**SMART LIBRARY MANAGEMENT SYSTEM**

1. **TECHNICAL FIELD**
2. The present invention generally relates to inventory monitoring and management and particularly relates to a RFID based system and method for handling inventories in a library. The present invention more particularly relates to an automated library management system for administering the circulation of various library inventories to patrons.

1. **BACKGROUND OF THE INVENTION**
2. The major problem faced by current library management system is unavailability of books in the assigned location. Other frequent problems are books with torn pages, scratched CD and DVD disks, improper management etc. The theft of books is also an acute problem in many libraries. To prevent such misuse and problems, various methods have been employed such as barcode scanning, magnetic stripes etc. The barcode system operates on battery power and is a time consuming method. The limitations of barcode and other similar methods are overcome by RFID technology. The RFID technology is being used in many libraries across the globe but the use has widely been limited to as a substitute of bar code. The RFID technology is not utilized to full extent and potential.
3. One of the existing prior art provides an inventory control system for handling library items such as books, attached with a RFID tag. The RFID tag provides a unique ID number to the attached item. The prior art also maintains a record of the borrowed books and provides patron self-checkout system. A patron returns the borrowed library item in a book drop area. The book drop area is equipped with scanners to scan the returned book details and process the identity. The library staff stacks the returned library items from the book drop area into the designated shelf or rack. The prior art is semi-automated and requires a dedicated person for placing the returned library item in the designated shelf or rack. The system involves heavy machinery and conveying mechanisms which further incurs high cost and proper maintenance. Also, the library cannot be operated 24 hours due to requirement of constant monitoring and laborious work by a library staff for sorting the returned library item and for other security reasons. Thus, the prior art does not handle the problem caused due to misplaced library items.
4. Another prior art provides a library management system employing theft detection. The prior art provides patron self check-in/check-out, book drop section for returning the borrowed books, theft detection of un-borrowed item etc in the library. The prior art discusses a method for detecting an un-borrowed book and integrating the theft detection with a camera. The prior art does not facilitate the detection and verification of the patron borrowing an item with a stored image in the database. Also the location of the returned items are not updated in real time and requires a person to scan the shelf with a handheld RFID portable reader to find and sort the misplaced items. Sometimes the data is collected and stored in the onboard memory of the handheld RFID reader and the collected data needs to be synchronized with the central server at regular interval of time leading to time consuming process.
5. The above mentioned and other prior arts neither discuss about detecting the patron responsible for book tampering nor detecting an unauthorized ID cards used by a patron in a library. Also, the misplacement of the library item is monitored with semi-automatic means and employs humans for sorting back the returned library items.
6. Hence, there is need for a system for automatically (on-the-fly) updating the location of the misplaced library item in a central server. Also, there is a need for a system for integrating an anti-theft detection module with a camera for effective and enhanced security. Further, there is a need for a method to provide an option for a patron to write and read reviews for any desired library item. Still further, there is a need for a low cost automatic library management system to easily integrate with the existing library systems with minimal human intervention.
7. **OBJECT OF THE INVENTION**
8. The primary object of the present invention is to provide a smart library management system and method for applying RFID transponders as tags in library items and completely automating the circulation process in the library.
9. Another object of the present invention is to provide a RFID based system and method for transforming the rack/shelf of the library into a circulating section where the library items are instantly borrowed and returned by a patron.
10. Yet another object of the present invention is to provide a method for locating the desired library item in the library, logging the reviews, reading the reviews of the library item, and thereby making a user friendly library.
11. Yet another object of the present invention is to provide a security and monitoring systems networked with RFID systems and cameras to detect any malpractice inside a library.
12. Yet another object of the present invention is to provide a cost effective library management system which is easily installable in the existing libraries with improved security, surveillance and requiring minimum human intervention.
13. These and other objects and advantages of the present invention will become readily apparent from the following detailed description taken in conjunction with the accompanying drawings.
14. **SUMMARY OF THE INVENTION**
15. The various embodiments of the present invention provide a method and system for handling various inventory items in a library. The present invention is a smart library management system utilizing RFID technology. The inventory/library items (including books, magazines, CDs etc.) in the library are adhered with RFID transponders known as RFID tags. Each RFID tag includes a unique identification number (UID). A patron/user is provided with a dedicated RFID tagged ID card to be used in the library. The smart library management system comprises at least one administrator computer, at-least one search computer and at-least one master computer. The master computer is connected to the administrator computer and patron computer through a network. A library staff/administrator places library items in a sequential order based on the category of the library item. The administrator computer helps in monitoring the location of the library items placed in the rack/shelf. A RFID antenna is fixed in each compartment of the rack. The RFID antenna reads/scans the library items placed in the rack. A processor links the RFID antenna and reader to the master computer. The master computer serves as a central server and is connected to a security and monitoring systems and other sub-systems. The security and monitoring systems comprises one or more CCTV cameras. A Display screen is provided on the rack compartment for displaying the status of the circulation process (i.e. issuing library items, updating location of library item etc.) and other details. The Display screen is an indicator system which incorporates any of LEDs, LCD, TFT, etc.
16. According to one embodiment of the present invention, a plurality of passive RFID memory tags is attached to the library items. The plurality of passive RFID memory tag is encoded with a unique identification number (UID) for distinctly identifying each library item. Further, the passive RFID memory tag is encoded with separate identifying information with respect to each of the library items. The identifying information comprises an encrypted signature and/or other possible uniquely identifying data of the particular library.
17. The various embodiments of the present invention provide a method for searching any desired library item easily in the library. The method comprises: entering the search terms/ query for a desired library item inside a Form based Search Interface (FSI) in the search computer and sending the search query from FSI to the master computer through a network. Further, performing the search in the central server (database server), retrieving the search result from the central server, transferring the search result to the Search computer through the network and displaying the location of the library item in the search computer. The Search computer is linked to a master computer through a suitable wireless or wired communication network such as LAN, WAN etc.
18. According to one embodiment of the present invention, the library item is any of a textbook, magazine, journal, reports, CD, DVD, Question papers etc. The search terms, specific to the desired library item are entered in the Form based Search Interface (FSI). The search term is at-least one or combination of Title, Author, Category, ISBN, Edition, Publication etc.
19. According to one embodiment of the present invention, the smart library management system and method is applicable to other storage environments where articles/items are periodically borrowed and/or returned by different group of people.
20. According to one embodiment of the present invention, a system is provided for automatically updating the location of the library items placed in a particular rack/shelf. The automatic circulation system is a RFID based system comprising a RFID reader and an antenna fixed at appropriate position in each compartment of the rack/shelf. The RFID antenna fixed in each compartment is provided with a unique antenna number. The unique antenna number is tagged to a physical location of the compartment. The details of each RFID antenna are pre-configured in the master computer. Each RFID antenna transmits a pre-set radio frequency signals in the rack compartment, where the RFID antenna is attached. The library items affixed with the RFID tags are placed in a rack compartment mounted with RFID system. The RFID antenna detects the RFID tag of the library item and sends the detected RFID tag code to the RFID reader. The RFID reader interprets the code and forwards the code to the processor. The processor assigns/updates a location ID in the location field of the metadata corresponding to the detected RFID tag code. The central server (database server) is always updated with latest location of each and every library item.
21. According to one embodiment of the present invention, a method is provided for automatic circulation of library items to the patron. The circulation is referred to as borrowing and returning of the library item. The method comprises the steps of: scanning the ID card of the patron in the specific rack compartment where the library item is located. Further detecting and reading the ID card details by RFID antenna and reader respectively. Furthermore, informing the patron through the Display screen that the rack is ready and the patron is allowed to pick a library item. Still further, waiting for the patron to select a RFID tagged library item and sending the details of the selected and picked library item to the processor. Still further, issuing the picked library item to the patron and updating the records in the central server.
22. According to one embodiment of the present invention, the method for returning borrowed library item comprises: placing the library item in the designated compartment or any random empty compartment. The empty compartment refers to a place providing ample or free space for keeping library items. Further detecting the new location of the returned library item by the RFID antenna and reader. Furthermore, sending the scanned details of the returned library item to the central server through the processor. Still further, updating the new location ID in the location field of a metadata in the corresponding RFID tag code of the library item. Still further, setting/clearing the issue details of borrowed library item in the patron account from the central server.
23. According to one embodiment of the present invention, the patron is allowed to return an issued library item by simply placing the issued library item in a random empty rack compartment. Due to the feasibility of returning library items, the possibility of placing the library item in a first empty rack compartment instead of the original assigned location of the library item is more. The placement of library items in random rack compartment leads to mix-up of different library items in a rack compartment. The mixed up library items creates difficulty for a patron who wants to search section wise library items in the rack compartment. The returning method is improved and the difficulty is prevented by using the RFID system and integrated Display screen. When a patron places a library item in an empty rack compartment, the RFID system detects the library item and displays the actual position of the library item in the Display screen. The patron is also informed about penalties for not placing the library item at the right location through the Display screen. The patron then places the library item in the designated rack compartment which maintains the library items in categories. Depending on the requirement, a desired policy is adopted for directing patron to place the library items in the designated location.
24. According to one embodiment of the present invention, the policy for directing the patron to place the library item in the assigned location is a credit based method. A patron placing a library item in actual designated locations are awarded with a credit points and provided with more facilities such as borrowing more number of library items at once etc. If the patron places the library item in wrong location, a negative point is given to the patron and restricts the usage of library to the careless patron.
25. According to one embodiment of the present invention, the numbers of RFID antennas used in the rack are minimized by using grid arrangement. The grid arrangement is similar to matrix system wherein the RFID antennas are distributed in rows and columns of the rack. The grid arrangement minimizes the number of antennas used in a given rack. The grid arrangement assigns location of the library item in row and column order or in terms of x and y coordinates.
26. According to one embodiment of the present invention, a security and monitoring system is provided to curb malpractice by patron in the library. The security and monitoring system comprises at least one CCTV camera fixed near to the rack/shelf. The CCTV camera is coupled to the shaft of a servomotor. The servomotor is programmatically controlled and is connected to the master computer through a servo controller. A required number of CCTV cameras are used depending on the range of the camera. The patron is required to scan the ID card before picking the desired library item. Whenever a library item is removed from the rack compartment prior to scanning the ID card, the RFID system detects and sends a signal corresponding to picking of the library item to the processor. The processor receives a pickup signal corresponding to picking up of a library item. The processor receives this pickup signal prior to receiving the initial signal relating to the scanned details of patron’s ID card. The processor considers the incident as violation. Upon detecting the violation, the processor activates the alarm (audio/visual) and/or notifies to the administrator. The processor communicates with the master computer which in turn controls the CCTV camera and captures the image of the patron for security reasons.
27. According to one embodiment of the present invention, the security and monitoring system also detects and tries to verify a malicious patron. When the patron with the intention of borrowing a library item, scans the ID card in one of the rack compartment, the RFID system scans the details of the ID card and sends to the processor. The processor communicates the ID card details to the master computer. The master computer in turn controls a CCTV camera. The master computer rotates the CCTV camera to the detected/scanned ID card location. The CCTV camera captures the patron’s facial image and performs a facial recognition with a pre-stored image corresponding to the detected ID card. If the facial recognition is successful (matched), the patron is allowed to borrow the desired library item from the compartment. If the facial recognition is unsuccessful (unmatched), the administrator is notified about the incident and the patron is prevented from misusing the unauthorized ID card. In addition, the ID card is blocked to avoid any further misuse. The notification of the violation is also sent to the administrator through SMS, E-mail, alarm (audio/visual) etc.
28. According to one embodiment of the present invention, the security and monitoring system further comprises detecting the patron responsible for tampering of a library item. Consider a scenario where a patron tampers library item (such as tearing book pages, scribbling in the books etc) and places back in the rack compartment. The administrator notices the tampered library item and finds the responsible patron (defaulter) by tracking and investigating the usage log of the tampered library item. The usage log is stored in the central server. The central server provides a list of patrons borrowing the library items and also provides the usage time duration of each of the library items. By investigating the list and CCTV footage, the patron responsible for tampering the library item is tracked. Similarly, a lost/missing library item is also tracked by searching the usage log of the library item.
29. According to one embodiment of the present invention, the security and monitoring system still further comprises one or more sensor placed at the exit gate of the library. The patron carrying an issued library item walks out of the exit gate. The sensor placed at the exit gate verifies the patron as well as the carried library item. This sensor at the gate helps in cross checking the issued library items.
30. According to one embodiment of the present invention, a layered architecture of software is provided for enabling communication between the various sub-systems of the smart library. “Driver” software is used in the master computer for communicating with the RFID system (antenna and reader). The Driver software ensures that, the signals coming from various RFID systems are served with minimum latency. The Driver software produces low level signals (level 0) of the layered architecture. Level 1 software, which is above the driver software in the layered architecture, communicates with other systems such as central server (database server), search computer. “Review” software receives signals from level 1 software and fetches the reviews of a preferred library item from the central server. The “Review” of the library item is displayed on the Display screen in the racks.
31. According to one embodiment of the present invention, the RFID system software provides a graphical user interface in administrator and Search computer. The GUI is used for accessing, searching and monitoring the library items. The patron searches for desired library item through the RFID system software. The patron enters all the search details in the Form based Search Interface (FSI) of the software and conducts a search. The software displays the result and guides the patron for the desired library item through the computer interface. If the particular library item is issued to other patron, the software displays the details about the issued patron. The software also evaluates and summarizes the information of the particular patrons accessing the library items and creates a usage statistics of library items. The software also provides reviews of the library item to the patron.
32. According to one embodiment of the present invention, the layered architecture software, system components and other sub systems etc. are provided in a single entity. The layered architecture software, system and sub system components are also provided as separate physical machines interconnected through a network.
33. According to one embodiment of the present invention, the smart library management system provides an efficient and minimal cost RFID based solution requiring minimal change in the existing libraries. Also the installation of smart library management system provides refinement and easy upgrading options at later time.
34. These and other aspects of the embodiments herein will be better appreciated and understood when considered in conjunction with the following description and the accompanying drawings. It should be understood, however, that the following descriptions, while indicating preferred embodiments and numerous specific details thereof, are given by way of illustration and not of limitation. Many changes and modifications may be made within the scope of the embodiments herein without departing from the spirit thereof, and the embodiments herein include all such modifications.
35. **BRIEF DESCRIPTION OF THE DRAWINGS**
36. The other objects, features and advantages will occur to those skilled in the art from the following description of the preferred embodiment and the accompanying drawings in which:
37. **FIG. 1** is a block diagram illustrating the smart library management system, according to one embodiment of the present invention.
38. **FIG. 2** is a flow diagram illustrating the operations performed by an administrator computer, according to one embodiment of the present invention.
39. **FIG. 3** illustrates operations performed by an administrator through the administrator computer, according to one embodiment of the present invention.
40. **FIG. 4** is a flow chart illustrating automatic (on-the-fly) issue of a library item to a patron inside a library, according to one embodiment of the present invention.
41. **FIG. 5** is a flow chart illustrating automatic (on-the-fly) return of a borrowed library item by a patron, according to one embodiment of the present invention.
42. **FIG. 6** is a flow chart illustrating the process of verifying a patron by a CCTV camera, according to one embodiment of the present invention.
43. **FIG. 7** is an illustration of Graphical User Interface of the software for searching a library item, according to one embodiment of the present invention.
44. **FIG. 8** illustrates a Graphical User Interface (GUI), describing the details of scanned ID card of a patron, according to one embodiment of the present invention.
45. **FIG. 9** is aGraphical User Interface illustrating a process of monitoring a library item issued to a patron through the administrator computer, according to one embodiment of the present invention.
46. **FIG. 10** is a Graphical User Interface illustrating the process of alerting the administrator regarding a violation by a patron, according to one embodiment of the present invention.
47. **FIG. 11** illustrates a simplified block diagram of the smart library management system, according to one embodiment of the present invention.
48. **FIG. 12** illustrates a grid arrangement of the RFID antennas on the rack, according to one embodiment of the present invention.
49. **FIG. 13** is a central server illustrating the process of storing the details of the library item issued to a patron, according to one embodiment of the present invention.
50. **FIG. 14** illustrates an updated central server, after placing library items in one of the rack compartment, according to one embodiment of the present invention.
51. Although the specific features of the present invention are shown in some drawings and not in others. This is done for convenience only as each feature may be combined with any or all of the other features in accordance with the present invention.
52. **DETAILED DESCRIPTION OF THE INVENTION**
53. In the following detailed description, reference is made to the accompanying drawings that form a part hereof, and in which the specific embodiments that may be practiced is shown by way of illustration. These embodiments are described in sufficient detail to enable those skilled in the art to practice the embodiments and it is to be understood that the logical, mechanical and other changes may be made without departing from the scope of the embodiments. The following detailed description is therefore not to be taken in a limiting sense.
54. The various embodiments of the present invention provide a method and system for handling various inventory items in a library. The present invention is a smart library management system utilizing RFID technology. The inventory/library items (including books, magazines, CDs etc.) in the library are adhered with RFID transponders known as RFID tags. Each RFID tag includes a unique identification number (UID). A patron/user is provided with a dedicated RFID tagged ID card to be used in the library. The smart library management system comprises at least one administrator computer, at-least one search computer and at-least one master computer. The master computer is connected to the administrator computer and patron computer through a network. A library staff/administrator places library items in a sequential order based on the category of the library item. The administrator computer helps in monitoring the location of the library items placed in the rack/shelf. A RFID antenna is fixed in each compartment of the rack. The RFID antenna reads/scans the library items placed in the rack. A processor links the RFID antenna and reader to the master computer. The master computer serves as a central server and is connected to a security and monitoring systems and other sub-systems. The security and monitoring systems comprises one or more CCTV cameras. A Display screen is provided on the rack compartment for displaying the status of the circulation process (i.e. issuing library items, updating location of library item etc.) and other details. The Display screen is an indicator system which incorporates any of LEDs, LCD, TFT, etc. for display.
55. According to one embodiment of the present invention, a plurality of passive RFID memory tags is attached to the library items. The plurality of passive RFID memory tag is encoded with a unique identification number (UID) for distinctly identifying each library item. Further, the passive RFID memory tag is encoded with separate identifying information with respect to each of the library items. The identifying information comprises an encrypted signature and/or other possible uniquely identifying data of the particular library.
56. The various embodiments of the present invention provide a method for searching any desired library item easily in the library. The method comprises: entering the search terms/ query for a desired library item inside a Form based Search Interface (FSI) in the search computer and sending the search query from FSI to the master computer through a network. Further, performing the search in the central server (database server), retrieving the search result from the central server, transferring the search result to the Search computer through the network and displaying the location of the library item in the search computer. The Search computer is linked to a master computer through a suitable wireless or wired communication network such as LAN, WAN etc.
57. According to one embodiment of the present invention, the library item is any of a textbook, magazine, journal, reports, CD, DVD, Question papers etc. The search terms, specific to the desired library item are entered in the Form based Search Interface (FSI). The search term is at-least one or combination of Title, Author, Category, ISBN, Edition, Publication etc.
58. According to one embodiment of the present invention, the smart library management system and method is applicable to other storage environments where articles/items are periodically borrowed and/or returned by different group of people.
59. According to one embodiment of the present invention, a system is provided for automatically updating the location of the library items placed in a particular rack/shelf. The automatic circulation system is a RFID based system comprising a RFID reader and an antenna fixed at appropriate position in each compartment of the rack/shelf. The RFID antenna fixed in each compartment is provided with a unique antenna number. The unique antenna number is tagged to a physical location of the compartment. The details of each RFID antenna are pre-configured in the master computer. Each RFID antenna transmits a pre-set radio frequency signals in the rack compartment, where the RFID antenna is attached. The library items affixed with the RFID tags are placed in a rack compartment mounted with RFID system. The RFID antenna detects the RFID tag of the library item and sends the detected RFID tag code to the RFID reader. The RFID reader interprets the code and forwards the code to the processor. The processor assigns/updates a location ID in the location field of the metadata corresponding to the detected RFID tag code. The central server (database server) is always updated with latest location of each and every library item.
60. According to one embodiment of the present invention, a method is provided for automatic circulation of library items to the patron. The circulation is referred to as borrowing and returning of the library item. The method comprises the steps of: scanning the ID card of the patron in the specific rack compartment where the library item is located. Further detecting and reading the ID card details by RFID antenna and reader respectively. Furthermore, informing the patron through the Display screen that the rack is ready and the patron is allowed to pick a library item. Still further, waiting for the patron to select a RFID tagged library item and sending the details of the selected and picked library item to the processor. Still further, issuing the picked library item to the patron and updating the records in the central server.
61. According to one embodiment of the present invention, the method for returning borrowed library item comprises: placing the library item in the designated compartment or any random empty compartment. The empty compartment refers to a place providing ample or free space for keeping library items. Further detecting the new location of the returned library item by the RFID antenna and reader. Furthermore, sending the scanned details of the returned library item to the central server through the processor. Still further, updating the new location ID in the location field of a metadata in the corresponding RFID tag code of the library item. Still further, setting/clearing the issue details of borrowed library item in the patron account from the central server.
62. According to one embodiment of the present invention, the patron is allowed to return an issued library item by simply placing the issued library item in a random empty rack compartment. Due to the feasibility of returning library items, the possibility of placing the library item in a first empty rack compartment instead of the original assigned location of the library item is more. The placement of library items in random rack compartment leads to mix-up of different library items in a rack compartment. The mixed up library items creates difficulty for a patron who wants to search section wise library items in the rack compartment. The returning method is improved and the difficulty is prevented by using the RFID system and integrated Display screen. When a patron places a library item in an empty rack compartment, the RFID system detects the library item and displays the actual position of the library item in the Display screen. The patron is also informed about penalties for not placing the library item at the right location, through the Display screen. The patron then places the library item in the designated rack compartment which maintains the library items in categories. Depending on the requirement, a desired policy is adopted for directing patron to place the library items in the designated location.
63. According to one embodiment of the present invention, the policy for directing the patron to place the library item in the assigned location is a credit based method. A patron placing a library item in actual designated locations are awarded with a credit points and provided with more facilities such as borrowing more number of library items at once etc. If the patron places the library item in wrong location, a negative point is given to the patron and restricts the usage of library to the careless patron.
64. According to one embodiment of the present invention, the numbers of RFID antennas used in the rack are minimized by using grid arrangement. The grid arrangement is similar to matrix system wherein the RFID antennas are distributed in rows and columns of the rack. The grid arrangement minimizes the number of antennas used in a given rack. The grid arrangement assigns location of the library item in row and column order or in terms of x and y coordinates.
65. According to one embodiment of the present invention, a security and monitoring system is provided to curb malpractice by patron in the library. The security and monitoring system comprises at least one CCTV camera fixed near to the rack/shelf. The CCTV camera is coupled to the shaft of a servomotor. The servomotor is programmatically controlled and is connected to the master computer through a servo controller. A required number of CCTV cameras are used depending on the range of the camera. The patron is required to scan the ID card before picking the desired library item. Whenever a library item is removed from the rack compartment prior to scanning the ID card, the RFID system detects and sends a signal corresponding to picking of the library item to the processor. The processor receives a pickup signal corresponding to picking up of a library item. The processor receives this pickup signal prior to receiving the initial signal relating to the scanned details of patron’s ID card. The processor considers the incident as violation. Upon detecting the violation, the processor activates the alarm (audio/visual) and/or notifies to the administrator. The processor communicates with the master computer which in turn controls the CCTV camera and captures the image of the patron for security reasons.
66. According to one embodiment of the present invention, the security and monitoring system also detects and tries to verify a malicious patron. When the patron with the intention of borrowing a library item, scans the ID card in one of the rack compartment, the RFID system scans the details of the ID card and sends to the processor. The processor communicates the ID card details to the master computer. The master computer in turn controls a CCTV camera. The master computer rotates the CCTV camera to the detected/scanned ID card location. The CCTV camera captures the patron’s facial image and performs a facial recognition with a pre-stored image corresponding to the detected ID card. If the facial recognition is successful (matched), the patron is allowed to borrow the desired library item from the compartment. If the facial recognition is unsuccessful (unmatched), the administrator is notified about the incident and the patron is prevented from misusing the unauthorized ID card. In addition, the ID card is blocked to avoid any further misuse. The notification of the violation is also sent to the administrator through SMS, E-mail, alarm (audio/visual) etc.
67. According to one embodiment of the present invention, the security and monitoring system further comprises detecting the patron responsible for tampering of a library item. Consider a scenario where a patron tampers library item (such as tearing book pages, scribbling in the books etc) and places back in the rack compartment. The administrator notices the tampered library item and finds the responsible patron (defaulter) by tracking and investigating the usage log of the tampered library item. The usage log is stored in the central server. The central server provides a list of patrons borrowing the library items and also provides the usage time duration of each of the library items. By investigating the list and CCTV footage, the patron responsible for tampering the library item is tracked. Similarly, a lost/missing library item is also tracked by searching the usage log of the library item.
68. According to one embodiment of the present invention, the security and monitoring system still further comprises one or more sensor placed at the exit gate of the library. The patron carrying an issued library item walks out of the exit gate. The sensor placed at the exit gate verifies the patron as well as the carried library item. This sensor at the gate helps in cross checking the issued library items.
69. According to one embodiment of the present invention, a layered architecture of software is provided for enabling communication between the various sub-systems of the smart library. “Driver” software is used in the master computer for communicating with the RFID system (antenna and reader). The Driver software ensures that, the signals coming from various RFID systems are served with minimum latency. The Driver software produces low level signals (level 0) of the layered architecture. Level 1 software, which is above the driver software in the layered architecture, communicates with other systems such as central server (database server), search computer. “Review” software receives signals from level 1 software and fetches the reviews of a preferred library item from the central server. The “Review” of the library item is displayed on the Display screen in the racks.
70. According to one embodiment of the present invention, the RFID system software provides a graphical user interface in administrator and Search computer. The GUI is used for accessing, searching and monitoring the library items. The patron searches for desired library item through the RFID system software. The patron enters all the search details in the Form based Search Interface (FSI) of the software and conducts a search. The software displays the result and guides the patron for the desired library item through the computer interface. If the particular library item is issued to other patron, the software displays the details about the issued patron. The software also evaluates and summarizes the information of the particular patrons accessing the library items and creates a usage statistics of library items. The software also provides reviews of the library item to the patron.
71. According to one embodiment of the present invention, the layered architecture software, system components and other sub systems etc. are provided in a single entity. The layered architecture software, system and sub system components are also provided as separate physical machines interconnected through a network.
72. According to one embodiment of the present invention, the smart library management system provides an efficient and minimal cost RFID based solution requiring minimal change in the existing libraries. Also the installation of smart library management system provides refinement and easy upgrading options at later time.
73. **FIG. 1** is a block diagram illustrating the smart library management system, according to one embodiment of the present invention. The smart library management system comprises a plurality of racks for storing various library items. With respect to **FIG. 1,** the two rack compartments 103 and 111 are of two random racks of the library. The library items 104 comprise textbooks, magazines, disks, etc. which are kept in the rack compartment 103. All the library items 104 are affixed with a RFID transponder (hereby known as RFID tag). The RFID tag provides a distinct identification to the attached library item 104 and also stores specific information relating to the library item 104. The rack compartment 103 is mounted with an RFID antenna 105 at a suitable position. The RFID antenna 105 transmits radio signals of predefined frequency and range depending on the rack compartment area 103 and 111. The range of the radio signals from the RFID antennas 105 and 112 is altered as per requirement. Also each RFID antenna 105 mounted on rack compartments in the library is assigned with a unique antenna number. The unique antenna number is provided for identification purpose and is thus tagged to each physical location or rack compartment 103 of the rack. So the active RFID antenna 105 is identified by the unique antenna number and also locates the place of circulation (borrowing or returning) of the library item 104. The RFID antenna 105 detects the RFID tag of a particular library item 104 inserted or placed in the rack compartment 103 and sends the detected RFID tag code along with unique antenna number to a RFID reader1 (106). The RFID reader1 (106) interprets the received data and transfers the decoded information to a processor 108. The processor 108 feeds the received data in a master computer 109. The master computer 109 comprises a central server providing remote access to the stored information by the administrator and/or authorized person. At least one CCTV camera 101 is provided in the library premise for surveillance. The CCTV camera 101 is multipurpose camera used for surveillance and face recognition. The CCTV camera 101 is connected to the shaft of a servo motor. The servo motor is in turn connected to the servo controller 107. The servo controller 107 is programmable and is controlled by the master computer 109. One of the applications of the CCTV camera 101 is during the time of circulating library items 104. When a patron wants to borrow a library item 104, the patron scans the ID card in the rack compartment 103. The scanning of the ID card activates the servo-controller 107. Based on a pre-installed algorithm, the servo-controller 107 rotates the servomotor to the detected location of scanned ID card. The CCTV camera 101 is coupled to the servomotor and hence is also rotated to the location. The CCTV camera 101 then captures the image of the patron for acquiring additional authorization information. Optionally, a facial recognition is conducted on the patron for authorization. In another case, when the patron picks a library item 104 from any rack compartment 103 and 111 before scanning the ID card, the CCTV camera 101 rotates to the incident and captures the image of the patron.
74. Similarly, a rack compartment 111 is mounted with RFID antenna 113 which in turn is connected to RFID reader2 (113). The RFID reader2 (113) is connected to the processor 108 for communicating with the master computer 109. The processor 108 is either a single processor, to which all the other RFID readers are linked or independent processor for each RFID reader. The connection between the processor and RFID system is established as per the requirement and feasibility. The administrator monitors the activities within the library with the help of an administrator computer 102. A Search computer 114 for patrons is provided in the library to search the location of the desired library items for borrowing or reading purpose. The administrator computer 102 and the Search computer 114 are interfaced with the master computer 109 through a suitable wired or wireless network 110.
75. **FIG. 2** is a flow diagram of operations performed by an administrator computer, according to one embodiment of the present invention. An administrator computer 102 is provided for monitoring the activities within the library. The administrator computer 102 is always in communication link with a master computer. Whenever a violation is detected such as improper borrowing of library item, use of other’s ID card etc, a notification is sent to the administrator computer as a network message. The network message 201 contains the details about the location of the book 203 and is stored inside the central server as a log (202). The network message 201 is also sent to the administrator as notification in terms of SMS, emails, audio/video alerts etc. The network message 201 is processed by the administrator computer 102. Based on the status of ID card scanned or not, the administrator computer 102 initiates one of the two algorithms (205). One algorithm tries to verify the identity of the patron by face detection and recognition process based on the scanned ID card (207). Even if the face detection is not very accurate, a list of users (along with the photos) with matching faces is displayed in the administrator computer, whom the administrator looks and find manually by analyzing at the CCTV footage. In case the patron does not scan the ID card, the second algorithm alerts the administrator by an audio/visual message along with the specific location of the violation (206). A CCTV camera rotates to the incident automatically and captures the image or the CCTV camera is manually rotated by the administrator to the desired location (204).
76. **FIG. 3** illustrates operations performed by an administrator through the administrator computer, according to one embodiment of the present invention. The administrator enters the library and initiates the smart library management system (301). The administrator log-in in the administrator computer (302). Upon successful log-in, an administrator window is displayed on the administrator computer screen. If the login is unsuccessful, an error message is displayed on the administrator computer screen and redirects the administrator to the login page (305). After successful login, the administrator is provided with various selectable options (304). The selectable options comprises a “add library item” for adding a newly arrived library item in the inventory or stock (307), a “Change details” option for modifying/changing any detail of the library item (308) and a “Delete library item” for removing any invalid/old or obsolete library item from the central server (309). The selectable options further comprises an “Add new sensor” option for adding new RFID tags, antennas and readers in the smart library management system (310), a “Delete sensor” option for deleting the details of nonfunctional, improper, tampered RFID based systems from the central database (311) and a “Manage patrons” option for renewing memberships, addition of patron, calculating the fine etc for the patron (312). After performing any one of the above mentioned options, the administrator validates the changes (313). The validated change is reflected in the central server and the administrator computer again provides choices of repeating the selectable options to the administrator (314). If “yes”, the various selectable options are again displayed to the administrator. If “No” the administrator logs out (315).
77. **FIG. 4** is a flow chart illustrating automatic (on-the-fly) issue of a library item to a patron inside a library, according to one embodiment of the present invention. The smart library management system is initialized by the administrator prior to use by any patron (401). The patron enters the library for borrowing a library item (402). The patron uses a Search computer installed with the software for searching/locating the desired library item. The patron fills the Form based Search Interface (FSI) by entering the possible details of the desired library item such as title, author etc. for locating a book, discs etc (403). The software in the Search computer performs a search in the central server (database server) and displays all possible library items with corresponding location. The patron obtains the location of the desired library item and visits the location (404). The patron scans the ID card in the compartment where the library item is located. The RFID antenna and reader detects the ID card of the patron and sends the ID card information to the master computer via a processor (405). The Display screen indicates the patron to pick a library item. The patron picks a desired library item, which activates the CCTV camera. The master computer controls the CCTV camera and captures the image of the patron. Optionally, the face recognition is carried on the captured image of the patron. After successful verification, the patron picks up the desired library item from the rack compartment (407). Once the patron picks up the library item, the RFID antenna mounted on the rack detects the removal of the library item (in turn detects the removal of attached RFID tag) and sends the information to the master computer through the RFID reader and the processor. The master computer updates the library item RFID code in the patron account and issues the library item to the patron. The patron either repeats the process or exits from the library (409).
78. With respect to **FIG. 4,** if the patron directly picks the library item before scanning the ID card, the RFID antenna detects the removal of a library item and sends the detected signal to the processor though the RFID reader (406). The processor receives a pickup signal corresponding to the removal of the library item. The pickup signal is received prior to receiving the mandatory initial signal relating to the scanned ID card of the patron. The processor regards the action as a violation. An interrupt is generated by the processor for notifying the master computer about the violation by the patron. The master computer rotates/positions the CCTV camera to the location of the incident. The CCTV camera captures the patron’s image (408). Also a message is sent to the administrator over a communication channel regarding the violation (410). If there are any disturbances in patron identification process, the face detection algorithm provides all matching faces to the administrator for finding out the malicious patron.
79. **FIG. 5** is a flow chart illustrating automatic (on-the-fly) return of a borrowed library item by a patron, according to one embodiment of the present invention. The smart library management system is initialized inside the library (501). A patron with a borrowed library item enters inside the library (502). The patron searches for a rack with empty space in a rack compartment. The patron places the library item inside a suitable empty rack compartment (503). As soon as the patron places the borrowed library item inside the rack compartment, the RFID antenna detects the RFID tag attached of the library item and sends to the RFID reader. The RFID reader interprets the code and sends the interpreted code to the processor. The processor in turn communicates with the master computer and captures the image of the patron as additional information (504). Once the library item is placed inside the rack compartment, the central server updates the location in the metadata of the corresponding RFID tag code. The patron exits from the library (505).
80. **FIG. 6** is a process flow chart for verifying a patron by a CCTV camera, according to one embodiment of the present invention. The CCTV camera is activated whenever a violation such as picking a library item without scanning the ID card, using a false ID card etc. is detected. The CCTV camera rotates/ positions to the location of the violation automatically. Alternately, the administrator manually rotates/ positions the CCTV camera by controlling the servo motor (601). The CCTV camera captures the image of the patron and performs facial detection. The facial detection is performed by using an algorithm based on Haar principle or other method (602). The facial detection 605 is performed by comparing the captured image 603 and actual image 604 of the patron. The actual image 604 of the patron is pre-stored in the central database corresponding to the ID card of the patron. If the actual image and the captured image of the patron is different (or false), an alarm is activated either audio or visual to the administrator (606) is notified. If the actual image and the captured image of the patron is same (or true), the patron is authorized for further actions (607).
81. **FIG. 7** is an illustration of Graphical User Interface of the software for searching a library item, according to one embodiment of the present invention. The smart library management system comprises a Search computer for patrons for searching the location of a library item. The Search computer is installed with software for carrying out library item search. The software provides a Graphical User Interface (GUI) 701 with a Form based Search Interface (FSI). The FSI is an input field for entering the search terms such as Title, Author, ISBN, Publisher, Code of Subject etc for searching a particular library item (702). The patron selects the “Search” button after entering the search terms. The software communicates with the central server. The central server receives data from the FSI and executes a search query for searching within the database. The results of the search are displayed in the list box 703 (or any suitable table-like interface for displaying details of multiple items found for that search criteria). The List box 703 displays the location of the library item along with other details such as unique identification (UID) number of the library item, Title, Author, etc.
82. **FIG. 8** illustrates a Graphical User Interface (GUI), describing the details of scanned ID card of a patron, according to one embodiment of the present invention. The patron visits a particular rack of library items after searching for the desired library item in the Search computer. The patron scans the ID card in the rack compartment. The RFID antenna detects the ID card details and sends the information to the RFID reader. The RFID reader interprets the details and forwards to the master computer through the processor. The master computer fetches the stored information from the central server (database server) and displays the patron information on the Display screen. Upon, picking a desired library item, the library item is issued to the patron. In case of any malpractice, the administrator is notified instantly. The GUI 701 displays UID of the ID card, Name, Roll number, library items issued etc. Once the patron is authorized, the GUI displays a dialogue box 802 displaying “Pick a desired library item” (This indication also appears on the Display screen). The patron picks the library item from the particular rack and same is updated in the central server corresponding to the metadata of patron’s ID card UID.
83. **FIG. 9** is aGraphical User Interface illustrating a process of monitoring a library item issued to a patron through the administrator computer, according to one embodiment of the present invention. The patron is authenticated before borrowing a library item form the rack compartment. After successful authentication, the patron picks the library item from the rack compartment. The RFID antenna detects the removal of a library item from the rack and the RFID reader sends the interpreted code to the processor. The processor sends the code to the master computer and updates the patron’s account in the central server. A dialogue box 902 is also displayed with a message indicating the issuance of the selected library item with the UID of the library item. The same message is displayed in the Display screen.
84. **FIG. 10** illustrates a Graphical User Interface alerting the administrator regarding a violation by a patron, according to one embodiment of the present invention. A patron visits a rack compartment for borrowing a desired library item. The patron accidently or intentionally picks the library item from the rack compartment before scanning the ID card. The processor receives a signal relating to the picking of a library item before receiving an initial signal of the scanned patron’s ID card. The incident is regarded as violation and the processor alerts the administrator by an alarm signal (audio/visual). The GUI 701 activates a dialogue box 1002 displaying “Alarm”. A dialogue box 1002 is displayed alarming the administrator and indicating the location of violation. In another case, the patron scans the ID card in the rack compartment. A CCTV camera rotates/ positions to the location of scanned ID card and performs the facial recognition. If the captured image and the pre-stored image of the patron do not match, the administrator is notified by activating the alarm. The administrator is also notified visually through a dialogue box 1002 or by an indicating light placed in different section of the library or in the administrator’s cabin etc.
85. **FIG. 11** illustrates a simplified block diagram of the smart library management system, according to one embodiment of the present invention. A patron enters inside a library installed with smart library management system (1105). The patron is any of a student, lecturer, staff etc (1101). The library items are placed in the rack compartment. The smart library management system incorporates a Search computer for allowing the patron to search a desired library item. The Search computer act as a location directing system to the patron. The Search computer displays the location of the library item textually or graphically (1102). The rack compartment is mounted with RFID system consisting of RFID antenna and RFID reader. The RFID antenna detects the presence and removal of the library item from the rack compartment. The RFID reader interprets the detected code and forwards to a processor. The processor is either a single centralized processor or individually connected to each RFID system. The processor is connected to the master computer (1103). The master computer is connected to security and monitoring system comprising alarm and CCTV cameras and other sub-systems. Any violation detected inside the library is notified to the administrator by the security system (1104).
86. **FIG. 12** illustrates a grid arrangement of the RFID antennas on the rack, according to one embodiment of the present invention. A RFID antenna is mounted on each of the rack compartment for monitoring the circulation of the library items. With respect to **FIG. 12,** a rack 1204 is shown with eight rack compartments 1203. The RFID antennas 1202 and 1201 are arranged in a way to form a grid. The grid arrangement is similar to rows and columns of a matrix and similar to the coordinate axes. An antenna 1201 is mounted vertically over the top of the rack compartment 1203. An antenna 1202 is mounted laterally to the rack compartments 1203. The location of the library item is recorded by the corresponding vertical 1201 and lateral 1202 antennas. The grid arrangement of the antennas reduces the number of antennas used in a given rack and also provides an accurate method of assigning location to the library items.
87. **FIG. 13** illustrates a central server for storing the details (history) of the library item issued to a patron, according to one embodiment of the present invention. The central server stores the patron’s ID card under “User\_UID” (UID) 1302 column. The details of the library items borrowed by the patron are recorded under a column “Book\_UID” 1303. The date and timing of borrowing the library item is updated under a column “Time” 1304. The borrowing location of the library item (where the borrowable item was located before picking) is updated in the central server under the column “Last\_location” 1305. The central server also provides various options 1301 to the administrator for correcting any errors. The “Options” 1301 includes “Edit”, “Copy”, “Delete”, “Selecting all the entries at once”, “Print”, “Display the usage in graphs”, “Exporting the details to different location” etc. The issue details of the patron are obtained by selecting a section “Issue\_history” 1306.
88. **FIG. 14** illustrates an updated central server, after placing a library item in one of the rack compartment, according to one embodiment of the present invention. A patron returns a borrowed library item by placing the library item in an empty rack compartment. Based on the detected RFID tag of the returned library item, the RFID system updates the new location of the returned library item in the central server. When the patron picks a library item from a rack, the location field in the central server changes to ISSUED, so that when another patron searches the book the status of the book is shown as ISSUED. The details of the returned library item are viewed under the section “book” 1405**.** On selecting the section “book” 1405, the details of the library item such as UID 1303, Name 1401, Authors 1402, Publisher 1403, new location 1404 etc. are displayed. The “Option” 1301 provides several actions like “Change”, “Edit”, “Copy”, “Delete”, etc for altering the records as per requirement to the administrator.
89. The foregoing description of the specific embodiments will so fully reveal the general nature of the embodiments herein that others can, by applying current knowledge, readily modify and/or adapt for various applications such specific embodiments without departing from the generic concept, and, therefore, such adaptations and modifications should and are intended to be comprehended within the meaning and range of equivalents of the disclosed embodiments. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

**ABSTRACT**

The various embodiments of the present invention relates to a method and system for handling various inventory items in a library utilizing RFID technology. The library items (books, magazines etc.) are affixed with RFID tags providing a unique identification number to each library item. A patron/user is provided with a RFID tagged ID card to be used in the library. A RFID antenna is fixed in each compartment for scanning/reading library items placed in the rack. An administrator computer helps in monitoring the overall working of library (issuing the library items, security, etc.). A master computer is connected to the administrator and search computer through a network. A processor links the RFID antennas and readers to the master computer. The master computer serves as a central server (database server) and is connected to security and monitoring systems and other sub-systems. The status of circulation is displayed in a Display screen.

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**1/14**

**Administrator Computer**

**Search Computer**

**Network**

**Servo controller**

**Reader 1**

**Reader 2**

**Antenna 1**

**Antenna 2**

**Processor**

**Master**

**Computer**

**102**

**101**

**103**

**105**

**106**

**107**

**108**

**109**

**110**

**104**

**111**

**104**

**112**

**113**

**114**

**FIG. 1**

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**Administrator computer**

**Central Server**

**The user scans ID card**

**No**

**Yes**

**System alerts Administrator through audio or visual message about the location**

**Face Detection according to ID card**

**Network Message**

**Location of book**

**102**

**201**

**202**

**203**

**204**

**205**

**206**

**207**

**FIG. 2**

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**Select**

**Show Admin Panel**

**Manage patrons**

**Repeat**

**Log Out**

**START**

**No**

**Enter Library**

**Login**

**Success**

**Show Error Message**

**Change details**

**Delete library item**

**Add New Sensor**

**Delete Sensor**

**Add library item**

**Validate Changes**

**Yes**

**No**

**Yes**

**301**

**302**

**303**

**304**

**305**

**307**

**308**

**309**

**310**

**311**

**312**

**306**

**313**

**314**

**315**

**FIG. 3**

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**4/14**

**Initialize the smart library management system**

**STOP**

**START**

**The Patron searches a library item**

**The patron obtains the Location of the library item**

**The patron enters the library**

**Face detection and verification of the patron (optional)**

**Scan library ID card and Pick a library item**

**Library item Issued to the patron**

**Send message to alarm system over a communication channel**

**Directly pick a library item**

**CCTV camera captures the Patron’s image**

**401**

**402**

**403**

**404**

**405**

**406**

**407**

**408**

**409**

**410**

**FIG. 4**

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**Initialize the smart library management system**

**START**

**The CCTV camera captures the patron’s image**

**The central server updates the location of the library item and calculates for fine details (if any).**

**The patron enters the library**

**The patron places the library item in an empty rack**

**STOP**

**501**

**502**

**503**

**504**

**505**

**FIG. 5**

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**6/14**

**Actual Image**

**Activate Alarm**

**Face Detection algorithm using Haar principle**

**Detected face image**

**Face Recognition**

**Authorize Patron**

**601**

**602**

**603**

**604**

**605**

**606**

**607**

**FIG. 6**

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**7/14**

**SMART LIBRARY MANAGEMENT SYSTEM**

**Search a library item**

**Computer System Architecture**

**Search**

**Library item UID:** E00700001F826615

**Title:** Computer System Architecture

**Author:** Morris Mano

**Book Found at location:** XYZ

**701**

**702**

**703**

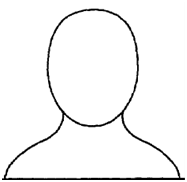
**FIG. 7**

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**8/14**

**701**



**SMART LIBRARY MANAGEMENT SYSTEM**

**User Information**

**ID card:** E00700001F826615

**Name:** Deepender Singla

**Roll Number:** 100904023

**Maximum Items:** 4

**Library Items Issued:** 0

**Pick a Library item to issue**

**List of Library Items Issued:**

**1)**

**2)**

**3)**

**4)**

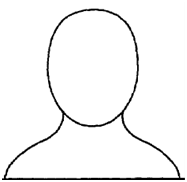
**802**

**FIG. 8**

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**SMART LIBRARY MANAGEMENT SYSTEM**

**Patron Information**

**ID card:** E00700001F826615

**Name:** Deepender Singla

**Roll Number:** 100904023

**Maximum Items:** 4

**Library Items Issued:** 0

**The Book** E00700001F826615 **has been issued**

**List of Library Items Issued:**

**1) Computer System Architecture**

**2)**

**3)**

**4)**

**701**

**902**

**FIG. 9**

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**10/14**

**SMART LIBRARY MANAGEMENT SYSTEM**

**User Information**

**Library ID card:**

**Name:**

**Roll Number:**

**Maximum Items:**

**Library Items Issued:**

**ALARM**

**List of Library Items Issued:**

**1)**

**2)**

**3)**

**4)**

**701**

**1002**

**FIG. 10**

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**11/14**

**Location Directing System for Library item**

**Security System Alarm and Camera System**

**Patron {Students, Lecturers …}**

**RFID System and Processor**

**1101**

**1102**

**1103**

**1104**

**1105**

**FIG. 11**

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**12/14**

**1201**

**1202**

**1203**

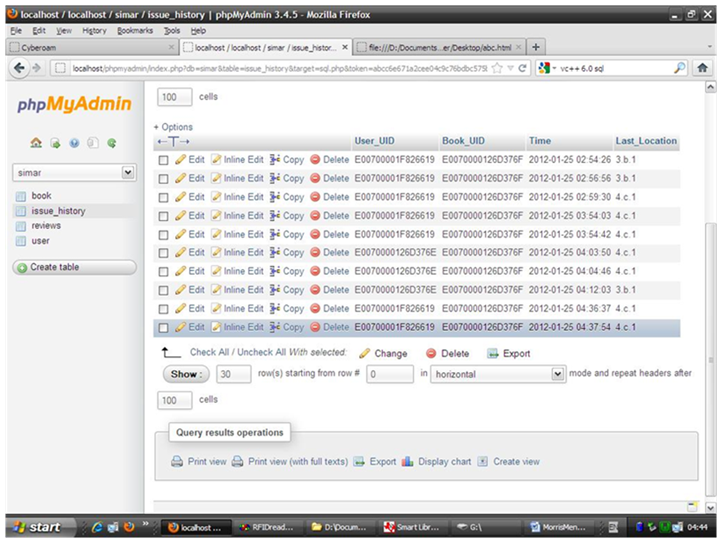
**1204**

**FIG. 12**

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**13/14**



**Central Server**

**1301**

**1302**

**1303**

**1304**

**1305**

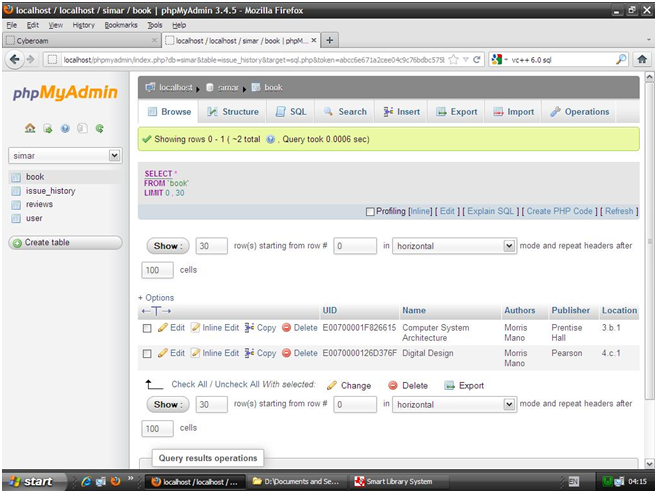
**1306**

**FIG. 13**

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**Central Server**

**1301**

**1303**

**1401**

**1402**

**1403**

**1404**

**1405**

**FIG. 14**

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