# TEXAS INSTRUMENT'S SMART LIBRARY SYSYTEM

**In connection with the Analog Design Contest-2011**

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## 1.1 INTRODUCTION:

The quality of service that a library provides depends greatly on its book management system. As the libraries are growing everyday, it has become practically impossible to manage books manually. So it is the need of the hour to fully automate the library management system. Larger volume of books doesn't always ensure that library is reader friendly. On the contrary, it can become more chaotic if the books are not managed well. So book management system is the most crucial part of library.

One of the major problems that the current management system face today is that most of the times books are not found at their assigned location. Tearing of pages and theft of books are also acute problems specific to Indian libraries. In this proposal, we will try to plug in the loop holes of the present system with our new smart library management system.

We will use RFID to establish a smart library system which will know what is the location of each book and updates the changes in location in real time. Thus the books are never misplaced. Though RFID is already in use in many libraries in India and across, there use has widely been limited to as a substitute of bar code. Our solution goes beyond conventional approach to present RFID systems to achieve a more robust, theft free, secure and fully automated library.

Moreover care has been taken the proposed system is compatible with the existing infrastructure so minimal change is required to update the present semi automated system to our fully automatic solution. Many 'out of box' ideas have been accommodated to make the system cost effective and indigenous.

We believe that our proposed solution will be a stepping stone for the next generation libraries. This work will provide plethora of scope for many more research in this field. We can explore new horizons and integrate applications like GPS, image processing etc to achieve even more automation.

## 2.1 Problem Statement

Right in the beginning, we did extensive brainstorming that yielded many good ideas that we eventually improved. As the problem that we decided to deal in this project is quite new and unimplemented, we decided to go further in a rather research bent of mind. This insisted us to list all the solutions with their advantages and disadvantages so that we can have a detailed case study of the problem.

First of all we would like to talk about what are the most basic requirements or needs of a library management system. Then we propose some existing solutions that fulfil some needs of such an automated system and then we propose some new additions in automation and then its solution which will be of major concern in this project.

Typically we have **two most basic needs** of a library management system (LMS).
1. The user should be able to search for a particular book in the main database provided he knows the name, author or other fields and find out….
   a. Whether the book is available in the library and is issuable.
   b. Where the book is located in the library.
   c. Preferably what are the reviews of the book.
2. The user should be able to find out the details of a particular book in the main database, provided he has located the book himself from the shelves.
   a. What is the issuing policy related to the book.
   b. Get the book issued as easily as possible, if he desires.
   c. Preferably reviews of the book.

Over and above these basic requirements, the fully automated LMS should have
1. Scope to detect tearing of pages and theft of books.
2. Automatically update the new location of misplaced books.


## How the system is implemented in theory

To fulfil this primary requirement, we will need to authenticate and recognize a particular book with a unique ID or a tag.  This unique tag helps to uniquely identify that particular book in the main database of the automatic system. Along with this unique tag we have some typical *metadata* such as 'name of book', 'author', 'publisher', 'location' etc in the main database which facilitates the searching facility. This *metadata* is searchable from an interface using a computer.

So if a user knows name, author, etc he can find the book in the main database, and hence locate the book from the interface in the computer. On the other hand he has the book located himself physically; he can find it in the main database using its unique ID and hence check its *metadata* like issuing policy, reviews, etc.

## 3.1 Existing Solution

The two most commonly used systems in libraries are
- Barcodes
- RFID

Both use a technique that embeds a unique tag which can be read from the book. There are many possibilities of adding such a unique tag but one main requirement is that it should be passive and should not operate on battery. These are the two most commonly used tags and how they are implemented in libraries.

**BARCODE**

Almost all the libraries across the globe use bar code that uniquely identifies a particular book. A barcode is an optical machine-readable representation of data, which shows data about the object to which it attaches. The barcode is read with the help of a barcode scanner and corresponding information or metadata can be located in the main database. Library at our university has bar codes attached with all books and even with all the member cards. All the allied information regarding each member and books are linked with the bar-code. This system makes the library management hassle free. To a large extent, issue and return of book becomes automated. User can search about all the information of the book and its assigned location through the computer connected to the library database.
 But this arrangement has following loopholes.
   1) Use of bar-code hardly fulfils our objective of automation. Each time a book has to be issued or returned, bar code on the book has to be scanned using a bar code scanner. It also calls for extra man power.
   2) Incidents of theft can't be controlled using bar-code as it can't check unauthorised trespasses.
   3) Most often than not, books are misplaced in the libraries from their designated location and hence it becomes impossible for users to locate books.
   4) One of the serious flaws with barcode is that a bar code reader can scan only one bar code at a time. So it becomes cumbersome and time consuming to handle large volume of crowd and results in big queues in libraries.

**RFID**

To locate a misplaced books, the method used till now in most 'automated libraries ' are quite tedious. A person has to scan the RFID tag of all the books using a hand  held devise and if any misplaced book is found, hand held device responds either by glowing LED or turning on the buzzer. What we propose is fully automated Book location finder passive RFID tag. If a book is misplaced, the database of library will be likewise updated, so as to point to the location of the book.

RFID is already in use in many libraries in India and across, but the use has widely been limited to as a substitute of bar code. No doubt, they have made check-in and check-out semi automated with minimum human interference. The major loopholes of the system are:
   1) There is no provision to locate misplaced books. Book that has been displaced has to be located manually and put back into proper place.
   2) There have been incidents of RFID tag theft. Thus adding to the worries of libraries.

## 4.1 Problem we will be dealing

The main problem we will be dealing with is identifying the location of the book. Embedded to the *unique tag*, we have a *location* field in our main database along with other details of that particular book. So when a user come searching for a particular book, our automatic system can direct him where the book lies. Normally librarians categories the books on the basis of some location identifier. So the user can find out the book in the particular shelve tagged with that location identifier. So every time a malicious or careless user come and places the book in some other wrong location the user who is looking for that book can never find it where the automated system says.

Now our main concern is that when a malicious so careless user places it in some wrong place the book automatically updates its new location in the *location* field of the *metadata* attached to its unique ID. So this system will work in real time and updates the new location of the book whenever it changes, so any user who will be looking for that book can find it easily.

As this problem is completely new and no practical solution exist till date, our main innovation of the project lies in this part. We will come up with three solutions with their respective advantages and disadvantages and eventually propose our final solution.

- Active tags – The very first thing that come to mind is that the book should transmit its location to the main server using wireless like a GPS. This sounds quite interesting. Once we have the new location we can update the new location in the main database. Using this system user will be able to issue the book automatically when he moves out of library However it has the following disadvantages.

  - Use of active tags means we have to use battery which adds to the expenses.
  - It is less durable and will require a lot of change in the current library management system.
  - Drained batteries will have to replaced regularly, which will involve still more man power.
  - Books are still prone to theft as a malicious user can remove that battery module and can safely take the book out of library.

- Passive Tags

  - Full barcode line – We can have a full length barcode sensor that can read the barcode of the books when they lie on the shelf.
    - There is no off the shelf sensor available for such a purpose. We have to make a custom order for such a sensor.
    - It would be quite expensive.
    - It would require a lot of change in the current system.
    - It's not a portable system.
    - Prone to errors.
    - Still prone to theft as the system will never know who picked the book.

  - RFID – This is the solution that we think is the most appropriate. We will use RFID antennas at each compartment of shelve which will be connected to microcontrollers and hence when a book is picked up or placed in that particular compartment, the RFID antennae connected to that particular shelve will detect it

and report to the main system. The system will in turn update the *location* field of the metadata immediately as per the requirement. This way we can track down the location of each book in real time and can guide a user looking for the book up to that location from the computer interface. We will also add a security check that when a user wants to pick up a particular book he can do that only if he shows his RFID based library card to the RFID antenna in that particular compartment. This way the system will know who picked up the book. If a malicious or careless user tries to pick the book without showing up his card, the system will alert the authorities and the user using an alarm and the CCD camera will take a picture of the incident. More details about the technical details of the system are explained later in the section.

- Loopholes
  - The user can still tear pages from the book.

- Advantages
  - Library will have details of all users who pick a particular book within a given time frame. So user tearing the pages or tampering the book can be identified.
  - No security loophole
  - User will not be able to remove RFID tags and take the book along.
  - It is a more close approach to personless 24x7 library.
  - Implementation of this system will involve minimal change.

## 5.1 Our solution:

Here we will show how we dealt with this problem of locating books in real time. The solution is very simple, track books in real time and somehow get and update the location when a user keep it back on the rack. Once we know where the user kept it back, we can accurately direct the next user looking for that book without any problem. In the figures below, there is a typical organisation of books in a library. Here we have a rack and a compartment. Our system will be able to tell the user that in which compartment the book lies.
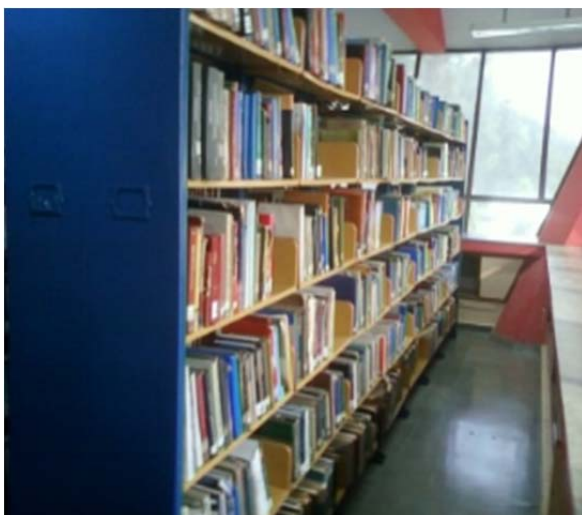
Fig 5.1(a) Entire Rack                    Fig 5.2(b) Two compartments of the rack

We will have a separate antenna for each compartment of the Rack, which is connected to some ADC pin of the microcontroller. The main system will know beforehand that where an antenna is located in accordance to the unique ADC pin of the MCU to which it is connected. This information will be conveyed to the main system by the microcontroller using a unique antenna number. This way we have a unique number, the *antenna number* tagged to each physical location or compartment of the shelf. So based on where the signal is coming from, the main system can recognize form where in the physical world the book is being picked up or kept. Along with this *antenna no* the unique RFID tag read by the RFID antennae is also sent to the main system. Thus the main system will be able to recognize which book is picked up or kept down from where in the physical world and hence update the location of each book in the main database.



But by using a separate antenna for each compartment the cost increases and also it will be quite difficult to install antennas in each compartment, therefore we plan to use antennas in a manner a typical 2D sensor tracks the location (x,y) like in a touchpad. Following is a CAD drawing illustrating our idea.
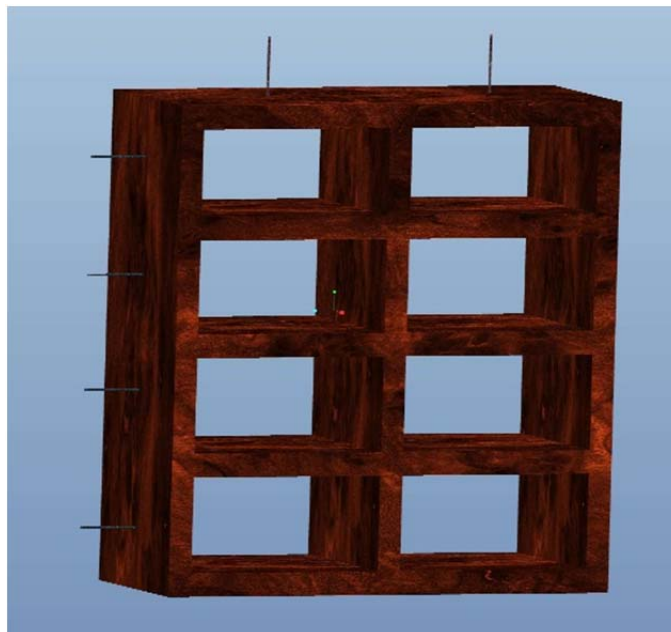


Fig 5.2(b) CAD view showing proposed location of antenna

Instead of using separate antenna for each compartment of a shelf, We would divide entire shelf into distinct regions by providing antenna only at the top and side of the shelves for e.g. if we have one shelf containing 35 compartment it can be covered by just 10 antennas instead of using 35 antennas for each shelf with the above proposed design.

By using the above design we can get exact 2-D coordinate of the book in the shelf depending on the intersection of beam of horizontal and vertical antennae. This is where our innovation will also come into picture to design a system of antenna with minimum cost. We will also consider the fact that two antenna should not interfere so that we get exact coordinate.

Now regarding the communication of antennae to the main computer system. For the above system we will use hierarchy of 10 microcontroller (that are connected to 10 different shelf) will act as slave and will be communicating with one master microcontroller and then master microcontroller to our main computer therefore in a library containing 22 racks that is nearly 60,000 books we will have 22 microcontroller as slave and 2 as master which will be in communication with our main computer.

## 5.2 Block diagram of third hierarchical system



Ten slave microcontrollers attached to
ten different shelves

Ten slave microcontrollers attached to
ten different shelves
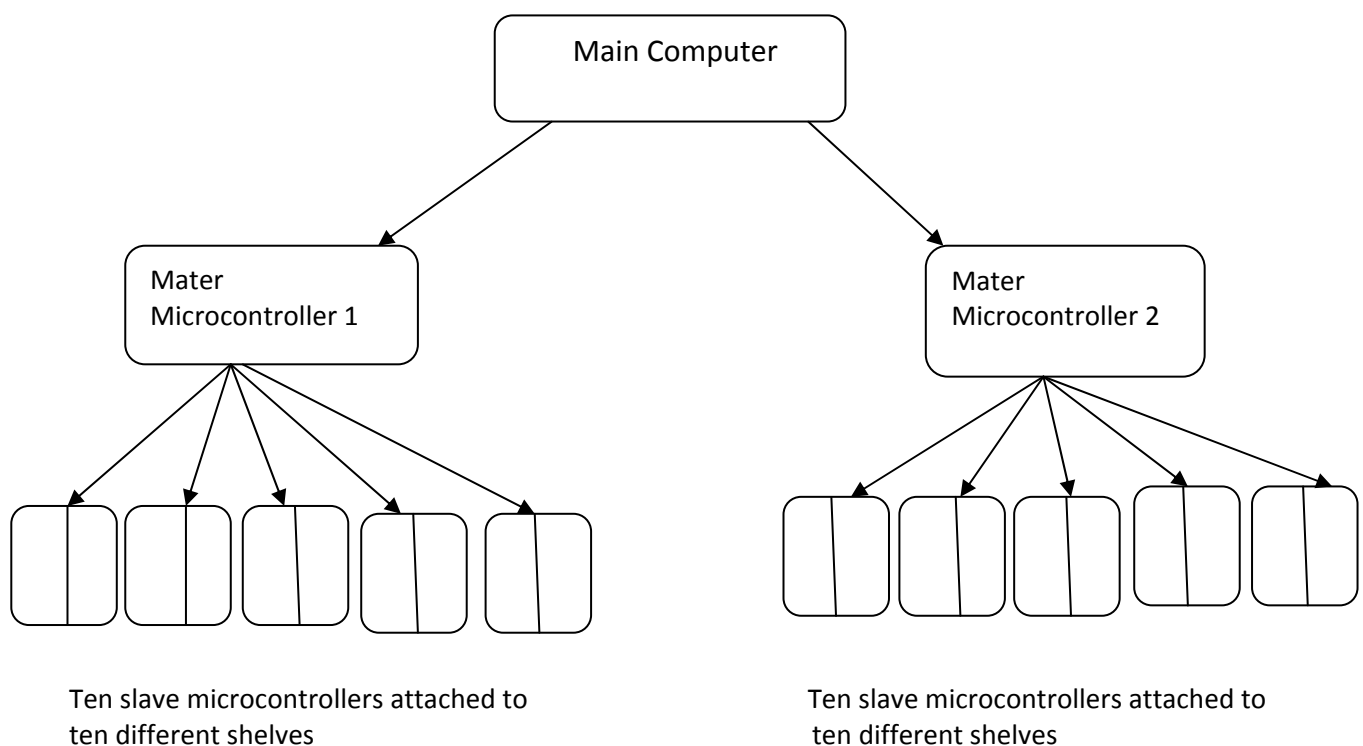
When a user searches for a particular book using name, author name, etc from the computer interface, he can be guided from the computer interface where the book lies using various manners.

- Using a mobile based application that will be integrated using GPS and the user will be guided where to go in the library using direction guiding instructions.
- Using a map on the computer from his current location.

- We can have some LEDs and the LED on that particular compartment will glow where the book lies.


Fig 5.2(c)-One compartment of Shelf contains 15-20 books

- This is a brief scenario on how it will work – Suppose if a user picks up the book the RFID antennae will detect that the book has been taken up so it will update the location field to **PICKED_UP** and when another user searching for that particular book will come to main system interface and search for that book using name, author name, etc he will be immediately informed that the book is with some other user. When the user who has the book keeps it back anywhere on the shelf, the RFID antenna of those particular shelves will detect its entry and update the location of the book immediately in the main database.

    o Problem of tearing of books and RFID tags can very smartly be addressed by our proposed system. As we know each of our antennas will be connected with microcontroller, when person picks a book he has to show his library card in front of concerned antenna. Now there are two possibilities:

        ▪ User shows his card before lifting the book hence in our database we would know the exact details of the user who is picked up a particular book. If any user tries to tear away the tag for stealing the book, he can be caught very easily. If a book is neither kept back onto any shelf (need not be the shelf from which it was picked) nor issued for a long (a time limit can be set), the book would be considered 'missing' and the last user who picked it can easily be identified.

        ▪ User tears the book page and keeps the book again in library and authorities come to know about it after 2 days. In this case, we know the identification of the persons who has read this book in the given time span.  Let us assume that 3 users used the book in the given time period.

            • We can get to know the exact duration for which a particular book was with a user. All the libraries have CCTV camera installed. Hence we can see the recording of all the 43persons and will be able to detect which person among them is the culprit, therefore there will be no need of a person watching CCTV camera every time.

            • User doesn't show his card and lifts the book. Antenna will be able to detect that book has been lifted but microcontroller won't receive initial signal of person identification tag hence an interrupt will shootout from our microcontroller through which it can run siren or alarm. Microcontroller is communicating with master computer which in turn is in communication with library CCTV camera and it knows the location of any particular microcontroller and hence CCTV will take picture of that person and will be stored in

its database. This message can further be sent to admin's mobile via GSM module.

With the above system a student can't even harm antennas as well. And if anyone tries to, he can very easily be traced. So we have fully automated the following tasks with full security.

- Issuing and Returning
- Automatic checking and checkout using RFID are available.

## 6.1 Technical aspects

Chips

- **MSP430** microcontroller with every rack and each antenna of that shelf connected with it.
    - The reason for using it is ultra low power. One battery can work for 15+ years, so no frequent changes in the system required. This will also increase cost-effectiveness and reliability of our system.
    - The family is 16 bit therefore will be providing real time operation to us which is a necessity of this project.

- We will be using **MSP430F2619** as we will require nearly 50 GPIO pins to cover the whole rack and a high flash memory of nearly 100 kb and sufficient ADC channel for us.

DSP:

- For CCTV camera security and tracking and in future will be used for automatically displaying information related to books. **TMS320DM8165**

MASTER PROCESSOR:

**RFID KIT:**
We will be requiring RFID passive tag for each book and RFID antennas. We will customize antennas according to the project requirement. For the precise detection no interference between two antennas, we will be consider below mentioned point:

Power given to antenna can be varied as it is connected to microcontroller with this its range of detection can be varied according to the dimension of rack as here.

We also plan to use jammer to jam a particular antenna field beyond a limit so that it doesn't interfere with antenna nearby it. The range of jammer can be controlled by connecting it with microcontroller and regulating power given to it.

## 7.1 BUDGET:

This section deals with the estimated budget to convert a simple RFID library to a smart library proposed by us. **The whole detail is for library containing nearly 60,000 books with 26 shelf containing 600 shelf**

And 18 CCTV camera.

| COMPONENT | Estimated COST |
|---|---|
| MSP430F2619*25(no.of shelf) | $223 |
| TMS320DM8165 | $89 |
| ANTENNAS(nearly 150) | $200 |
| MISC(like led, connecting wire) | $100 |
| Total | $612 |

We have assumed our University library as the model for the project. The above cost is for converting thapar university library to a fully automated library if books are tagged with passive RFID tags.

**For the initial phase of our project we will be dealing with one nearly 5 compartments of the rack that is nearly 100 books and with one CCTV camera.**

## 8.1 Future vision

- Add screens enabled with RFID so when a user brings a book near that screen the screen will automatically display information related to that particular book from the metadata linked with the RFID tag. This way user can read reviews from other readers or users of the particular book and also check information on internet about that book like price. If he wishes he can buy and order that book immediately from services like amzon, ebay etc all using a touch screen interface of that screen
- To reduce cost, we can use simple screens instead of using RFID screens. When a user lifts the book and if he wants information about it, he just has to press a button. Microcontroller will send this signal to main computer through which the information stored about that book will be displayed. Hence our existing system will help here also.

- GPS system in mobiles..

- Person less … 24x7 library..

- Using image processing algorithm for detection of users who tear the pages from the book.

  We can develop algorithm based on image processing which can direcly identify any abnormality like tearing of pages or theft based on the analysis of CCTV footage.

## 9.1 Work done so far

**Intel:**
We (Team ID iec_1156)  have reached the final round of Intel embedded challenge 2011 clearing two round of it. In final round only 35 teams out of 5000 entries have been shortlisted. We proposed to make a smart cost effective prosthetic arm using speech recognition and Bluetooth control. We are developing the entire prototype using Intel atom processor. Intel has provided us with Intel atom kit and would reimburse the entire cost of project. Two Intel technologists are guiding us in the whole project. The final of this competition will be in 1st week of August 2011 at Bangalore.

**Freescale:**
 We Participated in Smart Car race national competition conducted by India institute of science (IISc) and Freescale at Bangalore, India and secured 2nd position in preliminaries. Here we were the youngest team in the competition. In this we, in a team of three members, made a completely autonomous line follower car, using a similar steering to actual car controlled by a servo motor and Motorola Mc9s12x512 MCU. In addition we used an innovative approach to sense signal from the black line using an array of IR LEDs and mathematical constructs. The controls system employed in car was PID controls system.

**KVPY:**
One of our team-mate got selected in KVPY. Kishore Vaigyanik Protsahan Yojana is a very reputed scholarship in India. For engineering stream you have to submit an innovative practical project. He made software for S60 platform on SymbianOS for Nokia E63 using 'python for S60' programming language. Using this software, you can send around 15 template messages even internationally free of cost. He has tested it and it works perfectly fine. You can also use this communication to use you mobile phone to switch on your AC before you get home, or switch off tubewell right from your home, for farmers. This project has been made keeping in mind this problem that farmer in Punjab faces.

**Ubuntu:**
One of our team mate  has been contributing to Ubuntu since Dec,2010, starting with triaging simple bugs related to desktop, later moving to xserver-xorg-input-synpatics (touchpad driver) and kernel as his deep interest lies in system level programming. In july, he become an official Ubuntu Bug control member. He has also written some documentation related to touchpad driver and is now maintaining the package in Ubuntu. Moreover he is also helping and encouraging others including us to contribute to open source.

**Light on off system using atmega:**
 We used Atmega8 and a pair of photo diodes to sample two lasers used to detect, whether a person is going inside or going outside and so it could keep track of how many people are inside the room. When people no are 0, turn the light off using a relay tied to ULN2003. The design is totally original.

**Our Technical skills**
- Matlab
- c/c++
- visual studio
- Gnome (GTK+)
  - Python (PyGTK)
- CAD – Solidworks
- Networking - Cisco packet tracer/ Nmap
- Web designing.