ICABS: Instant CAmpus Biking Solution

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1. Objective

1.1 Aim

The aim of this project is to build a renting system for bicycles to facilitate intra campus commuting. By providing security against theft and at the same time keeping user away from the headache of maintenance, this shall discourage the use of automobiles and encourage use of bicycles for travelling small distances. The idea is to have a chain of "smart bicycle stands" connected wirelessly to a central server, which will facilitate users to use a bicycle for commuting without owning or having to maintain one – in other words, "rent" the cycles for daily use through a prepaid smartcard system.

Such a system must be secure in every aspect. Thus one of the objectives besides the core idea is to make the system robust and secure so as to handle all possible kinds of usage.

1.2 Motivation

IIT Delhi students have classes at different timings and at different centres/departments. Even though there is a bus and rickshaw service in the campus, it is not available at all times and not as flexible as a self-owned bicycle. Last semester, Kumaon Hostel had introduced bicycle rentals at their hostel cycle stand. Even the DMRC has started a bicycle renting service at the "Vishvavidyalay" station, but both these services are manual and hence are time restricted. We present a smart solution which employs technology to provide an automatic 24X7 renting solution. The scheme is ideal for our campus but also easily adoptable for city-wide rental services. Hence the use of uniquely marked bicycles by people in IIT will certainly discourage automotive vehicles in the campus in addition to the regular exercise provided by the bicycles to their users.

Apart from this convenience for students, another major motivation is that of "clean environment, green environment". Thinking about a metro city, there is a need of an environment friendly service which provides 24-hour access to "private" transport and is user friendly. In the coming years, city roads and rural highways will improve substantially in number, capacity and quality, but a four-fold multiplication in the number of vehicles will tax the urban infrastructure to the limit. There is an urgent need to stop this "choking" of roads.

The citywide application of this system has the following key objective is “To revolutionize Public Transportation and in some sense prevent our metros and other large urban centres from choking to death”.

One key challenge in making the public transport popular is to solve the “last mile connectivity” problem i.e. the concept of connecting the public transport from each point of the city to any other point. As a public transport can’t reach every address of a city, especially inner areas, the bicycle service can be used to cover the “last mile” between the “out of reach and the within reach of public transport” points.

The idea of automated bicycle vending has been around for a while. Such systems exist in Paris, Amsterdam, Vienna and some other European cities. The system had not been that popular initially but in the last one year, it has picked up and is quite successful. In comparison to these systems, our system would be much cheaper in terms of deployment, operation and maintenance. Our design is also more user friendly than many of these systems.

2. Approach

2.1 Overall Design

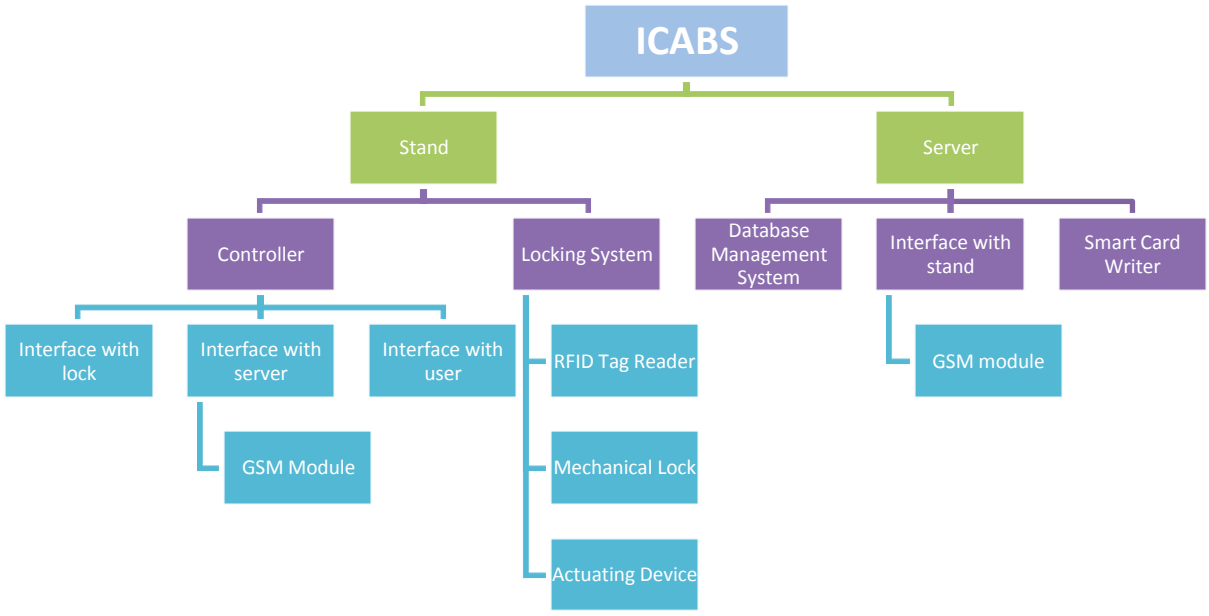

Figure 1: Design hierarchy of the complete system

The System's Perspective

We have a network of stands and a maintenance unit, interacting with the main server. The user has a smartcard by means of which he can authenticate himself. The stand has a controller to "actuate" the locks and a Radio Frequency Identification (RFID) tag reader to read the RFID tags used to identify the bicycles. It communicates with the central server via a GSM module. The stand keeps track of the bicycles that are parked on it, the empty slots that it has for further parking. It maintains a separate list of those parked bicycles that need repair and these are not issued till maintenance personnel come, repair them and inform the stand.

The central server has a smart-card reader/writer and a GSM modem. The user accounts are created and cards are issued at the central server. It also manages the database containing the user, cycle and stand records and all the transactions made. It generates statistics regarding the usage of cycles at different stands and at different times of the day.

The User's Perspective

- ✓ The user uses her/his smart card to request for the issue/return of a bicycle.
- ✓ The system reads her/his smartcard and checks if there is already a cycle in the user's name.
- ✓ If the user's request is justified, the lock gets opened and she/he is requested to withdraw/park the bicycle.
- ✓ The system checks if the lock has locked properly and the cycle tag is being read properly.
- ✓ The smartcard is updated (balance, issue status) and the user can remove it.
- ✓ In case of return the user is asked for a feedback, i.e. in case the user brings the cycle in an unusable condition she/he should report it.
- ✓ If the cycle does not get sensed when at the time of return then the cycle does not get returned. The user is asked to contact the maintenance.

The log of the transaction is maintained on the stand and is sent to the server periodically.

2.2 System Description

As mentioned above, the stand has two broad parts:

The controller:

- ✓ The controller interacts with the lock: when it gets the tag ID (read by the RFID reader), it triggers the lock actuator, which converts this electrical signal into a mechanical movement locking the bicycle. Tag is read again to confirm the presence of the bicycle.
- ✓ It also communicates with the server through a GSM module. Basically, the controller issues commands to the GSM chip to send SMS to the server about the transactions that have taken place. It does so when it is idle for quite a long time.
- ✓ It also provides a user interface comprising of a LCD panel and a keypad. The LCD panel is used to give directions and the information at the various steps of the issue/return transaction to the user. The keypad is used to get inputs from the user regarding the choice of the transaction: issue/return or to get feedback on the working conditions of the bicycle and whether it needs maintenance or not.

The locking system:

- ✓ The locking system has a RFID antenna which reads the RFID tag on the bicycle and communicates it to the stand controller
- ✓ It also has an actuating device which takes an electrical signal from the stand controller and converts that into the movement of the mechanical component. There is a small electrical circuit also to detect if locking has taken place successfully or not.
- ✓ Finally it has the “real lock” i.e. the mechanical component which actually locks the bicycle with the stand.

The server has 3 components:

- ✓ The smartcard reader/writer to issue new cards to the users.
- ✓ The GSM modem to receive SMS from the stand regarding the transactions.
- ✓ Both of these are integrated with administration software that manages the database of all the users, stands, bicycles and the transactions. This software also generates many statistics about the usage pattern as and when required.

2.3 Present Status

- ✓ Custom PCB: Designed and fabricated the first version of the PCB for the stand controller. In the first phase of the project, an evaluation board was being used for the testing purposes. After that, we designed a PCB that was an "optimised" version of the evaluation board and also had additional circuitry for SmartCard, Locking System and LCD, keypad interface. The design of the second version of the PCB (it will incorporate the GSM module) is under progress. An additional "less complex" PCB is also being designed for the lock relays and the RFID; it will also have an interface to communicate with the main PCB.

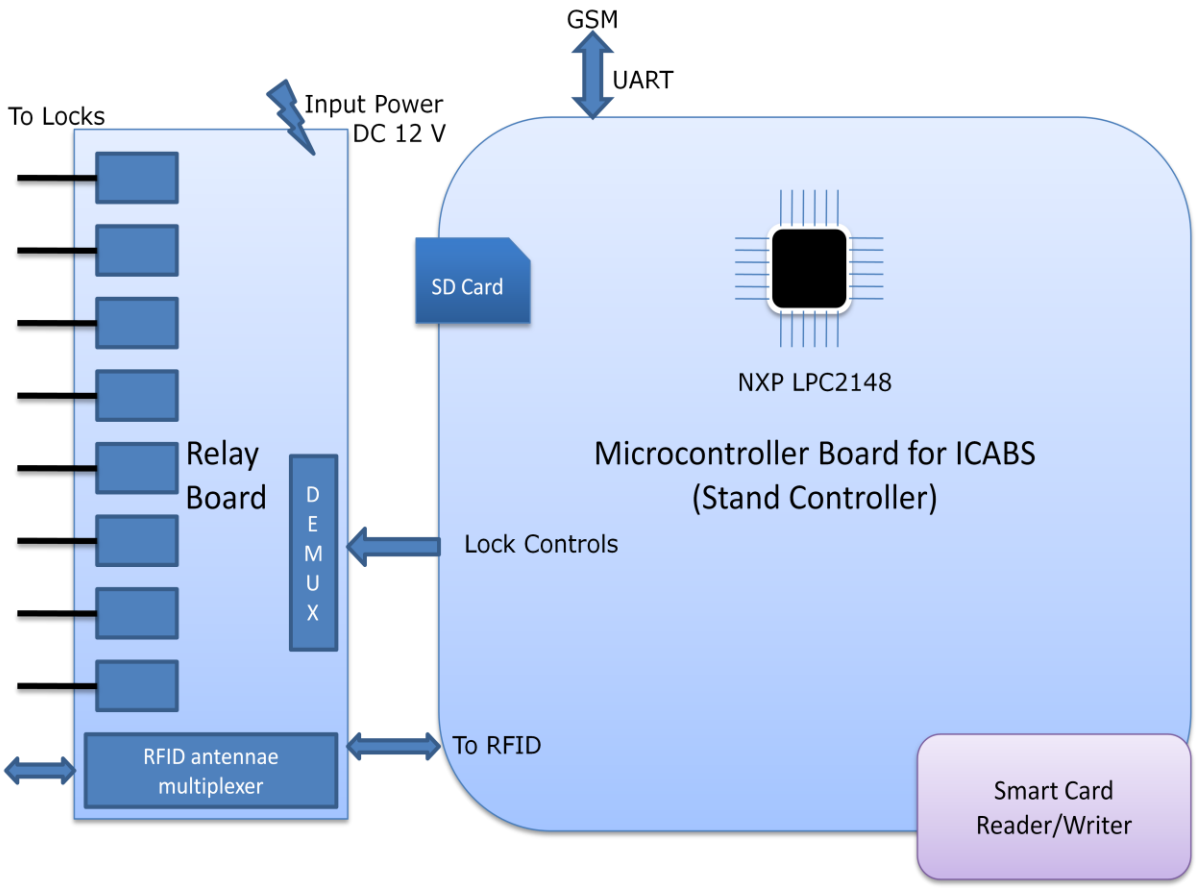

Figure 2: Various components and their interaction

- ✓ Embedded Software: The embedded software for the stand controller has gone through rigorous testing and is now ready for operation. It implements a very robust state machine for interacting with the user, operating the locks, communicating with the server and administrator mode for maintenance. It however doesn't have the RFID tag reading for the time being (which is being worked upon).

- ✓ Administration Software: GUI based software has been written for server side administration and database management. It has the following functionalities:
  - Creation of new user accounts and issuance of new smartcards
  - Database management and answering various statistics related queries
  - Communicating with the stands

- ✓ Mechanical Lock: We are in conversation with a NOIDA based company to guide us with the lock design. A lock had been designed and fabricated previously but we have identified many problems with that design making it infeasible, hence the need for re-designing.

3. Expected outcome of the project

- ✓ A fully functional prototype of the system can be expected by the end of the current semester.
- ✓ The installation of this system in the campus is the final aim to be achieved in the next semester.

4. Duration

The building of the prototype is expected to take 2 months and the process of technology transfer and installation in the campus will take another 4-5 months.

5. Budget

1	PCB Manufacture	Rs. 20,000
2	Lock and Stand	Rs. 25,000
3	Bicycle (3 test units)	Rs. 5000
4	Hardware Components (including evaluation kits)[1]	Rs. 60,000
5	Server[1]	Rs. 40,000
	Total	Rs. 1,50,000

6. Facilities required

- ✓ Digital Hardware Design Laboratory
  Department of Computer Science and Engineering

- ✓ Rapid Prototyping Facility
  Department of Mechanical Engineering

- ✓ Central Workshop
  IIT Delhi

[1] Purchase of components, kits and server, if not supported by TDP-IAS, would be done through department funds.

7. Glossary

- Actuator: A device that converts an electrical signal into a mechanical movement
- GSM: Global System for Mobile Communication
- GUI: Graphical User Interface
- LCD: Liquid Crystal Display
- PCB: Printed Circuit Board
- RFID: Radio Frequency Identification
- SMS: Short Message Service