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Integrated library service application platform based on the smart book shelf

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ABSTRACT

With the advent of the knowledge economy and the prevailing of the information technology, libraries are gradually introducing the automation mechanism to provide more convenient service. The time lag of the information retrieval still has influence on librarians' and readers' knowledge of the actual status of the library collections. The current practice is that the circulation record and circulation status are updated at the time when the book is borrowed or returned, with the identification component on the book or media being sensed. However, some readers use the reference books, periodicals and audio-video media in the library, therefore before the books are registered on the counter, the status of books in the library cannot be precisely confirmed, often making the information of the book shelves presented by the library database information not precisely reflecting their actual status. The "Integrated Library Service Application Platform" in this paper employs the RFID (Radio Frequency Identification) technology to construct the smart book shelf, and it is used as the trigger point for updating the retrieval status of the book to eliminate bottleneck at the counter that cannot render the real-time circulation status of book in the library upon borrowing or returning the book. With the help of software agent system to integrate the information architecture of the library and provide intelligent service applications, the overall structure is conducive in enhancing the circulation efficiency of the library collections and improving the satisfaction of readers.

Keywords: Smart Shelf; Radio Frequency Identification (RFID); Software Agent; Library operation management; Library circulation function

INTRODUCTION

The management of library operation which include various functions such as the reference interviews, reference services, acquisition and cataloguing of materials, bibliographic instruction, circulation, periodicals management and technical services among others, is becoming too complex and an automatic mechanism is required to reduce the processing time of the librarian, while enhancing the reading convenience for

readers and providing real-time information rendering of library collections. Therefore, in response to the diverse requests of library patrons, the traditional library counter operation employs hand-held bar code sensing device to read the bar code tag; however, in the case of peak time facing many book borrowings, the book borrowers have to wait in front of the circulation counter and form a long queue, while the library checkers have to scan the bar codes one-by-one and proceed with the degaussing operation for the books borrowed. This operation bottlenecks often cause library patrons to complain. In addition, the book inventory and search are often manually-operated, which, especially for a library with huge volumes of books, often cause the librarians to spend a lot of human efforts and time in book classification and arrangement.

Because the readers need more real-time feedback for the library collection information, this traditional counter-centred system architecture cannot render the status about the books or periodicals being read or browsed on the book shelves (Pitukwerakul and Promwong 2010). Therefore, the use of active identification technology to help manage the circulation of books and periodicals will effectively monitor the circulation information of these library resources (Akpınar and Kaptan 2010), and it can also be used as the basis for developing the interactive interfaces so as to enhance the value and utilization of all library media to the readers.

This paper reports the development of a smart book shelf library application that incorporates the use of the Radio Frequency Identification (RFID) technology and utilises the RFID tag as the entity-level sensing components of the library collections. This technology actively sends book information to the back-end system to help users grasp the actual status of the books on the book shelves and the circulation status of books in the library. The software agent system is the core, the integrated application service platform is constructed, and the interactive book information interface is developed so as to provide the readers with the book and media self-service environment, to increase the library user satisfaction, and also, with the support of the back-end information analysis mechanism, to create library value-added services.

The RFID Technology

The RFID technology, through the wireless sensing technology, can read more than one tag at one time; therefore it can carry diverse message contents. RFID has the read and write functions; therefore, when compared with the identification mechanism of the traditional bar code, the former has more extensive applications (Nath, Reynolds and Want 2006). The RFID has large memory capacity, so it can keep the identification numbers and attribute information of many kinds of goods, including: item code, brief description, registration date, and even brief circulation history. As for the goods inventory, the RFID has advantages such as the capability to read more than one identification tag at one time and directionless sensing, so it has better processing performance when compared with the traditional bar code. At the same time, the RFID identification system employs the reader to transmit the radio waves to the electronic tag embedded onto the object so as to facilitate the identification of target object and status information retrieval (Golding and Tennant 2007). This structure contributes to the design of active information and interactive interface (Roh, Kunnathur and Tarafdar 2009).

Besides, the software agent system integrates the network technology and artificial intelligence, and it can complete tasks assigned by the user (Chow, Choy and Lee 2007). According to the request contents of the task, its functionality and operation mode will vary, and the key attributes are mainly divided as “cooperative” and “autonomous”;

"cooperative" means that the software agent, via specific protocol, can cooperate with other agents to proceed with the task coordination or information exchange, and "autonomous" means that software agent can operate on its own without manual instructions and is able to respond to external environmental requests (Porcel, Moreno and Herrera-Viedma 2009).

THE PROBLEM AND OBJECTIVES

The automation of book borrowing and returning will be able to reduce the human effort required so that more resources can be applied to more value-added activities (Fennani and Hamam 2008). In order to reduce the waiting time for the readers spent on borrowing and returning books and to enhance the processing efficiency of librarians in the management of library collections, at present, libraries are beginning to employ RFID technology in lieu of bar codes so that the readers, through the help of automatic sensing mechanism, can save the waiting time (Coyle 2005). At the same time, through the help of RFID which supports the theft detection and book inventory, the human processing efforts of the library will be reduced (Stedman 2010).

However, the information retrievals of the traditional library occur at the register node on the library counter (Yu, Lu and Chen 2003), which cannot reflect the real-time status on the book shelf (Selamat and Majlis 2006). When analyzing the information architecture of library automation mechanism, it is known that a system is employed to register the borrowing and circulation status of books, and all information is obtained from the book records about the bibliographic codes and titles, the borrowers, borrowing dates, and the circulation status, registered by the librarian at the counter. However, after the reader gets the books from the book shelves and before (s)he goes to the counter for registration, (s)he may visit other book shelves; moreover, many readers just browse or read the books in the library. Therefore, the book information records displayed by the database will have discrepancy with the actual entity contents on the book shelves, therefore forming the so-called "information gap" phenomenon. The consequence is that when more than one reader has a common interest in a particular book or periodical, they may find out that the actual entities are not on the book shelves, and the librarians cannot immediately respond to the status either, thus causing the readers to complain of the service quality of the library.

This study aims to satisfy three purposes:

i) Employ RFID technology to construct a smart book shelf, and it is used as the trigger point to update the retrieval status of a book so as to eliminate the bottleneck at the library counter which cannot render the real-time circulation status of book upon borrowing or returning the book. The evaluation of system improvement, such as correct rate of book circulation information or efficiency of book searching in the library, can be improved 10% better than before;
ii) Make available the status of the book shelf, book and periodicals that can be completely controlled by the integrated library service application platform. The evaluation of system improvement, such as proportion of book dislocation and time required for inventory operation, can be decreased 20% less that before; and
iii) Develop a conducive system architecture that can improve the effectiveness of library operation and resolve the last-mile information bottleneck of library collections. The evaluation of system improvement, such as reader satisfaction and response time for reader service, can be improved 10% better than before.

RESEARCH METHOD

The study concerns a university library in Taiwan, which has approximately 1.5 million volumes of books, and the bar-code technology has been supported in its library automation process. The major library operations are summarised as follows:

i) Entry access control: Conventionally the bar code or magnet strip on the reader's identification card is scanned and after the identity is confirmed, the entry gate then will then be opened; however, the infrared sensor on the bar code is direction-oriented and the sensing speed of the magnetic strip must also be steady; therefore, if a readers fails to operate properly, all people waiting for admission to the library will be affected.

ii) Borrowing registration: The conventional workflow of using the bar codes to borrow books is that firstly, the reader brings the books to the circulation desk; then the librarian first uses the barcode reader to scan the library card; and after the borrower's identity is confirmed, the scanning and degaussing of books are proceeded; finally, the reader is allowed to go through the exit gate. However, the fact that only one tag for the bar code can be read at one time and the bar code is direction-oriented will often become an operation bottleneck.

iii) Borrowing and returning: The conventional workflow of returning the books is that the reader brings the books to the circulation desk or drops the books into the drop-box; the librarian scans the bar codes on the books returned one-by-one to cancel the borrowing record and further proceeds with the magnetization, which is a complicated procedure.

iv) Inventory management: As for the current library inventory, a part of the library collections are taken off the bookshelves and carried to the stacks, the bar codes are scanned one-by-one, the status of the books are recorded in the database system, and finally a batch of books are carried onto the book shelves, which is considerably time-consuming and labour-intensive.

The Problem Situation at the Case Setting

When analyzing the system mechanism and workflow of the information registration and inventory management at the case setting, it can be found that a passive mode, that is, scanning the identification tag done on the circulation counter, is employed to render the status of the library collections on the book shelves. However, the library users need more real-time and diversified response mechanisms, so the existing library system will encounter the following problems:

i) Difficulty in identifying the stock on the book shelves: The status information of actual collection contents is rendered on the book shelves before the books to be borrowed are registered at the circulation desk; however, if readers just read books in the library but not take them out of the library, the information presented by the library management system will be misleading to the users, resulting in a discrepancy between the information presented and the physical objects.

ii) Poor inventory management efficiency: The traditional inventory management employs the manual inventory method on a regular basis that is, scanning the library stock on a one-by-one basis. However, books must be individually sensed in this scanning process, which not only casts bad influence on the inventory time but also the passive sensing mode fails to effectively detect the books and periodicals misplaced on the book shelves.

iii) Difficulty in grasping the internal circulation: Traditionally, all the library collections must be registered in the library system upon the time being borrowed or returned so as to proceed with the information recording and summarization/statistics, which is

also used as the analysis basis for book utilization and reader behaviour. However, if a book is taken from the book shelf, the status that the book is circulated and read only in the library cannot be recorded. If the characteristics of user behavior, such as getting down the book for reading or reinstating the book can be stored in a database system, and then data mining technique is employed, it will be conducive to designing a library management system that cater more to the information needs and behavior of readers and librarians.

The status information about the library collections will give the readers the most straightforward impression, and from the analysis presented above, it is argued that the traditional library management system architecture cannot provide the real-time service. Therefore, to address these issues and provide integrated library service applications, the RFID entity management mechanism is used as the starting point for triggering the active information so as to eliminate the impact resulting from the information gap, and, through multiple software agent architecture, to integrate library information platforms, thus facilitating users to use self-service platform and intelligent book service applications. Besides, to quantify the system benefit, the sample data in the third quarter of 2010 is used. The RFID smart book shelves are constructed in the Chinese periodical area for the experimental group; then the traditional book shelves are also constructed in the same periodical area to acquire the data, which is used as the controlled group. Data obtained from these two groups are compared to show the indexes for reader service support and library management.

System Methodology

For the intelligent application service platform of the library, the overall system architecture is divided into three layers (Figure 1), namely:

i) First layer (System physical layer): This layer is establishes the RFID identification device and interactive smart book shelf to serve as the infrastructure for the integrated library service application platform.

ii) Second layer (Software agent layer): The mechanism of this layer is divided into two modules: front-end service and back-end application. The front-end service module supports the front-end reader's service requests, and, through the software agent, provides the reader with query about the circulation status of library collections as well as interactive self-service requests. The back-end application module provides the resources integration and pattern correlation analysis, which is used as the infrastructure for the integrated library service application platform and intelligent library analysis mechanism.

iii) Third layer (Service application layer): This layer provides the reader and librarian with the intelligent library service application so as to improve the satisfaction level of readers and the operating efficiency of bibliographic management for the librarians.

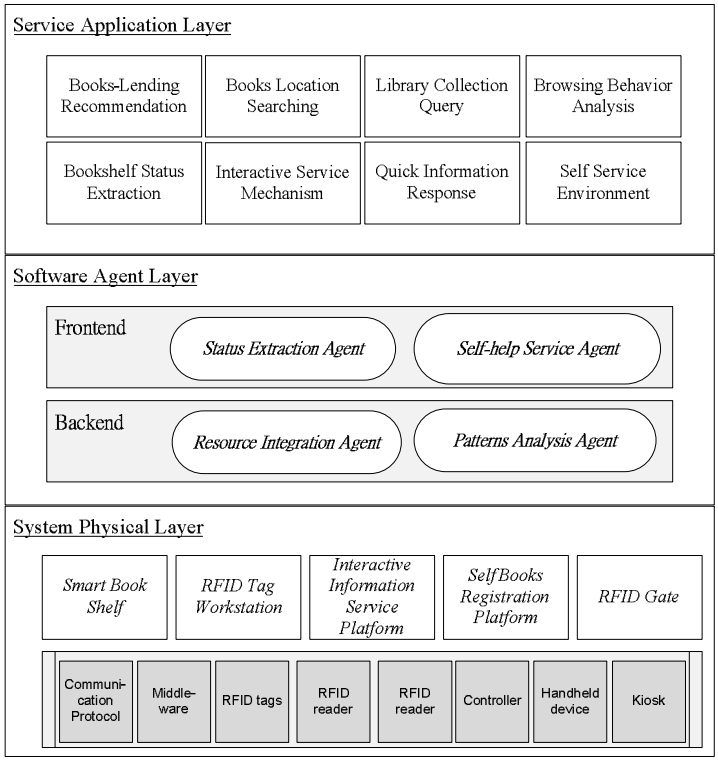


Figure 1: System Architecture for Library Smart Book Shelf

a) System Physical Layer

In response to the application requests for reader service and library management, the system physical layer of the integrated library service application platform deploys RFID-related device to serve as the mechanism for retrieving dynamic book information. The components of the system physical layer (Figure 2) are described as follows:

i) Smart book shelf: Combined with the miniaturized RFID tags and antenna, the distributed communication control interface and detection components are used to construct multi-functional smart shelves. In this way, the RFID tags attached on the individual books or periodicals can proceed with the message communication with the RFID antenna on the book shelves, and then the RFID tags serve as the interface devices triggering the status messages and retrieving information contents.

ii) RFID tag station: After the book metadata is written onto the RFID tag, the contents of the tag is loaded with the book title, author, publisher and other bibliographic information, and the tag can serve as the base component for the smart book shelf, interactive application platform and miscellaneous service agent software.

iii) Interactive information service platform: With the RFID reader equipped,

readers can use this interface to directly communicate with the books in order to query related book information; or, directly with the bibliographic indexing and with the dynamic circulation information sent from the smart book shelves, the real-time library collection status or book recommendation service can be rendered.

iv) Self-service book borrowing/returning platform: It provides readers with the ability to identify the RFID tags on the books through the RFID reader upon borrowing or returning books, which not only can be used as the interface for registering books but also as a base module for the mechanism dealing with the book correlation analysis.

v) Circulation status sensing gate: The stationary RFID reader on the electronic detecting gate is not only used in the occasion for entry access control but also for rapidly detecting and sensing the circulation status of the books to verify that the books are no longer on the original floor or in circulation.

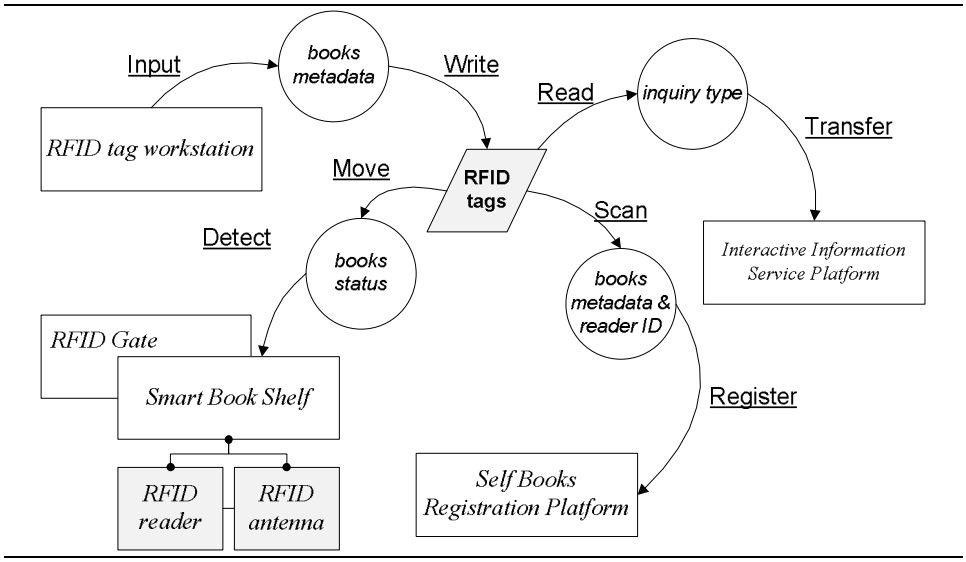


Figure 2: Components of the System Physical Layer

b) Software Agent Layer

The front-end module of the integrated library service application platform is primarily responsible for constructing the input and output environment, and the status extraction agent retrieves the status of books on the book shelves through the active triggering device to transmit the real-time information to the back-end system module. The interactive environment provided by the self-service agent is also used to communicate with the back-end library information system.

In addition to the operation resources provided by the back-end library system, the back-end software agent also constructs the integration interface and utilises the

system resources provided by the resources integration agent to improve the efficiency for bibliographic and circulation query. At the same time, to improve the performance of information retrieval, the pattern analysis agent utilises data mining technique to analyse the correlation between the bibliographic and reader service to meet the requests for book shelf analysis and book recommendations. Figure 3 presents the architecture of the software agent layer comprising four software agents.

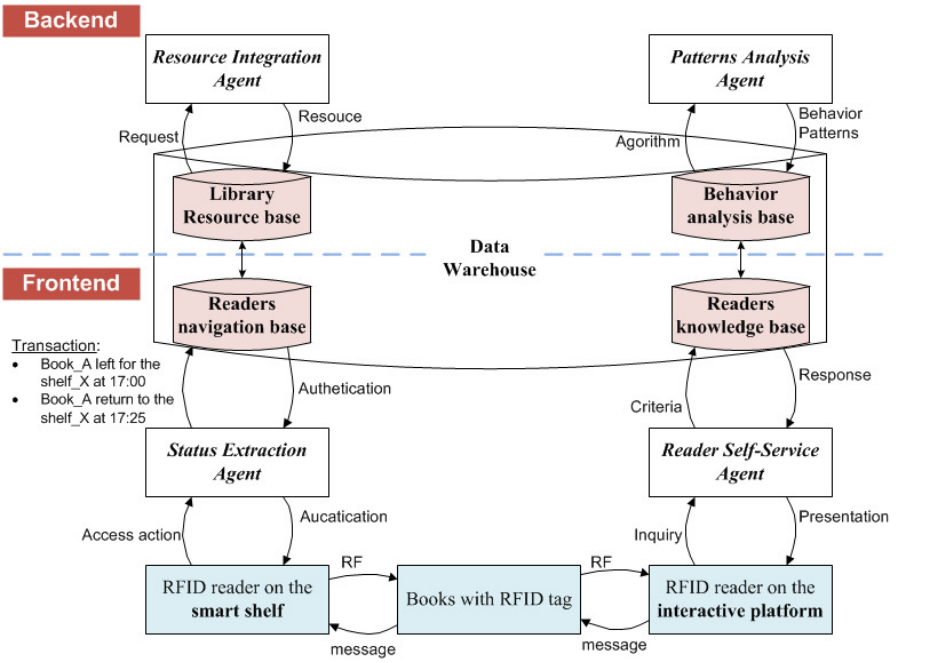


Figure 3: The Architecture of the Software Agent Layer

i) Status extraction agent: As for the workflow status of the library collections, the interaction between a reader and a book begins with getting the entity off the book shelf. After browsing the book, the reader may place the book back onto the book shelf, register at the circulation counter for borrowing out, or just read the book in the library. If the book is not registered at the circulation counter, the internal circulation status will result in the information gap. Therefore, the status extraction agent will, with the help of active detection mechanism, trigger the behaviour information of background record so as to reduce the burden and annoyance on the users and, at the same time will also transmit the real-time information on the book shelf as the base information of internal circulation.

ii) Self-service agent: In addition to borrowing and returning books, the interaction between readers and librarians also occurs in the information indexing, collection search, or even book recommendation service; however, the librarians are not always

available to provide such consultation service. Thus, the self-service agent employs the sensing device on the tag and also integrates traditional function such as borrowing/returning registration, information indexing and book shelf display so that readers can easily use the interactive platform and update information record or display information contents, which similar with the interactive service between the librarian and reader. At the same time, the self-service agent will link the data mining mechanism of the back-end platform, which, based on the input conditions, renders the associated book information, thus providing the reader with recommendations for collection borrowing.

iii) Resources integration agent: To meet the service requests coming from various library users, such as information retrieval, indexing presentation, access right management, storage sharing, and knowledge retrieval, the resources integration agent will link the book metadata and transaction records to automatically create full-text indexing and information association so as to provide the services such as bibliographic or circulation status query. At the same time, an information exchange interface is constructed, which integrates the information of the library branches to execute the inter-library resources service.

iv) Pattern analysis agent: In order to fully utilise the value of dynamic book status, the front-end status extraction agent will transmit the access status information of the books on the book shelves to the back-end for correlation analysis done by the pattern analysis agent. This judges the popularity of books on the book shelves and reader interest and shows the usage degree of library collections and book-borrowing correlation in order to provide librarians with the book procurement planning or readers with the borrowing recommendations. In order to complete the correct statistics about book reading rate, the antenna are set up in the book shelf area and book carts, and the threshold value of the book from being taken off the book shelf to being returned is also set up as the basis for counting the times of being read . In addition, information such as reader background, quantity and type of books read, entry time and frequency are also used for cross-analysis which will serve as the basis for reader's behaviour analysis.

c) Service Application Layer

The information platform constructed with the RFID smart book shelf and software agents will provide the integrated library service application (Figure 4). At the time when the books, periodicals and media are purchased, the RFID tag workstations are employed to generate the identification tags and to proceed with the bibliography and registration. When the book is placed onto the book shelf, the RFID identification device on the smart book shelf will register its original location. When the reader takes the book off the smart book shelf, the status extraction agent will be triggered. The reader, through the RFID tag on the book, communicates with the interactive information service platform, then the front-end self-service agent is linked with the back-end resources integration agent, and the response result is then rendered. The reader is also free to use the self-service borrowing and returning platform to register borrowing and returning, and at the time when the reader passes through the circulation status sensing gate, the system will automatically update the circulation information within the library. Finally, all book information can be submitted to the pattern analysis agent for further processing, and the correlation rule analysis mechanism is employed to provide the reference information.

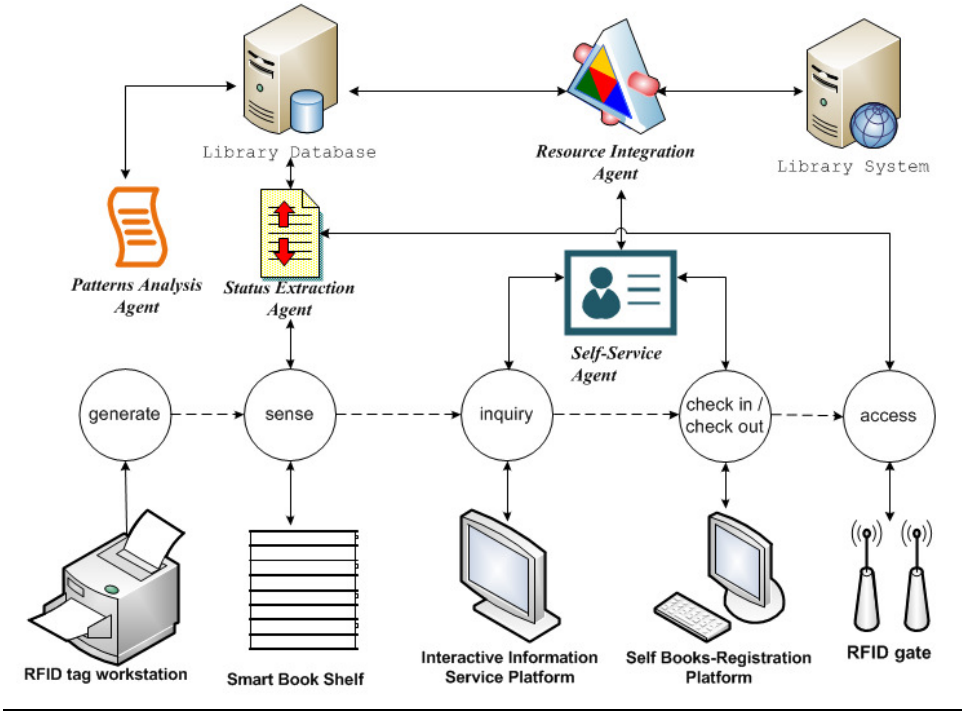


Figure 4: The Framework of Smart Shelf Based Service-Integrated Platform

SYSTEM IMPLEMENTATION AND BENEFITS EVALUATION

System Implementation

In order to eliminate the information gap resulting from getting down the book off the book shelf to registering on the circulation counter, and to enhance the user satisfaction through the integrated service platform, the use of the RFID technology and agent software architecture to implement the intelligent integrated library service application platform will enhance the library workflow automation and information transparency. Based on the system methodology comprising three layers and four software agents, the implemented system functions are described as follows:

i) Generating the identification information for individual book and periodical: The circulation process of the library collections includes data entry of a new book into the bibliography, getting the book off the book shelf for reading, borrowing/returning registration at the circulation desk and checking the book out of the library. In order to effectively proceed with identifying and recording individual book and publication in each node, it is necessary to generate the identification tag using the RFID tag workstation upon book acquisition and bibliography, and the book metadata is written to the RFID tag which is then embedded onto the book or publication so as to facilitate ensuing system

application. The information content format (which is an XML tag) of the metadata is shown in Figure 5.

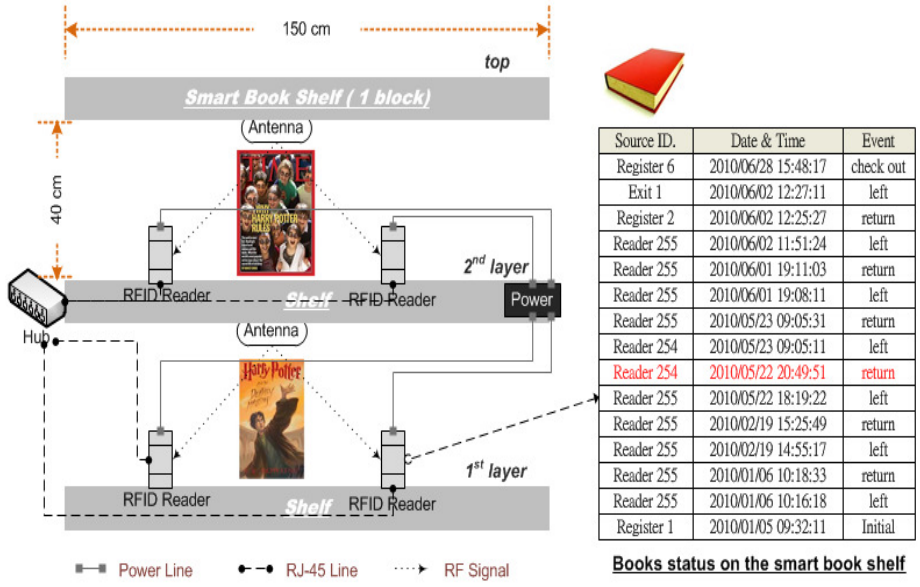
```
<?xml version="1.0"?>
<catalog>
   <book id="HD45 .H294 2010">
      <RFID_code>F416986</RFID_code>
      <author>Hossein Bidgoli</author>
      <title>The handbook of technology management. Vol. 2</title>
      <genre>Marketing and Advertising Management</genre>
      <price>1850</price>
      <publish_date>2010-04-01</publish_date>
      <description>The Handbook of Technology Management is a comprehensive
      handbook series on technology management with coverage of the core
      topics including:
      •Reference material for students, educators and practitioners in the
      management, business, .</description>
   </book>
</catalog>
```

Figure 5: A Book Metadata in XML

ii) Real-time collection of book status: In order to collect real-time information about the book status on the book shelf and reader's access behaviour, the smart book shelf employs the UHF RFID reader as the medium, and multiple antennas are also installed on the book shelf (Figure 6). At the same time, to expand the application of RFID sensing gate, the status extraction agent is developed to collect the circulation records of books on the book shelves, on the floor and in the library as the basic information for analyzing the book access, book dislocation, and circulation status (Figure 7).

iii) Presentation of the self-service model: When the reader takes the book or periodical to the RFID reader of the interactive information service platform for sensing, the interface automatically reads the contents of RFID tag and through the assistance of self-service agent, obtains services such as book search and circulation query. The reader can also use the self-service borrowing/returning platform to register and update the borrowing/returning records (Figure 8).

iv) Decision support of book application: When the book is taken down from the book shelf, sensed at the RFID gate on the floor or at the entrance, or registered at the circulation desk, the pattern analysis agent constructs correlation analysis rules of book circulation (as shown in Figure 9), to confirm the utilization of library collections and readers' characteristic behaviour which will serve as the reference information for library planning or borrowing recommendations.



Source ID.	Date & Time	Event
Register 6	2010/06/28 15:48:17	check out
Exit 1	2010/06/02 12:27:11	left
Register 2	2010/06/02 12:25:27	return
Reader 255	2010/06/02 11:51:24	left
Reader 255	2010/06/01 19:11:03	return
Reader 255	2010/06/01 19:08:11	left
Reader 255	2010/05/23 09:05:31	return
Reader 254	2010/05/23 09:05:11	left
Reader 254	2010/05/22 20:49:51	return
Reader 255	2010/05/22 18:19:22	left
Reader 255	2010/02/19 15:25:49	return
Reader 255	2010/02/19 14:55:17	left
Reader 255	2010/01/06 10:18:33	return
Reader 255	2010/01/06 10:16:18	left
Register 1	2010/01/05 09:32:11	Initial

Books status on the smart book shelf

Figure 6: The Prototype Architecture of Smart Book Shelf

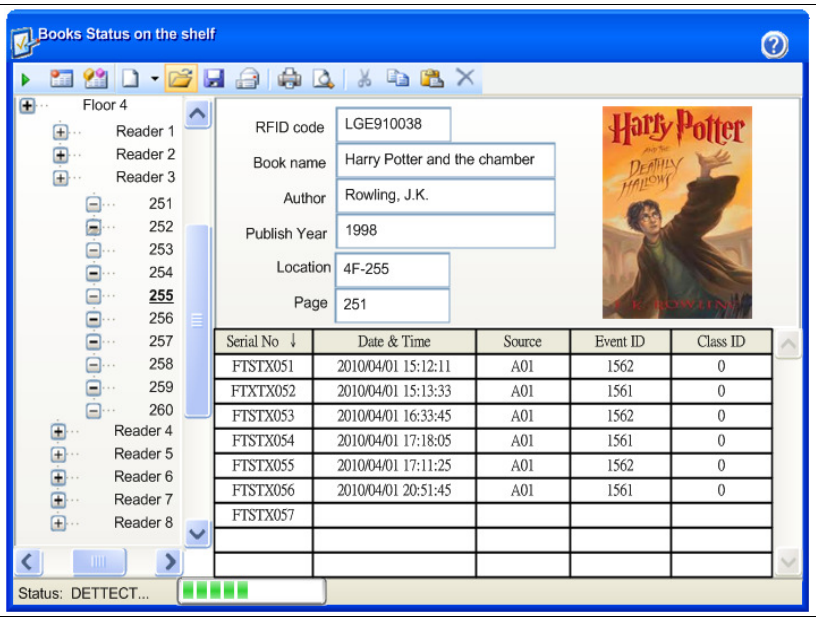


Figure 7: The Status Extraction Agent

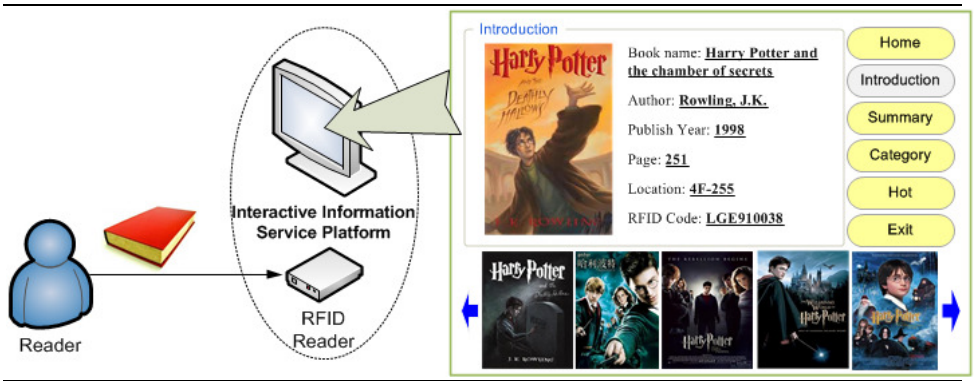


Figure 8: The Self-Service Agent

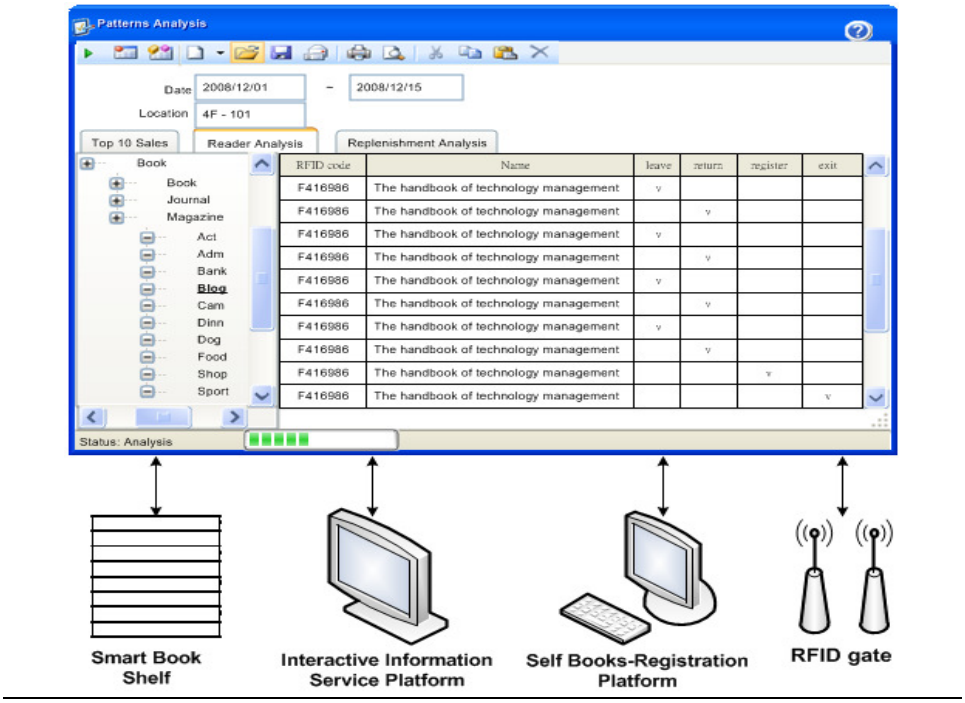
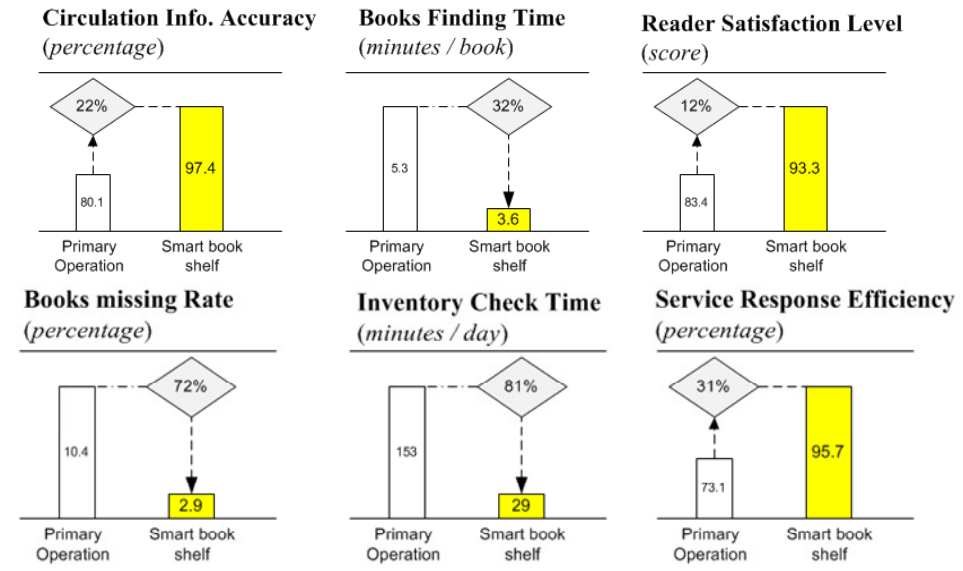


Figure 9: The Patterns Analysis Agent

Benefits Evaluation

Focusing on the library users' accessing and browsing behaviour on the book shelf, and from interaction with the librarian, the integrated library service application platform, developed from the combination of RFID technology-based smart book shelf and software agent system, will be able to render the real-time circulation status of the entities through the RFID sensing mechanism; and through the

interactive interface, communicate with the back-end system so as to improve the service quality. To measure the system benefit, the sample data (totaling 25,788 data records) in the third quarter of 2010 were used. The RFID smart book shelves were constructed in the Chinese periodical area as the experimental group. The traditional book shelves were also constructed in the same periodical area to acquire the data in the first half year of 2010, which is used as the controlled group. It was found that the integrated library service application platform constructed with the smart book shelf has significant improvement in library efficiency. Among them, in terms of reader service support, the correct rate of book circulation information, efficiency of book searching in the library, and reader satisfaction, are improved by 22%, 32% and 12% respectively. In terms of library operation, proportion of book dislocation, time required for inventory operation, and response time for reader service are also improved by 72%, 81% and 31% respectively. Figure 10 illustrates the findings.



The improvement rate % = | index of primary operation – index of smart book shelf | / index of primary operation*100%
<Example> **Books missing rate 72%** = | 10.4 – 2.9 | / 10.4*100%

Figure 10: Reports of Improving Effect

These findings infer that the integrated library service application platform constructed with the smart book shelf, when compared with the traditional library operation mode, can provide the library with more optimal information utilization and operating efficiency in terms of book shelf monitoring, book shortage, customer service, borrowing recommendations, information retrieval, inventory control and storage spaces. Table 1 compares the business processes between these two modes of library operations

Table 1: Comparison of Business Processes between Two Different Operations

Items	*Primary operation*	*Our smart book shelf platform*
Shelf monitoring	Off line	On line; detected by RFID mechanism
Books shortage	Control by human experience	On line display by the system
Customer service	Passive mode	Self-help with interactive mode
Books recommendation	Handled by experience of users	Evaluated by artificial intelligence
Information taking	Search by human and barcode	More efficiency; Retrieve with RFID
Inventory control	Control by the transaction system	Advanced a trend analysis mechanism
Storage management support	Allocation by administrator	Automatic guide by electronic system

To sum up, based on the empirical findings, the integrated library service application platform constructed with the intelligent book shelf has demonstrated the following benefits:

i) Real-time status control for the books and publications on the book shelves: After the RFID book shelf and software agent system have been constructed, several system mechanisms, such as book circulation tracking and reader's access behaviour analysis are more efficient. Moreover, the interactive service application platform can provide the self-service borrowing/returning for readers, book searching in the library, and recommendations for book borrowing, which will improve the circulation efficiency of books and periodicals and hence enhance the utilization of the library. By employing the RFID system in which the wireless identification device is embedded onto the Personal Digital Assistant (PDA), the librarian with the handheld device goes to the book shelf to sense the RFID tag, which, combined with the back-end library system, will successfully detect the book shelf.

ii) Easy control for the circulation status of books in the library: Through the linking mechanism of the smart book shelf and status extraction agent, the history about the book or publication on the book shelf, on the floor, registration on the circulation desk and at the library exit will be completely tracked, making the status of the book shelf, book and publication can be completely controlled. In addition, the status of the book onto/off the smart book shelf will be monitored through real-time communication between the resources integration agent and back-end system platform so that the circulation status of book or publication in the library is more transparent, the probability of book dislocation is reduced, and the efficiency of book searching is enhanced. By using the RFID automatic sensing device for the drop-box, the system can identify and classify books returned, and the librarian only needs to bring the books onto the book shelves so that the management and circulation efficiency of the library collections can be substantially improved.

iii) Enhancement of the library service quality and value: The interactive information service platform and self-service book borrowing/returning system constructed with the RFID device, combined with the software interface of self-service agent, will effectively provide the reader with more self-service ability to reduce the service reliance coming from the librarian. By using the RFID, multiple tags can be read at one time so that multiple book

borrowing registrations can be completed at the same time, so that the RFID system, when compared with the traditional bar code operation mode, can provide a more convenient library service and improve the overall library service quality and utilization.

CONCLUSION

Focusing on the information gap resulting from getting down the book off the book shelf to registering on the circulation counter, the combination of RFID technology and multiple software agent mechanisms can provide the practical solution while changing the static information display mode of the traditional shelf. Through the smart book shelf and interactive information service platform, the establishment of active sensing mode and self-service environment, the active sensing mode and self-service environment are established so as to facilitate the management of books getting off /onto the book shelf as well as the real-time response of the circulation information. Significant research contributions are as follows:

i) Being different from the current library which only employs the RFID technology to replace the traditional bar code on the identification application of the book, the combination of RFID technology and software agent mechanism can meet the allover requests coming from the front-end reader and back-end librarian, which literally solves the information bottlenecks about book circulation and book shelf status, as well as provide the readers with self-service and interactive service model.

ii) With the combination of smart book shelf and interactive customer service platform, it is feasible to collect real-time information about the reader's book access behaviour and the circulation status of books and publications in the library. The overall system architecture is conducive to improve the effectiveness of library operation and to resolve the last-mile information bottleneck of library collections.

iii) The RFID technology- based smart book shelf not only improves the information visibility on the book shelf, but its integrated library service platform integrated with multiple software agents also provides a systematic data analysis and recommendations, which will be conducive to the research of book browsing behaviour analysis in the future.

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