inventory of the goods on the shelves. Most consumers often look over other goods after taking off the goods from the shelf and before checking out; therefore, the inventory information displayed by the POS system may be different from the actual quantity of the commodity on the shelves, which is the so-called "time gap of information".

When customers are very interested in specific products and get started with buying them, these products will become popular, and they will be an important source of revenue because of their potential to attract consumers and promote the sales of other products. Similarly, if the consumers deem the popular commodities as the main shopping objects but finds out them absent from the shelves, they, not satisfied with the quality of service, may leave and turn to other stores for consumption. Because the popular commodity is characteristic of the rapid decline of value over time both for the retailers and customers, malls and sales outlets must pay more attention to the real-time information to ensure the turnover rate of goods and economic efficiency.

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To address the issue of replenishment of goods, many studies (Simchi-Levi, Kaminski, & Simchi-Levi, 2000) mostly focus on the enhancement of the supply chain management by improving the internal operation procedures, or the information integration with the upstream suppliers in order to provide real-time and transparent inventory information to the suppliers, manufacturers, retailers, logistics providers, and so on, to minimize the forecast error of the end-consumer demand while improving the information efficiency of the warehousing management; however, the popular goods have intensive demand for the real-time information, so the traditional replenishment model, which is of the warehousing-centric architecture, cannot appropriately provide the customers with direct feel to the goods on the shelves. Therefore, if the use of active mechanism to monitor the inventory status of the malls or stores is feasible, it will have effective control over the end-sales information of the popular goods, and it will provide the interactive interface to provide consultation or promotional advertisement of the products to promote consumer demand for specific commodity procurement.

Therefore, to address the issue about the real-time demand of popular goods in the retail outlets, we bring up the "intelligent service-integrated platform" mechanism, which employs the software agent as the framework to construct the integrated information system mechanism and employs the radio frequency identification (RFID) technology to realize the smart shelf. With the use of the RFID tag as the sensing element on the product item level, which passes the real-time status on the shelf to the back-end system, it provides effective control over the quantity of popular commodity and out-of-stock condition, which facilitates the real-time replenishment done by the warehousing center to meet consumer demand. At the same time, the completion of installing an interactive commodity information platform provides the consumers with the autonomous commodity consultation environment, with the goal to improve the customer satisfaction and, with help of back-end sales analysis system, to provide appropriate goods service so as to enhance the performance of the stores.

The structure of this article: Chapter 2 explains the relevant technologies; Chapter 3 covers the case study and problem statements; Chapter 4 discusses the system architecture; Chapter 5 covers the system implementation and benefit evaluation; Chapter 6 is the conclusion.

2. Relevant technologies

2.1. Software agent

Software agent is a realization of the artificial intelligence and network technology (Chen, Jeng, Lee, & Chuang, 2008), and is a program capable of completing tasks delegated by the users (Yang, 2008). Its functionality and operation modes vary, according to the characteristics of the tasks (Chen & Chen, 2008). The key attributes of this software can be classified as autonomous, *learning*, and *cooperative*, according to the classification rules done by the scholar (Nwana, 1996).

- Autonomous: able to operate on its own without the instructions issued by the user.
- Learning: able to respond to the change of the external environment or user behavior.
- Cooperative: able to communicate, coordinate, and exchange information with other agents.

With the rapid development of e-commerce, consumers have access to the Internet to obtain more market intelligence and product contents to make sure that the goods purchased meet the demand. However, due to the huge volume and complexity of the information, in order to address the dilemma of information overloading imposed on the customers and help them proceed with the effective search for the goods needed so as to further enhance their consumption desire, research on the "commodity service agent" has got the focus (Chen & Yu, 2008). Various agent systems for the retail industry are summarized as follows: (Ribeiro, 2002 Yang, Chiu, & Ho, 2004)

(1) Product sales agent: a virtual sales person on the network platform; when the consumer surfs the Internet for shopping online, it can provide interactive services and commodity suggestions to the consumer according to his or her behavior and intention, just like a true sales person.
(2) Commodity intermediary agent: provides the optimized shopping suggestions, such as price-oriented or function-oriented through the comparison and analysis of specific product items.
(3) Information service agent: helps filter the huge volume of messages on the Internet and renders only the information needed by the consumer so as to facilitate the search and evaluation.
(4) Learning agent: has the ability of machine learning and, by incessantly receiving external information to adjust its operating behavior, enhances the efficiency and accuracy.
(5) Interface agent: provides the easy-to-use man-machine interface to allow users to interact with the machine and assists users in addressing operation problems.

2.2. Radio frequency identification

Radio frequency identification (RFID) can provide message read/write functions, which is helpful for keeping the message contents of diversified goods (Doerr, Gatesa, & Mutty, 2006); the study (Finkenzeller, 2003) shows that the RFID is indeed able to enhance the management automation of commodity, and in the retail industry the empirical observation of pallets and shipping carton packaging coming from the bellwether Wal-Mart and its primary suppliers shows that RFID is more useful in the commodity tracking and information share for the retailers (Fuji Chimera Research Institute, 2005). With the help of wireless sensing technology, more than one tag can be automatically read; when compared with the traditional bar code or magnetic card, it can be found that RFID will be used more widely and is a realization of ubiquitous Internet (Want, 2004).

Due to the larger memory capacity, RFID can be used to collect the identification numbers and attribute information of various types of commodities (Chen & Tu, 2009), including: commodity item, expiry date, production history, the flow of circulation, as well as commodity price, etc. (Chen, Chen, Yeh, Chen, & Kuo, 2008; Nath, Reynolds, & Want, 2006). When the RFID is employed, the warehousing people do not need to open the carton to check the goods inside, more than one ID can be read at one time, and the inventory status is always available any time , which is beyond the ability of the traditional bar code (Chen, Tsai, & Tu, 2008). What is more important is that the RFID uses the reader to send radio waves to the electronic tag embedded or attached to the object to identify and retrieve the wireless data; the overall framework will be favorable to the active message interaction mechanism design, as shown in Fig. 1.

At present, the research on the use of RFID to the active message response in the retail industry is mostly applied to logistics tracking (Masciari, 2007), warehousing management (Han, Gonzalez, Li, & Klabjan, 2006), etc., and the use in the retail stores for sales support has not been prevailing, mainly due to the fact that the RFID tag is still very costly, and the use of the RFID tag on the low-priced goods to the product item level is not cost-effective; however, in
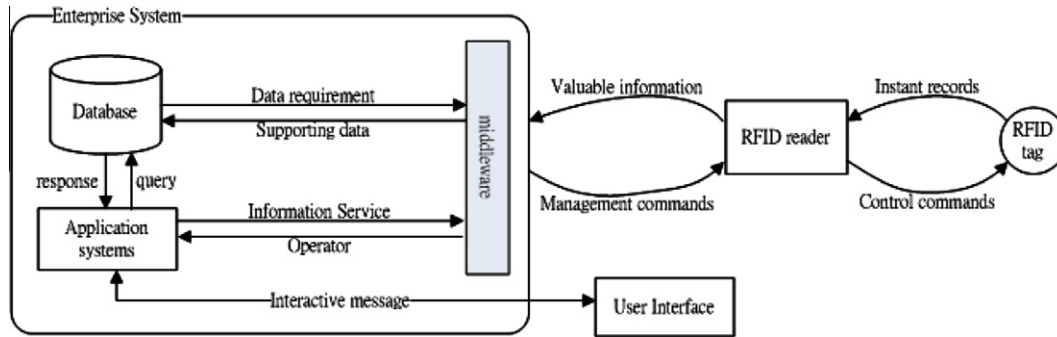
Fig. 1. The RFID interactive mechanism.

the case of high-priced or popular goods, since the cost of the RFID tag accounts for a relatively small proportion of the price, retailers and consumers will be happier to accept it, so the use of popular products as the focus of the study will help achieve the feasibility of application.

3. Case study and problem statements

3.1. Case study

The case in this study is a well-known footwear manufacturer, which has its own sales channels, such as the store outlets and department stores; due to great endeavor on the product quality and brand image and incessant launch of new styles for consumers of different market segments, it has good customer royalty. Because the competition of current market is becoming more intensive, existing logistics management and support system have failed to meet changes in the market demand, and as shown in Fig. 2 for the service model of retail stores, the original management information system can provide common support for the manufacturing plants and warehouse management but cannot provide real-time information services for customers.

3.2. Problem statements

When analyzing the operating model of the case company, it can be found that from the design and production processes of the manufacturing plant to the inventory management and logistics mechanism of the warehousing center, the sales forecasting model is heavily used to estimate future market demand for products, and the replenishment or back order is done based on the sales information fed back by the POS system. As far as the store outlets are concerned, replenishment, products hitting the store shelves, shopping, sales information, etc., have more urgent demand for the real-time response mechanism, so the "push" sales model will encounter the following operation bottlenecks:

(1) Inefficient replenishment: inventory is done in a manual and periodical fashion; the product barcode is scanned to confirm the quantity of stock, and replenishment request is sent to the distribution center for replenishment purpose; however, the life cycle of popular products is shorter, combined with the fact that the barcode must be scanned one by one, which casts adverse impact on the time of products hitting the shelves, so the sales opportunities during the promotion period may be missed and the change in the customer demand cannot be met.

(2) Poor control over the products hitting the shelves: the sales persons of the store outlets employ personal experience to determine the timing and quantity of stock, but the understocked condition often occurs, which makes consumers unable to get what they need and hence may reduce the sales performance; moreover, human misjudgment could also result in increased inventory; if proper promotion programs are not taken for stork clearance, the use of store space will be seriously harmed.

(3) Lack of shopping services: during the sales process, consumers often want to buy goods in the pressure-free environment; after comparison of the styles or size of goods, in addition to the advice about whether or not going along with the costume, they often inquire into the status of inventory. The sales persons query the existing stock also through the product model and from the inventory management system; therefore, installing an interactive shopping
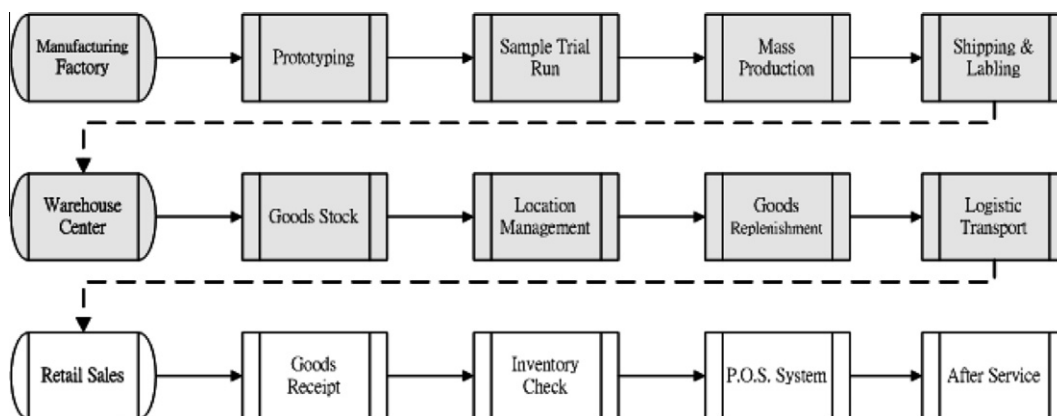

Fig. 2. The primary service model for retail stores.

service mechanism, in addition to assisting clients in the inventory query on their own, can also provide real-time personalized promotion activities.

(4) Inefficient utilization of information: traditionally, information of all goods sold must be retrieved form the POS system upon checkout, so it can be used for the sales statistics purpose and as a reference for the analysis of consumer behavior; however, activities, such as taking off goods from the shelves, try-on, comparison, etc., cannot be recorded; if consumer preferences can be immediately stored in the database system, then the use of data mining technology that ensues will help the design of products so as to better cater to customers.

As shown from the problem analysis above, the traditional POS system architecture cannot provide real-time information services, and products on the shelves will be presented to the consumers the most direct impression; according to the statistic data, the loss of customers reaches to 34% due to out-of-stock reason, which means that if there are no spot goods on the shelves to meet consumer demand, it will have an adverse impact on their satisfaction and then they even turn to competitors' products. Therefore, to address the problems the stores encounter, we first employ the item management mechanism of the RFID tag, which serves as the trigger point of active information, to generate related value-added services and business operations and, through multi-agent framework, to retrieve customer information as well as to integrate the enterprise information systems to facilitate and enhance the performance of overall operations of the supply chain; finally, the completion of installing an interactive service platform can provide consumers with the information they need in an interactive and autonomous fashion and therefore, in an innovative business mode, enhance the operation efficiency of the stores.

4. Application architecture

Focusing on the application requirements of the stores, the system architecture is divided into two major modules, as shown in Fig. 3, one of which is the product support for the front-end consumer and the other is the decision support for the back-end management; the service function is divided into three layers. The lowest is the physical layer, which mainly employs the RFID sensing devices and interactive systems as the infrastructure of the application platform. The second is the software agent layer, which employs multiple agents to provide consumers with shopping recommendation and commodity query, and to provide managers with the suggestions on the replenishment and shelf analysis; the third is the application service layer, which provides information service for both the customer service and the operation management request so that the overall system operation can be realized.

4.1. Software agent architecture

When the consumer interacts with the commodity, the traditional e-commerce agent system often requires complicated operations, which make the customer unable to find useful information. Therefore, two kinds of agents, as shown in Fig. 4, are designed, aiming to address the issues for the consumer about personalized advice, shopping recommendations, online promotion, and VIP service.

(1) Information extraction agent: in the case of retail store, the interaction of the consumer and products begins with taking off them from the shelves, and after inspecting the outer appearance or functionality, he or she may place the products back onto the shelves or just check out; the information extraction agent records related behavior information in the background through the active trigger mechanism to reduce the burden imposed on users, and it also feedbacks the real-time shelf information which in turn can be used as reference data for replenishment or back order.

(2) Sales service agent: when consumers turn to the sales service agent for help, the agent filters relevant commodity information and in turn displays the result, and, at the same time, provides consumers with shopping recommendations and promotion programs, just like a counter sales lady interacting with the consumers.
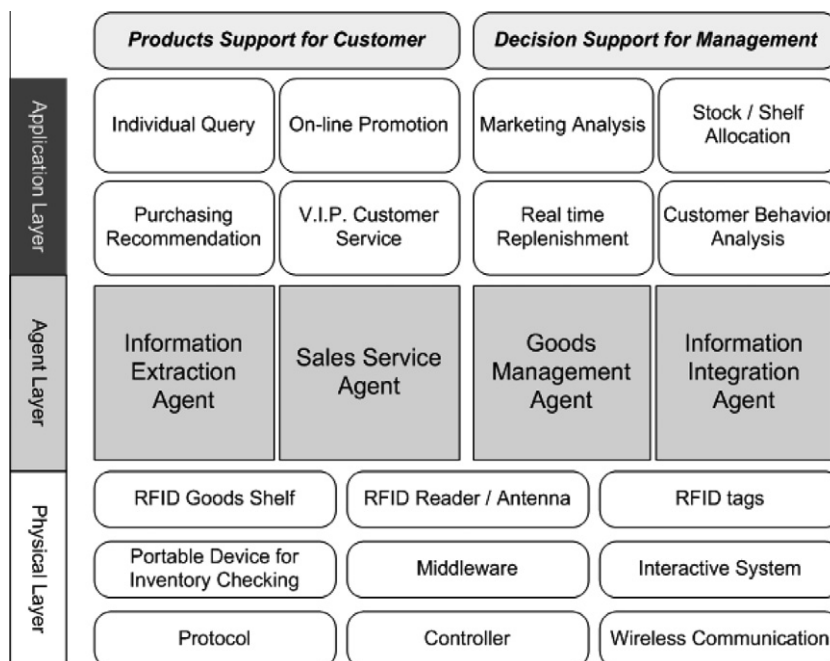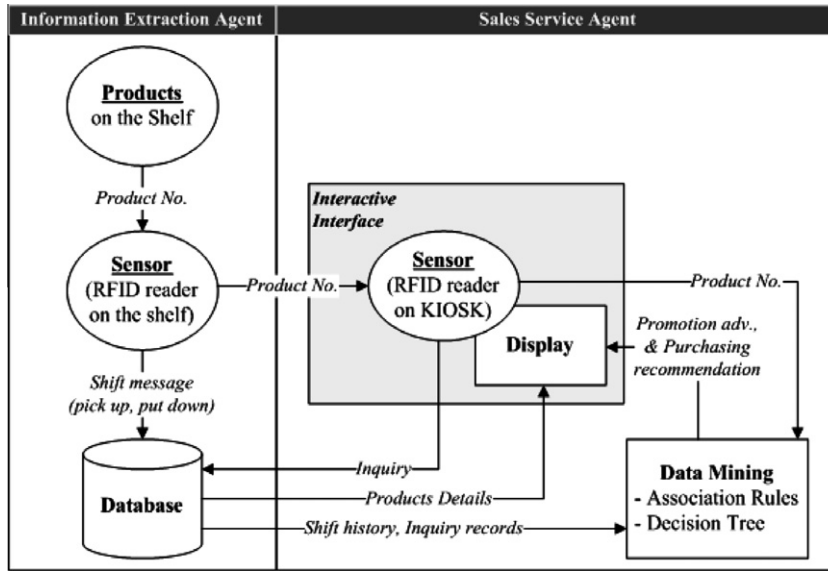

Fig. 3. Proposed system architecture for retail stores.

Fig. 4. Software agent for customer service.

While the front-end information extraction agent extracts the real-time commodity information through the active trigger mechanism, an effective back-end information analysis is also needed so that it can feedback the effectiveness of information contents obtained to the information extraction agent and ensure the accuracy of the result provided by the sales service agent. Therefore, in the case of management decision-making application, two kinds of agent mechanism are constructed, as shown in Fig. 5, to meet the functional demands on the market analysis, shelf arrangement, consumer behavior analysis, and real-time replenishment suggestions, among other things.

(1) Commodity management agent: Adopts the shopping analysis of traditional POS checkout systems in order to have control over the contribution degree and relevance of the actual sale of products and, at the same time, the information extracted from the shelf by the information extraction agent will go through the statistic process to determine

the prevalence degree of products and customers' interests, which can provide managers with the suggestions on the replenishment or shelf arrangement.

(2) Information integration agent: The information application of headquarter includes modules such as warehousing management, product sales, financial planning, logistics and transportation. In order to achieve the real-time information sharing between the back-end system platform and front-end store, this agent interlinks the product title, specifications and characteristics of each product item and, through the mobile platform device, enhances the efficiency of instock and inventory.

4.2. System architecture of the intelligent service-integrated platform

Based on the demand arising from the retail outlets for the front-end product consumption and back-end operation management, we propose the idea of multi-agent to provide the service
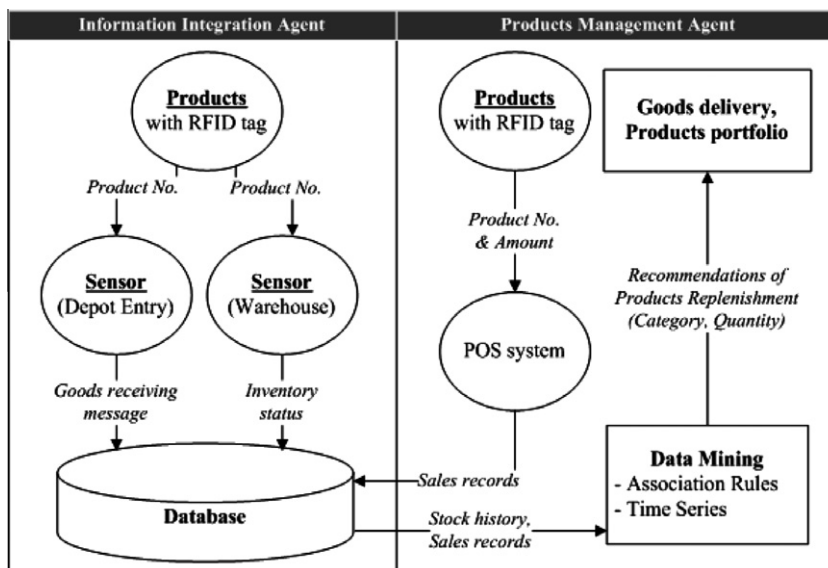

Fig. 5. Software agent for management support.

function and further develop the "intelligent service-integrated platform" system architecture to link the information contents that the physical layer RFID tags carry and response to the service demand coming from the application layer. The main function of the system is as follows:

(1) RFID tag generator: Its main function is to generate the RFID tag onto which the generator writes the basic information. The RFID reader module is integrated into the RFID tag coding system so that the RFID system and bar code operation can be streamlined and synchronized; moreover, the contents that the RFID tag carries can provide messages, such as product tile and production history, to the smart shelves, customer interaction application platform and various service agents for further use.

(2) Fixed gate: With the help of the fixed RFID reader which is on the gate and rapidly counts the quantity of incoming/outgoing products, the system can provide users with the ability to set up the incoming-product or outgoing-product mode; after the order entry or shipping order entry is completed, the RFID reader can get started with reading the commodity information; if the data received by the fixed reader is not complete, the operator can use the handheld reader to get the items not yet read.

(3) Handheld inventory reader: The store worker uses the handheld RFID reader for goods-receiving and inventory, and the result read is uploaded to the enterprise operation platform system through the information integration agent. In addition, each storage cell for the new-arrival products is encoded and assigned an RFID tag. The storage management function provided by the system links the RFID tag of the storage cell and product RFID tag so as to facilitate users at

the store to use handheld device to quickly query detailed information such as the current location of the product and inventory.

(4) Smart shelf: With the combination of miniature RFID tag and antenna and the use of distributed RFID communication control and sensing element, the multi-functional and modularized smart shelf is constructed; through the message interaction between the RFID tag attached onto the individual commodity and the antenna on the shelf, the information extraction agent can proceed with the information triggering and contents extraction.

(5) Customer interaction application platform: With the RFID reader, the consumer can directly sense the commodity in order to query the commodity information; the message contents include product description, specifications and inventory; the multimedia technology is employed to display value-added services, such as commodity promotion and shopping suggestions that the sales service agent provides, and it can also keep playing the enterprise image advertisement and promotions when no consumer uses this system.

The relationship between the agent system and the intelligent service-integrated platform is shown in Fig. 6; commodity tag is generated by the RFID tag generator in the manufacturing plant; when the goods go to the store warehouse from the distribution center, the fixed gate and the handheld reader are used for rapid inventory receiving and storage cell preparation, and the data obtained is in turn linked with the back-end system through the information integration agent. When the customer takes off the commodity from the smart shelf, this action will trigger the information extraction agent, and the information extracted will serve as the basis for replenishment and backorder. The customer uses
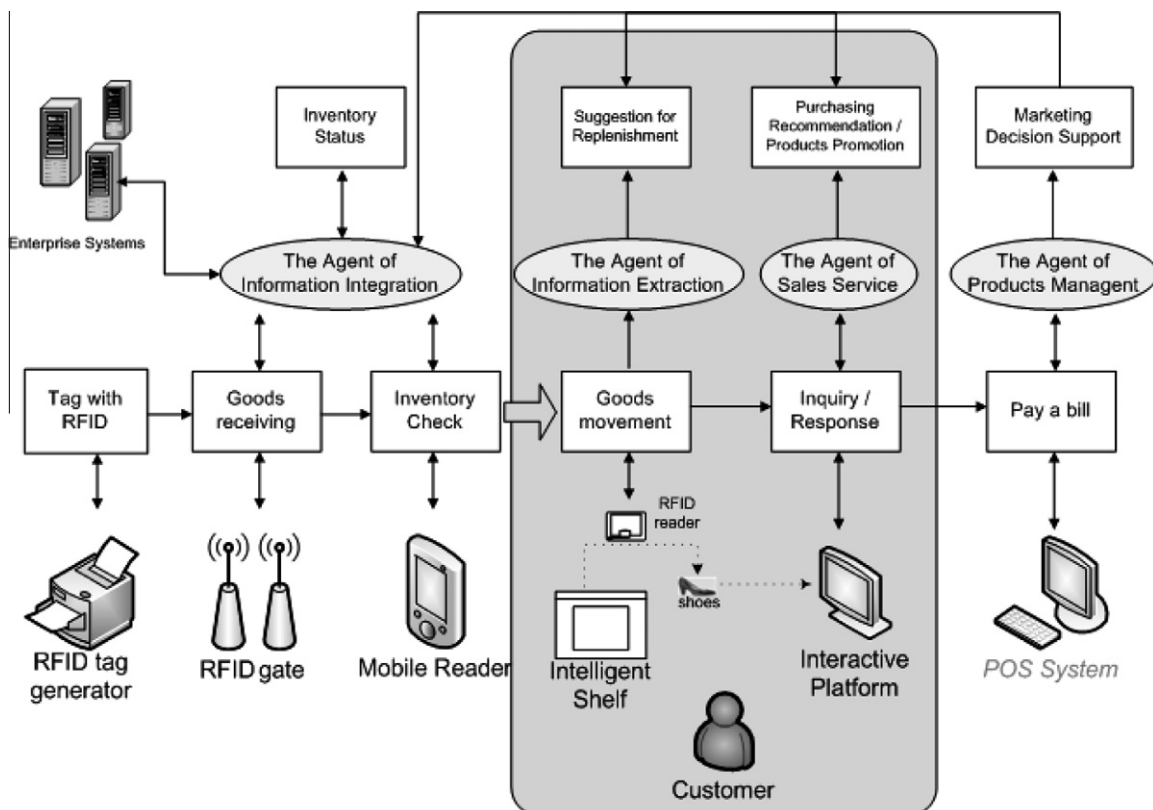

Fig. 6. Architecture of the intelligent service-integrated platform.

the RFID tag to sense the customer interaction application platform and the sales service agent makes the response; finally, after the customer checks out, the commodity management agent is employed to provide managers with various decision support information.

5. System implementation and benefit evaluation

5.1. Development environment

The communication frequency of the RFID mechanism adopted by the system platform is 875–945 MHz in bandwidth, and the specifications of major devices are as follows:

(1) The antenna on the fixed gate adopts 4 TNC duplex antenna ports, and communications interface is 10/100 Base-T Ethernet RJ45 connector.
(2) The antenna on the handheld reader device adopts "Linear with excellent polarization diversity". The communication interfaces is Wi–Fi 802.11 b/g and fixed/dynamic IP is supported. The operating system is Microsoft Windows CE Professional 5.0.
(3) The RFID interface of the smart shelf is compliant with the EPC global C1 G2 standard.
(4) The customer interaction application platform employs Kiosk equipped with a 17-in. touch screen. It has a 4 GHz CPU and 1 GB DDR2 memory.

5.2. System implementation

To eliminate the information gap from taking off the products from the shelf to the final checkout and to enhance the customer shopping satisfaction with the help of integrated service platform, we make use of the RFID technology and agent software architecture to implement an intelligent service-integrated platform so as to improve the sales operation automation. The implemented functions are as follows:

(1) Creation of identification contents for individual product: The retail outlet logistics covers processes such as product-receiving, sales, and checkout. To effectively identify and record each product at each stage, the RFID tag generator is employed to generate the product tag which is in turn attached onto the product or carton, and the product information is then written into the RFID tag in the form of XML format, as shown in Fig. 7, so as to facilitate the application of sales outlets.
(2) Extraction and reuse of product information: When a batch of goods goes into the store, it will pass through the RFID fixed gate so that information of incoming products can be obtained, and then the information integration agent, as show in Fig. 8, confirms the product items and quantity; when the purchased goods are to be stored in a warehouse location, a handheld RFID reader can be used to confirm the status of inventory, and then the information integration agent passes the storage cell to the mobile device to facilitate people to proceed with the inventory operation.

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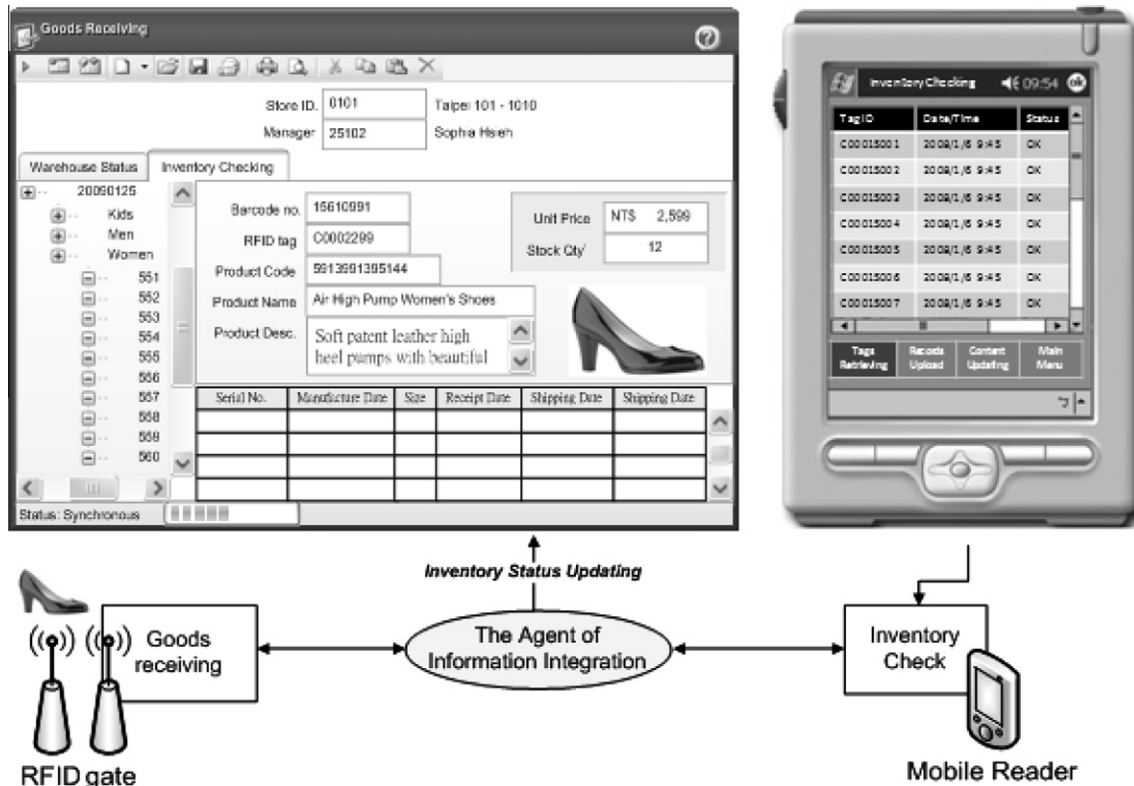
Fig. 7. Information contents of products.

Fig. 8. Information integration agent.

(3) Real-time dynamic access to consumer behavior: In order to have real-time control over the consumer behavior and shelf status, this study references several commodity demand types (basic, popular, promotion, special offer of limited quantity) for planning of the smart shelf. The UHF RFID reader is used as a media, and more than one antenna is installed in the smart shelf, as shown in Fig. 9, so as to facilitate the information extraction agent to collect information about the product on-or-off the smart shelf, which is in turn used as the basis for analyzing the status of product, as shown in Fig. 10, in order to effectively control the inventory status and replenishment request in the store.

(4) Access and feedback of the customer service information: When the consumer submits the commodity to the interactive interface for sensing, the information KIOSK, for example, automatically reads the contents of the RFID tag for shopping analysis, and at the same time, after the sales service agent processes the information, messages such as the inventory status of the commodity and shopping suggestions are fed back to the customer, as show in Fig. 11.

(5) Sales management decision support: The commodity management agent proceeds with the analysis according to taking off the commodity from the shelf, sensing the commodity in the interactive interface area, or actual checkout
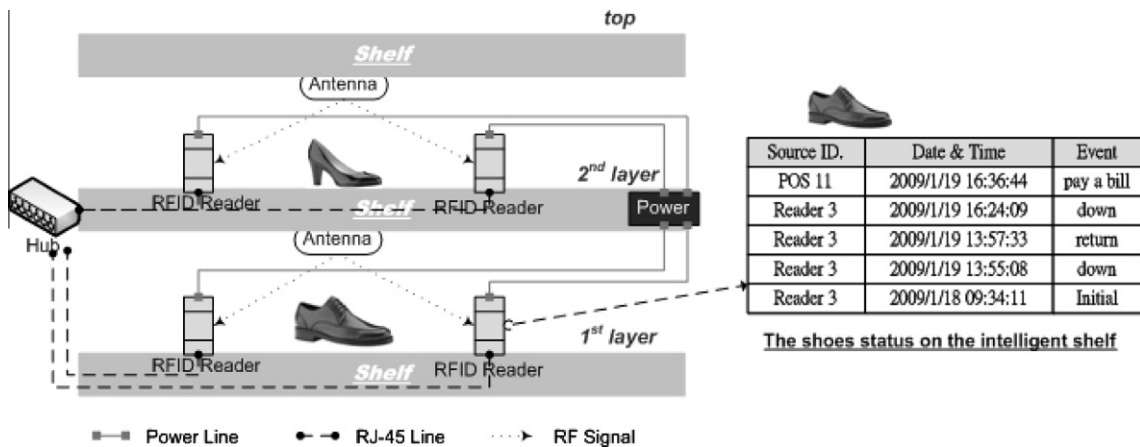

Source ID.	Date & Time	Event
POS 11	2009/1/19 16:36:44	pay a bill
Reader 3	2009/1/19 16:24:09	down
Reader 3	2009/1/19 13:57:33	return
Reader 3	2009/1/19 13:55:08	down
Reader 3	2009/1/18 09:34:11	Initial

The shoes status on the intelligent shelf

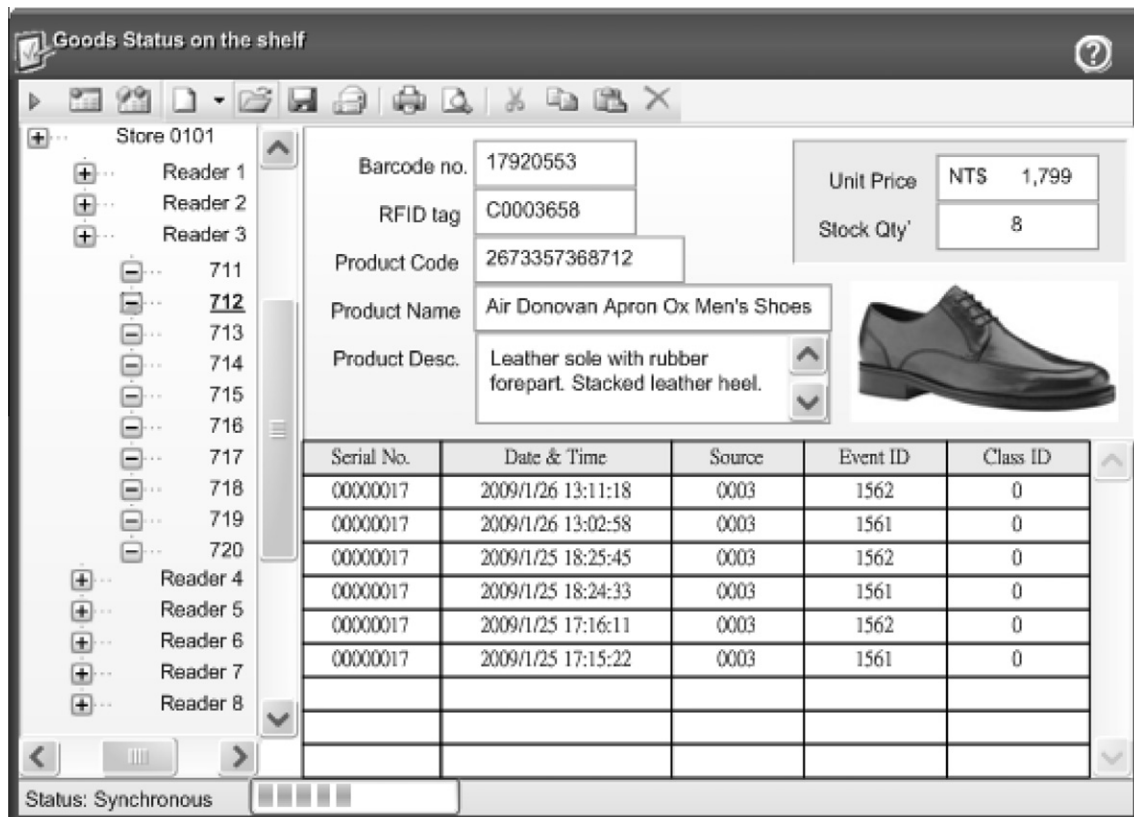**Fig. 9.** The prototype architecture of the smart shelf.
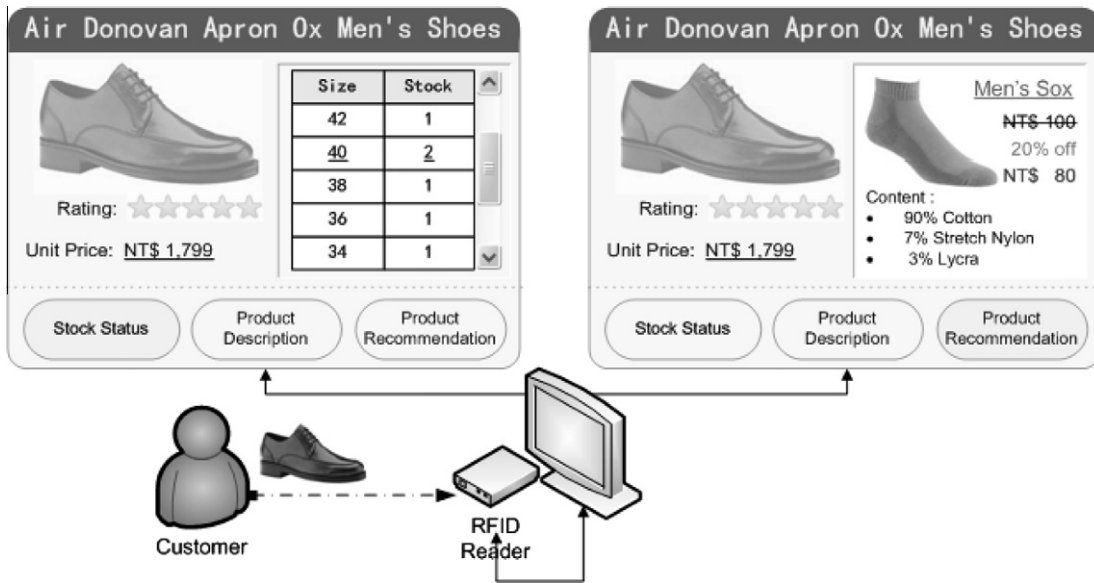

Fig. 10. Information extraction agent.

Fig. 11. Sales service agent.

through the POS system, as show in Fig. 12, to confirm the utilization effect of the commodity and consumer behavior, which can in turn be used as reference for the decision-making of replenishment or promotion planning.

5.3. Benefit evaluation

Focusing on the consumer's behavior characteristics for using the commodity shelf in the retail outlet and interaction with the sales persons, combined with RFID technology and agent software, we propose the integrated service application platform so as to enhance the information extraction efficiency during the sales stage and customer service quality, and, through the real-time RFID message feedback, to reduce the information gap; to illustrate the system benefit, the sales data (totally 7168 data records) of quarter four 2008, obtained from the smart shelves (RFID mechanism) of retail outlet A of the case company, is compared with the sales data

obtained from the traditional shelves and exhibition counters of retail outlet B of the case company, and it can be found that the smart shelf with RFID mechanism and intelligent service-integrated platform can contribute to significant performance enhancement for the management, as shown in Fig. 13. Among them, for the index of customer service support, the shortage rate of goods on the shelf is reduced by 90%, and the sales amount, staff productivity and customer satisfaction are increased by 14%, 31% and 22%, respectively; for the index of management decision support, inventory turnover rate, time spent for stock inventory, warehousing costs and time for incoming/outgoing products are reduced by 34%.

In addition, if we compare the proposed intelligent service-integrated platform with the traditional operation mode, as shown in Table 1, it can be found that several management mechanisms, such as shelf monitoring, product shortage, customer service, purchasing recommendation, product promotion, goods picking,
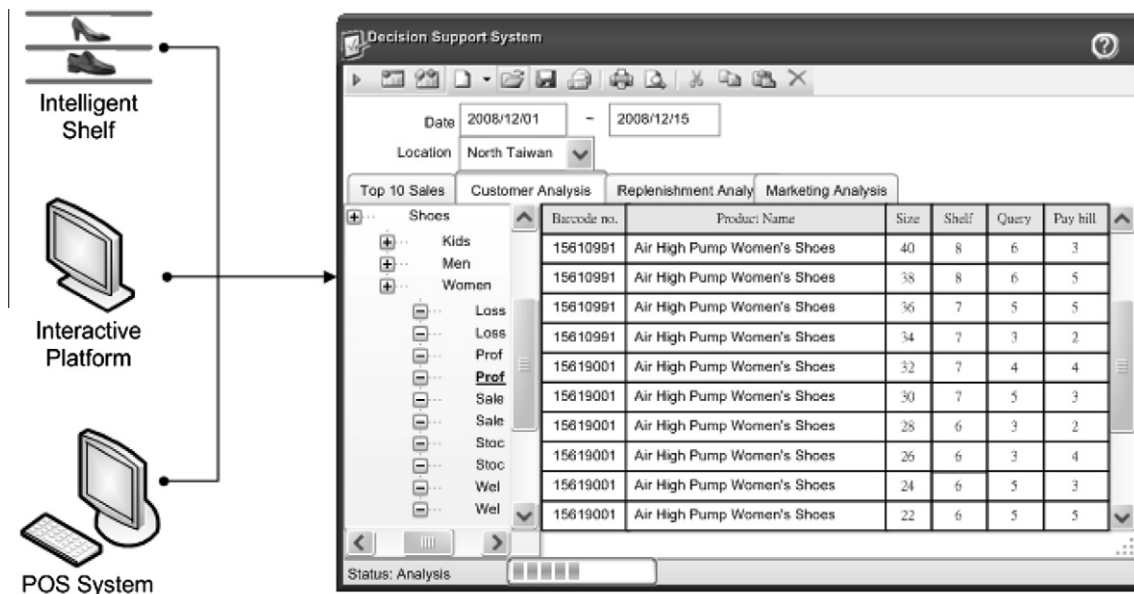

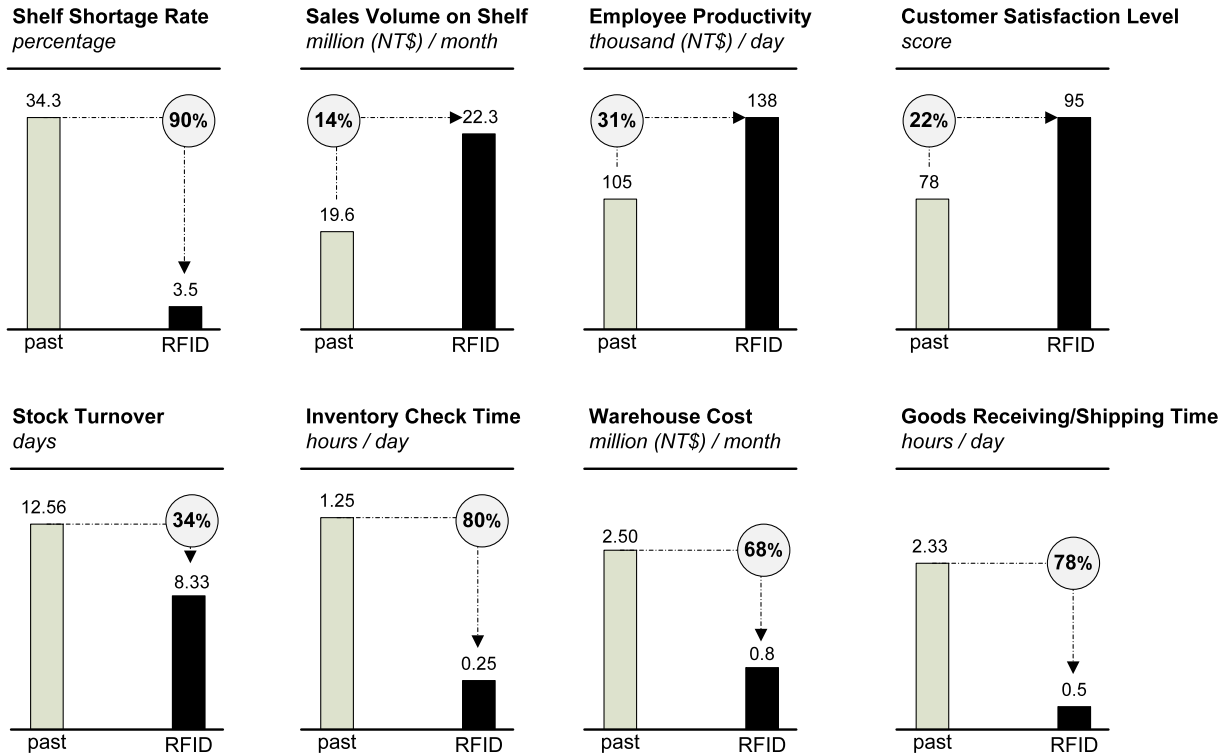**Fig. 12.** Product management agent.

Fig. 13. Reports of improving effect.

Table 1
Comparison of business processes between two different strategies.

Items	Primary operation	Our proposed platform
Shelf monitoring	Off line	On line; detected by RFID mechanism
Products shortage	Control by human experience	On line display by the system
Customer service	Passive mode	Self-help with interactive mode
Purchasing recommendation	Handled by experience of salesmen	Evaluated by artificial intelligence
Products promotion	Depend on the marketing forecast	Real-time message based on data-mining
Goods picking	Search by human and barcode	More efficiency; Retrieve with RFID
Inventory control	Control by the ERP system	Advanced a trend analysis mechanism
Replenishment support	Allocation by salesman	Automatic guide by electronic system

inventory control and replenishment support, can provide better information utilization and operation efficiency for the sales outlets.

Therefore, we summarize the benefits as follows:

(1) Enhancement of performance for the retail outlet: After the case company in this study implemented the RFID goods shelves, several mechanisms, such as product tracking on the shelf and assessment of consumer behavior, can be more convenient, and, at the same time, through the interactive customer service application platform and sales service agent which provide the consumers with the shopping guideline and discount message, customer purchase desire can be encouraged and hence the sales growth opportunity is feasible.

(2) Enhancement of commodity replenishment efficiency: The information extraction agent and commodity management agent described in this study can track all stages from the goods on the shelve to shopping checkout, making full control over the shelf status and identification of individual commodity possible; moreover, through the information integration agent, the commodity message on the shelf is integrated in a real-time fashion with the back-end information system, making the backorder and replenishment requests more transparent and the proportion of out-of-stock items and shoplifting reduced. This is helpful for improving the overall logistics planning of the sales outlets and warehousing centers.

(3) Reduction of the inventory operation cost: If the RFID system installation is not available, then any commodity in and out of the warehousing area of the sales outlet as well as in the inventory stage must be scanned one by one, which is time-consuming and painstaking . After the system architecture in this study is implemented, the fixed gate or mobile device for inventory purpose can be used to read multiple RFID tags at the same time, hence substantially reducing the cost needed for goods confirmation and goods inventory.

6. Conclusion

Focusing on the time utilization issue between the outlet sales and warehousing management for the popular goods, combined with RFID technology and multi-agent software mechanism, we propose a practical solution, and at the same time outdate the traditional mode of displaying products on the shelf in a static fashion. With the implementation of smart shelf and interactive customer service platform, also as an approach to drawing the consumer and products on the shelf closer by "last-mile", it attain several goals such as the convenience of management for products on or off the shelves, real-time response of the commodity

information, and interactive product contents recommendation; and, through the integration between the information agent and back-end enterprise operation system, real-time sales and inventory information can be provided so as to support activities of the retail outlets. At last, we use the RFID to improve stock replenishment efficiency and cut down on the human labor cost. Substantial research contributions are as follows:

(1) Different from the existing smart shelf that existing retailers simply use the RFID mechanism for trial purpose, this study combines the RFID and agent mechanism to meet the overall demands coming from the front-end consumers and back-end managers, thus addressing issues about shortage and replenishment and also providing consumers with the autonomous, interactive and innovative shopping activities.

(2) Through the smart shelf and interactive customer service platform, it is feasible to have real-time control over the consumer demand and product status, and it is also feasible to integrate the enterprise information systems; the system architecture will help improve the overall supply chain performance, and resolve the "bullwhip effect" of information bottleneck.

(3) Integration of the agents and intelligent service integration mechanism improves the inventory visibility of products on the shelves, and provides more accurate forecast of inventory data, which will contribute to the ensuing consumer behavior analysis and topic study.

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