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Design of an Automatic Fare Collection System Using Near Field Communication with Focus on Indian Metrorail

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Abstract:- Traditional ticketing system for railways involves serpentine queues for passengers and requires constant human processing. Attempts to fix this problem include coupon books for passengers and more recently smart cards for standard railways. In standard railway, the purpose of the smartcard is to automatically print a ticket for the passenger. However, if a smart card system is to be implemented for Metrorail the purpose of this smartcard will be to give the passenger access to the station by commanding the turnstile to rotate(or a flap gate to open) and then again enable the passenger to exit at the destination station. Building on this idea, we propose a more advanced automatic ticketing system using Near Field Communication keeping in mind the specific needs and requirements of Metrorail systems in India and also the convenience of the passengers. The prototype of this system is implemented and described in this paper.

Keywords:- Ticketing system, human processing, smartcard, Metrorail, automatic ticketing, Near Field Communication, RFID, automatic fare collection

I. INTRODUCTION

NFC(Near Field Communication) technology enables simple and safe two-way interactions between electronic devices, allowing consumers to perform contactless transactions, access digital content, and connect electronic devices with a single touch.[1] (NFCIP-1) Standard specifies the interface and protocol for simple wireless communication between close coupled devices. These Near Field Communication (NFC) devices communicate with bit rates of 106, 212, and 424 kbit/s.[2]

Another option is to use a Bluetooth for communication. However, Bluetooth based applications have the additional procedure of requiring the users to pair their phones, which will be time consuming and additional burden for the system server. With NFC it is possible to skip this step. Also, the users have the dual option of using NFC tags or NFC enabled mobile phones. If NFC enabled mobile phone is used it acts as a NFC tag emulator.

Some important conditions to be met are NFC Data Exchange Format (NDEF) [2],[3], Record Type Definition (RTD) [4], and Type Name Format (TNF) a for the operation of all NFC applications. They show the type of an NFC message, record, and format, respectively.

The proposed system consists of an NFC based device which is kept at the station and an NFC tag/ NFC enabled mobile phone which the user carries, the tag/mobile phone used by the user has a unique identification number of the user. The system also allows more than one passenger to pass through the turnstile via one tag/mobile phone if such a request is made.

II. METHODOLOGY

The methodology consist of hardware interfacing of the system and the software implementation

A. *Hardware Description and Interfacing*

The hardware used in the prototype consists of an Arduino Micro board, a NFC/RFID 13.56MHz module, Mifare/transponder tag and a computer which functions as a central server of the ticketing system.

1) Microcontroller Board: The Arduino Micro is a microcontroller board based on the ATmega32u4, developed in conjunction with Adafruit. It has 20 digital input/output pins, a 16 MHz crystal oscillator, a micro USB connection, an ICSP header, and a reset button.[5] The UART port of Arduino Micro is used to communicate with NFC/RFID reader module. And the USB2.0 port is used to communicate with the computer based server. Both communications use speed of 19200 baud/sec. The board will take passenger count for each user and give control input for turnstile. All entry, exit and recharge point have a microcontroller board.

2) NFC/RFID module: The CR038A Mifare Reader/Writer is a device to read and write information from/to Mifare card, Classic 1K or 4K. The module reads NUID of NFC tag/NFC phone on command from Arduino Micro board. The module has its own data frame format which must be followed for any operation. It communicates via UART at default Baud rate of 19200.[6] Each microcontroller board has its dedicated NFC/RFID module.

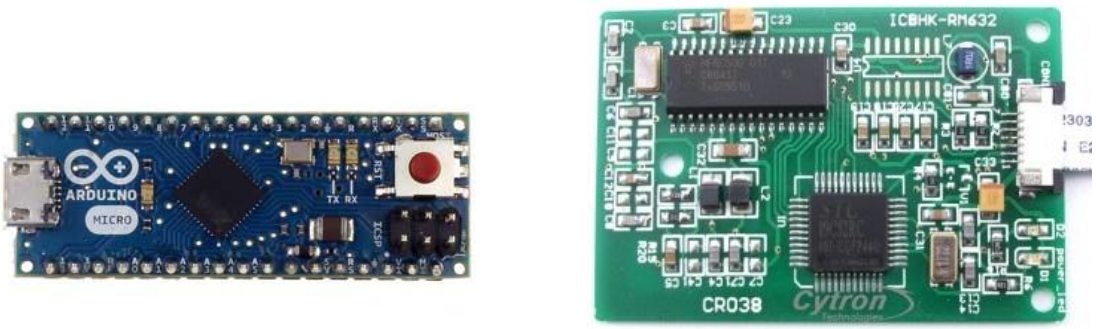

Fig. 1: ARDUINO BOARD [5] and NFC/RFID module [6]

3) MIFARE Classic 1K Tag: The MIFARE classic 1k tag, i.e. MF1S503x chip consists of a 1 kB EEPROM, RF interface and Digital Control Unit. Energy and data are transferred via an antenna consisting of a coil with a small number of turns which is directly connected to the MF1S503x. No further external components are necessary. This is the part of system which will be with the user.

4) Central Server: The central server will store data and status of all users. The central server is connected to all the microcontrollers of the system.

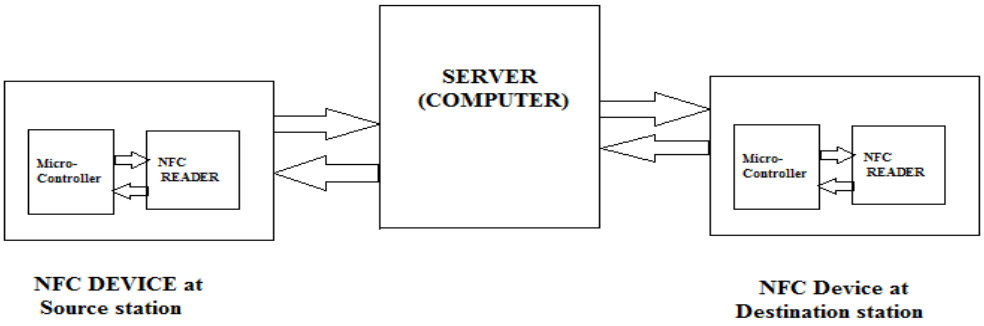

Fig. 2: Block Diagram of the proposed system

B. Software implementation

The system consists of two types of processing units which interact with each other. One is the microcontroller board at each entry, exit and recharge point which controls NFC/RFID module, turnstile, number of passengers. The other is central server which maintains and updates all user accounts, sends required data to all microcontroller boards.

1) Microcontroller Software: The code for Arduino Micro is developed in Arduino IDE. Arduino IDE is an open source software to develop and upload code for Arduino boards. The environment is written in Java and based on Processing, avr-gcc, and other open source software.

2) Central Server Software: The central server is implemented on computer and code is developed on Processing Development Environment(PDE). Processing is an open source language for development of codes on different platforms for different purposes. Default Java mode is utilised for developing the code in PDE. [7]

3) Code Flow: The microcontroller commands NFC/RFID module to continuously scan for NFC tag/NFC phone in vicinity. If the NFC tag/NFC phone is present in range, the microcontroller reads its NUID through NFC/RFID module. The NUID (Number Unique Identifier) is sent to central server with a header and some other data. This data includes details about station, type of point (entry, exit or recharge), number of passengers (only at entry point) and recharge value (only at recharge point). The central server acts according to data received. It updates the user account and sends a positive acknowledgement and number of passengers (only at exit point). If any error occurs, the central server will send negative acknowledgement. Based on acknowledgement received microcontroller gives or denies access to user.

The user is identified by the NFC device and the device asks the user to enter the number of passengers who want to gain access into the station. The device sends the NUID, the station code and the number of passengers to the server. Based on this data the necessary changes are made in the users account in the server. Now the system (server) knows that the user is travelling.

When the user alights at the destination station and taps the NFC tag/NFC enabled mobile phone at the exit NFC device, the device sends the NUID and the station code to the server.

Based on the data provided by the server, the device knows that the user is trying to exit the station and the number of passengers who were given access to the station.

Based on this information appropriate amount is deducted from the users account. The device commands the turnstile gates to allow exit to the passengers.

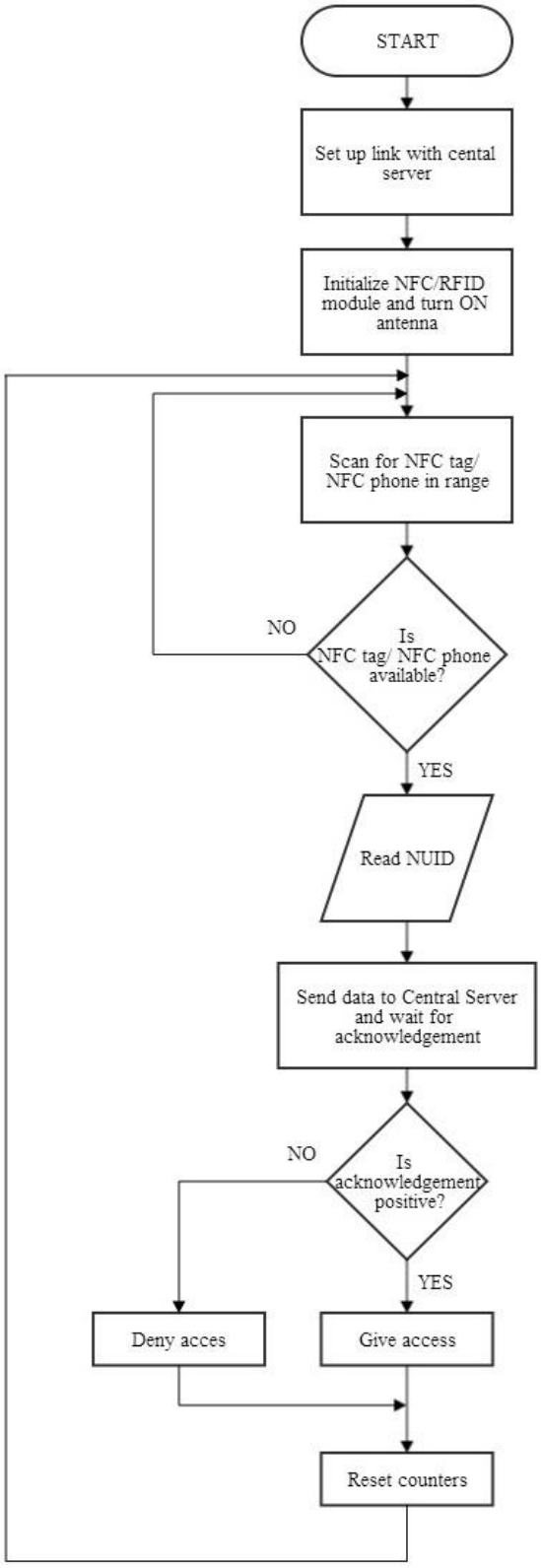

Fig. 3: Code flow at Microcontroller

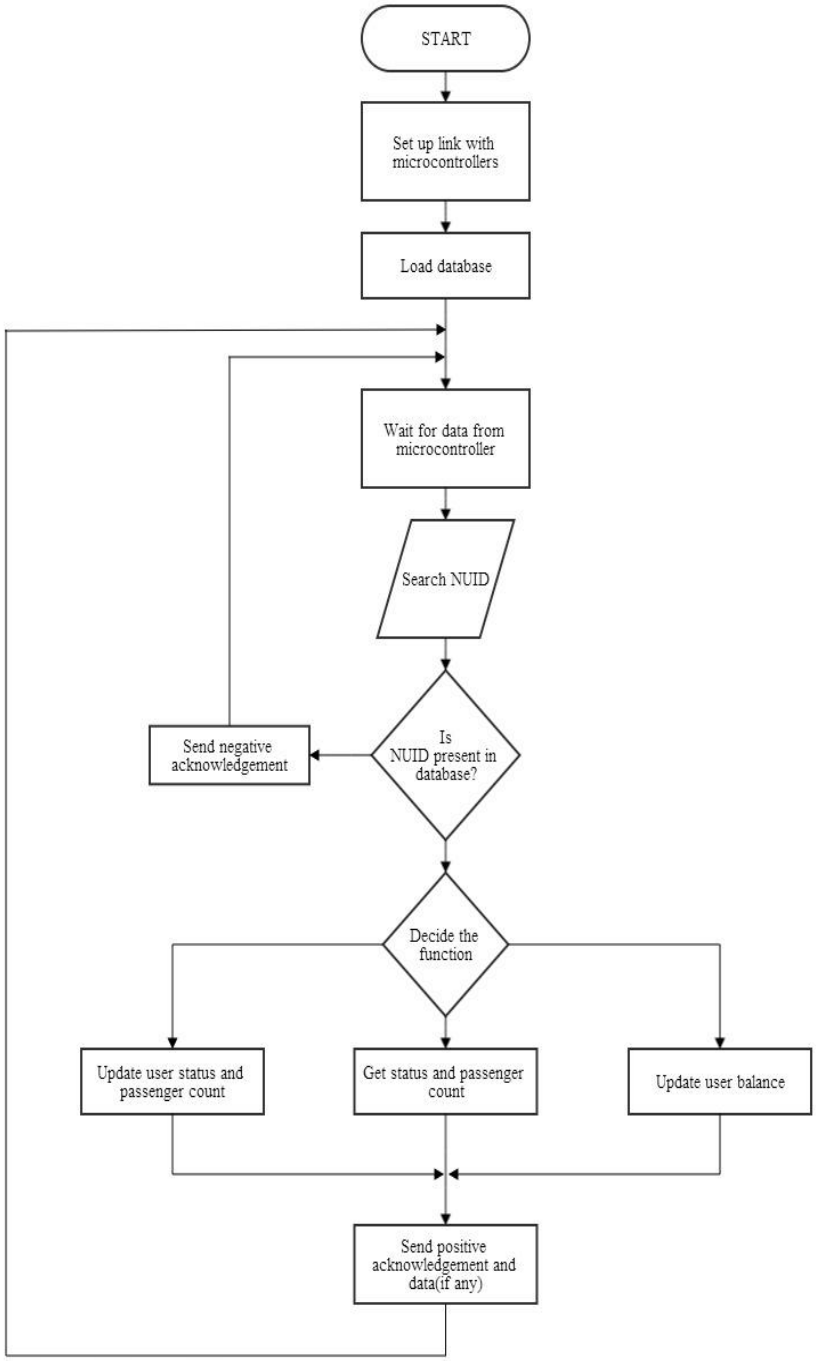

Fig. 4: Code flow at Server

III. ADVANTAGES OF PROPOSED SYSTEM

The NFC based ticketing system is a very convenient way of gaining access to the Metrorail system, it saves a lot of user's time which was wasted in getting a ticket as the access to the station is provided at the touch of a tap..The NFC based system is a secure way of getting the ticket as the range of operation of the device is just a few centimetres, no unauthorized person can hack the system. Moreover, even users with NFC enabled phones can use this system with complete security.[8] The hacker needs to be very close to the device if he has to gain unauthorized access.

Unlike Bluetooth and other wireless systems, the data transmission link is established and at the same time the data is transmitted, so the user does not have to wait for long time for the data exchange to take place. The NFC cards can be used again and again. This saves a lot of paper which was previously used to print tickets. The NFC tags are available at very less cost and hence can be provided at nominal price by the Metrorail system authority and NFC enabled phones are not required by the user to use the NFC based ticketing system.

The device's use can also be extended to do NFC based transaction at various places like colleges, buses, amusement parks, corporate offices, industries, etc. Thus requiring less paper work and saving the users valuable time.

IV. LIMITATIONS

The Initial set up cost of the proposed system will be higher as compared to traditional ticketing system. If NFC Tag is lost or stolen it can be misused. Also, the tag may not be read if the tag is not aligned properly at the NFC device or if the tag is not tapped properly at the device.

V. CONCLUSIONS

Although, the proposed system will have a high set up cost, in the long run it will be beneficial for the Indian Metrorail. Since the maintenance cost is very less due to absence of human ticket vendors, this ticketing system will quickly recover its set up cost. Also it will be very convenient for the passengers and solve the problem of making the passengers stand in large queues and thus increase the overall efficiency of Metrorail travel. Moreover, this system has future scope of being capable of extended to general transactions as stated in the advantages which will make it even more useful.

ACKNOWLEDGMENT

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