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GPS based Automated Public Transport Fare Collection Systems Based on Distance Travelled by Passenger Using Smart Card

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Abstract: ***The aim of this paper is to provide a comfort tension free and easy way of travelling and also to reduce the man power. This paper involves the combined usage of smart cards and GPS to make travelling smarter. In our paper, Smart card which has become a common thing now, holds the data of the card holders and GPS which is an efficient tool in many fields like surveillance and tracking, which is used in here to find the distance travelled by the user. The smart card can be used by the user for entering and leaving the bus. Depending on the distance travelled, the money which has been paid in advance will be deducted from the card. This paper includes implementation of the Microcontroller which controls the entire system. It works effectively with GPS and smartcard. This study also stresses the need to make this system practical and the result that we will obtain is explained in this paper.***

Keywords: Electronic Bus Ticketing, Gps, Smart Card, Rfid, Lcd, Micro Controller.

1. Introduction

In this paper "GPS based automatic bus fare collecting system using smart card Ticketing" [1]explained that a system that uses the same RFID-based location information to give the user navigation indications depending on his current location; provided that the user has indicated beforehand the places he intends to visit[2]. By using smart card instead of RFID with GPS, we can find the location of the passenger enter and exit [3]. Using the location we can find the distance travelled and amount. The amount can be withdrawn from the smart card. A microcontroller can be used to program this system by interfacing GPS and smart card. By implementing this system the usage of loose cash can be reduced and efficient ticketing can be implemented.

1.1 Existing System

In the general way, every bus is controlled by a conductor. The conductor will collect money from each passenger and issue ticket. Initially, printed papers or tokens are used as tickets. Nowadays, handheld machines are used to print tickets.

This system has many disadvantages. The passenger have to carry the ticket till the end of travel, the conductor should ensure that everyone has got the ticket, [3]the time taken for ticketing is comparatively more and more amount of paper is needed to print the Ticket. Nowadays conductors are trained to operate the handheld ticketing machine.

For example, if a passenger wish to travel in bus. He has to carry money with him. Then conductor will collect the money and he will give ticket. This has to repeat for all passengers. This will take more time and waste of human resource as well as energy. Even handheld ticketing machine is comparatively slow and need trained person to operate it.

2. Proposed Methodology

GPS is the latest technology used in various fields such as navigation [4], tracking and also in some of surveillance applications. Here we are going to use this GPS to calculate the distance travelled by the passenger. GPS module can configured to generate the latitude and longitude of the current position of the bus. The position of the bus can be monitored continuously using this GPS module.

Smart cards can provide identification, authentication, data storage and application processing [5]. These smart cards can be used as passenger identifications. Every passenger carries a smart card. The smart card has the information such as user identification number, available balance and status register [7] .These smart cards should be capable of recharging, so that the passenger can use it again and again.

Combining GPS technology and smart cards we can design a complete bus ticketing system [6]. A microcontroller is used to control the entire system. GPS and smart card reader are interfaced with themicrocontroller. It can be further connected with liquid crystal display and keyboard for user interface.

Every time when the passenger enters the bus he needs to swipe his smart card in the smart card reader [3]. The card

has a unique identification number, balance detail and a status register. The frame format in the smart card of the above details is shown in Fig.1 [3].

UNIQUEID IDNO.	ST STATUS REGISTER	BBALANCE

Figure 1: Smart card frame format

These details stored in the smart card are transferred to the microcontroller. Initially the microcontroller will check the validity of the card and balance available. Then microcontroller sends a request for current location to the GPS module. The GPS module sends back the latitude and longitude position to microcontroller.

Microcontroller has a lookup table which consist the information about the bus stop name according to the latitude and longitude data sent by the GPS system [3]. Every time when user swipe his card on entry the microcontroller checks the lookup table and store the appropriate location with the passenger details in the memory array.

While exiting the bus the passenger should swipe the card again. On swiping card for the second time the microcontroller will retrieve the data about the particular passenger and calculate the distance travelled. The bus fare for the distance travelled is not uniform. It is non-linear i.e., for more distance travelled the amount per kilometre is less. This can be determined using another lookup table.

On calculating the bus fare the equivalent amount is reduced by the user. This smart card can be recharged for further travelling when the balance is low.

2.1 Architecture

Figure 2 shows the block diagram for interfacing of the peripherals with the microcontroller.

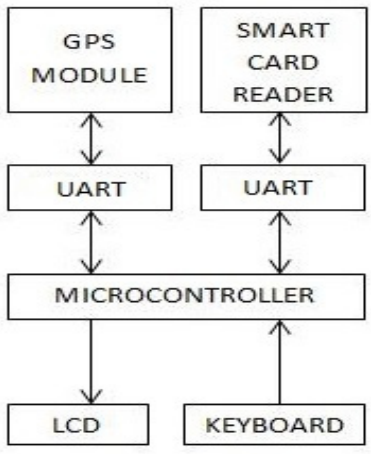

Figure 2: Block diagram

In the block diagram, the UART are used to establish serial communications between the GPS module and smart card reader and microcontroller.

GPS module has many configurations. For each configuration it will transmit different data such as time, date, latitude position, longitude position, velocity etc. Here it is enough to extract latitude and longitude positions. Smart card should have enough memory space for storing the passenger details.

Were LCD and keyboard are user interfacing peripherals. Keyboard is used for entering the number of passengers travelling using same smartcard. LCD is used to acknowledge the passenger about amount detected and one more LCD can be used to display the next bus stop.

2.2 Flowchart

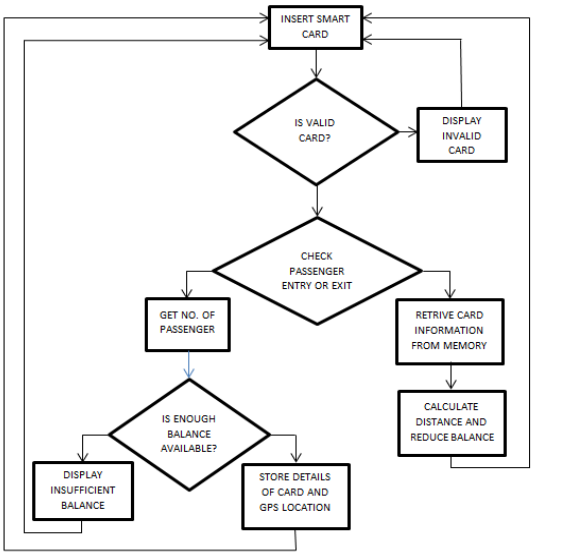

Figure 3: Operation of the system. The GPS locations are updated continuously

2.3 Lookup Tables

The lookup tables are preprogramed tables consists of fixed variables that can be stored in the memory of the controller [5]. It can be used as reference for further programming. Here we used two lookup tables. One for location identification and another for distance calculation.

Table 1: Bus stop identification

BUS STOP NUMBER	BUS STOP NAME	LATITUDE	LONGITUDE
1	FIRST	X1	Y1
2	SECOND	X2	Y2
.	.	.	.
.	.	.	.
.	.	.	.
N	NTH	XN	YN

Table.1 is an example of bus stops. The latitude and longitude position from the GPS module is compared with the lookup table shown; the bus stop number and location are extracted.X1,X2,…,XN and Y1,Y2,…,YN represent the appropriate bus stop latitude and longitude position.

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The bus stop number used to calculate the distance travelled and bus stop name is used to for displaying purpose. Bus stop name can be stored in ASCII format [6].

Table 2: Distance & amount calculation

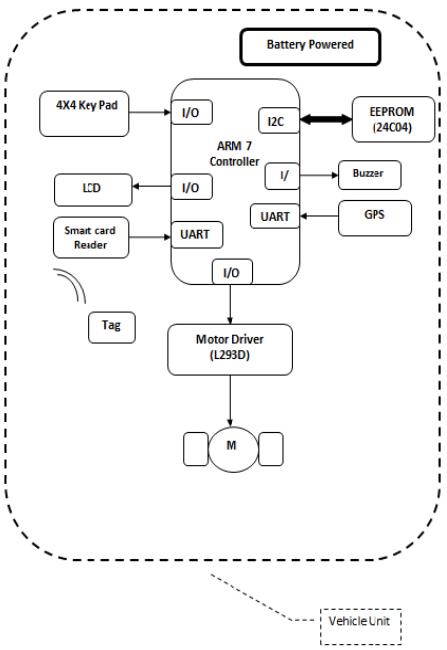
BUS STOP		DISTANCE	AMOUNT
FROM	TO		
1	2	X12	Y12
1	3	X13	Y13
.	.	.	.
.	.	.	.
1	N	X1N	Y1N
2	3	X23	Y23
.	.	.	.
.	.	.	.
2	N	X2N	Y2N
.	.	.	.
.	.	.	.
N-1	N	X(N-1)N	Y(N-1)N

Table.2 used for distance calculation is shown. The purpose of this table is to fix the bus fare between bus stops as the fare is non-linear. From the retrieved data the location from where the passenger travelling and the destination location from the GPS lookup table are compared with this lookup table and then appropriate amount is reduced from the smart card. The distance travelled and amount reduced can be displayed to acknowledge the passenger in LCD. X12, X13, X (N-1) N and Y12, Y13, Y (N-1) N are the distance between the bus stops and the equivalent amount for the distance travelled.

2.4 Problem Finding

Hardware debugging is the major problem. We fabricate all the components in PCB and test Power supply; Input and Output ports, if the ports are not working then check the code in simulation and rework the hardware.

2.5 Block Diagram



3. Software Used

- Keil Software
- Compiler
- Flash Magic
- Embedded C Language
- Proteus

3.1 Hardware used

- ARM 7 LPC2129
- EEPROM 24LC04
- L293D Motor Driver
- GPS
- 4X4 Keypad
- 16X2 LCD
- RFID Reader
- RFID Tags
- DC Gear Motor
- Buzzer

4. Development of Project

Before we go in to the project let us know about the Embedded Systems. Since the project was developed in embedded system, we will have a small glance about embedded System.

4.1 Embedded System

An embedded system can be defined as a computer system designed to perform specific functions. This generally goes with real-time computing constraints. Embedded systems bring together software, hardware and mechanical parts with either fixed or programmable capabilities. Embedded systems are very specific, and built to handle a particular task. The processing cores are crucial for the working of any embedded system. These processing cores are either microcontrollers or digital signal processors (DSP). The possible hosts of an embedded system are industrial machines, automobiles, airplanes, trains, medical equipment, video cameras, phones, PDAs, home appliances, vending machines and toys.

4.2 Application of Embedded System

In real life we are using so many embedded systems for example Home application (microwave oven, washing machine, security system DVD, Mp3 player etc) Air craft, missiles, automotive, nuclear research, personal use (mobile phone, I pod)

4.3 Types of Embedded System

Embedded System is broadly categorized as:

1. Standalone embedded system Example: Washing Machine.
2. Networking embedded system Example: Network Printer

4.4 Characteristics of Embedded System

The development of project is divided in to three stages as follows:

1) Embedded systems are designed to do some specific task, rather than be a general-purpose computer for multiple tasks. Some also have real-time performance constraints that must be met, for reason such as safety and usability; others may have low or no performance requirements, allowing the system hardware to be simplified to reduce costs.
2) Embedded systems are not always separate devices. Most often they are physically built-in to the devices they control.
3) The software written for embedded systems is often called firmware, and is stored in read-only memory or Flash memory chips rather than a disk drive. It often runs with limited computer hardware resources: small or no keyboard, screen, and little memory.

5. Proposed Method and Working

With its unique features, Automated Fare calculation System Public transport system [2]: An Economic & Management Approach Transit Systems provides a wealth of resourceful information to everyone with interest in mass transit, Public Transportation for Automation in Fare Collection.

5.1 Working

In Automated fare collection system, the unit has 2 modes;

1. Admin mode
2. User mode

Every time the unit is switched on, it will give a welcome note with mode selection. The modes are selected via keypad interfaced with micro.

Admin Mode

When the admin mode is selected, it gives three options:

1. Location Fixing
2. Add User
3. Recharge user card

Location Fixing

The admin responsible for the unit takes the unit to the locations and will saves the location details like latitude and longitude values to the EEPROM.

Add User

When this option is selected, the admin can add new user along with his recharge details and saves those in to EEPROM.

Recharge user Card

This option is used to recharge user card if their card balance got empty.

User mode

When the user mode is selected, it gives two options;

1. Enter destination
2. Auto mode

Enter destination

When this mode is selected, the user can show his unique digital ticket and can select the destination. The unit will automatically reduce the fare from his account and will update the data into the EEPROM. When the user reaches the destination, the vehicle will stop automatically and triggers a buzzer.

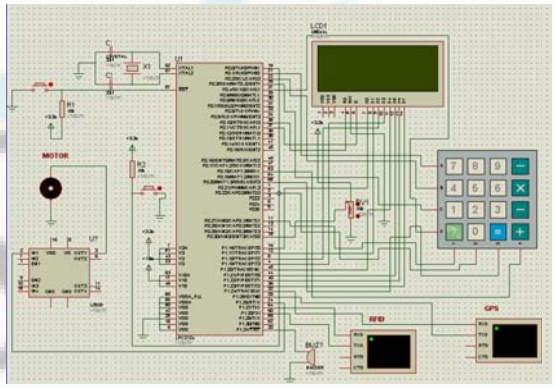
Auto mode

When this mode is selected, the user can show his unique digital ticket and no need to select the destination. The unit will automatically update the longitude and latitude data into the EEPROM. When the user reaches the destination, we have to swipe the card again and the unit will automatically calculate the distance and reduce the balance from their account.

Future Enhancements:

Instead of saving all the parameters in to a small EEPROM, the data can be saved into a server using GPRS, so that this system will be sued for large masses as in INDIA.

Circuit Diagram



First Stage: Testing of Software

We chose the microcontroller such that it will support my peripheral and support my hardware. Because microcontroller is the main hart of the part, according the embedded system definition we can concludes that, the hardware is also of the major part of the project

1. Microcontroller LPC2129
2. Smart Ticket SMART CARD

3. Transports system for Bus Model DC gear Motors
4. To drive the Motor L293D Motor driver
5. Display 20X4 LCD
6. Key pad for enter Data 4X4 Keypad
7. Tag Redder SMART CARD/RFID redder
8. Memory for Storing Data EEPROM
9. To find lactation GPS

The project is initiated with microcontroller. I chose ARM 7 and the IC number is LPC2129 because it supports my needs in this project. The following are the list of projects required to complete the project. It has in built UART to connect my GPS and smart card reader.

We should know about the microcontroller pins and its power supply design parameters. It helps us to buy a Printed circuit board (called PCB) after purchasing PCB will start testing like its Pin and power supply. On the same time we will start working in programming too. We write program to LPC2129 in C language.

To develop the program we use Keil software. Which support to develop the c program and also to compile and save the program.

Second Stage: Testing of Hardware

ARM LPC2129 PIN used in the Project

Input and Output Pins (I/O):

- 4X4 Key Pad
- Buzzer
- DC gear Motor (12v)
- 20X4 LCD

UART:

- RFID Reader
- GPS

I2C:

- EEPROM (24C04)

UART PINS:

PIN No for Details

19 Tx UART -1 transmitting pin
21 Rx UART -1 receiving pin
33 Tx UART -2 transmitting pin
34 Rx UART -2 receiving pin

Input and Output Pins (I/O) For 4X4 Key Pad

35 I/O
36 I/O
37 I/O
38 I/O
39 I/O
41 I/O
16 I/O
46 I/O

Input and Output Pins (I/O) For 20X4 LCD

12 I/O
8 I/O
4 I/O
48 I/O
44 I/O
40 I/O
36 I/O
32 I/O
28 I/O
24 I/O

Input and Output Pins (I/O) For Buzzer

55 I/O

Input and Output Pins (I/O) For DC gear Motor

1 I/O

I2C Pin Details for Connecting EEPROM

26 SDA: Serial Data PIN
27 SCL: Serial Clock PIN

Hardware Used

a) **4X4 Key Pad**

The 4 x4 matrix keypad is a general-purpose keypad. It consists of 16 switches arranged in 4 rows and 4 columns. It can connect to the MCU 8-bit port directly. The keypad is marked with numeric keys (0–9) and with function keys (A–F), as shown in Figure. It used to enter data to the controller.

b) Buzzer

A buzzer or beeper is a signaling device, usually electronic, typically used in automobiles, household appliances such as a microwave oven, or game shows.

c) DC gear Motor (12v)

In any electric motor, operation is based on simple electromagnetism. A current-carrying conductor generates a magnetic field; when this is then placed in an external magnetic field, it will experience a force proportional to the current in the conductor, and to the strength of the external magnetic field. As you are well aware of from playing with magnets as a kid, opposite (North and South) polarities attract, while like polarities (North and North, South and South) repel. The internal configuration of a DC motor is designed to harness the magnetic interaction between a current-carrying conductor and an external magnetic field to generate rotational motion.

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d) 20X4 LCD

This section describes the operation modes of LCDs, and then describes how to program and interface an LCD to PIC Microcontroller.

e) RFID Reader

RFID reader is the device used to read the RFID card.

f) GPS

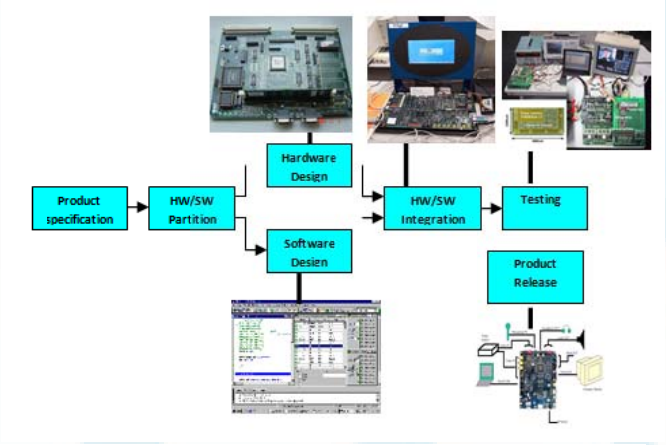
GPS is the device used to get the location details time to time.

g) EEPROM (24C04)

EEPROM is used to store the user date and location detail.

Third Stage (3): Testing of Hardware

Both software and hardware are combined together and the desired outputs are tested

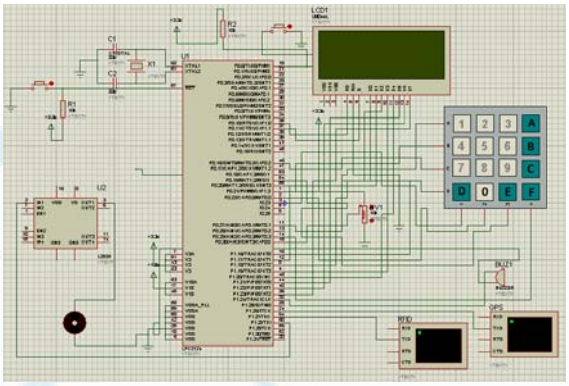


Simulation Methodology

- Proteus is software for microprocessor simulation, schematic capture, and Printed Circuit Board (PCB) design.
- You can build any project on your computer screen using Proteus.
- Proteus also has the ability to simulate the interaction between software running on a microcontroller and any analog or digital electronics connected to it.
- It simulates Input / Output ports, interrupts, timers, UARTs and all other peripherals present on each supported processor.

But we can't get the complete simulation result in the proteus because we can't add working GPS and smart card in the simulation.

Circuit Diagram



6. Conclusion

By implementing this paper as a real time project many disadvantages mentioned early can be rectified. The time taken by the microcontroller for computation will be in few microseconds, so time consumption is reduced. Nowadays almost everyone has ATM card or credit card. This system can be upgraded by changing the program for using ATM card or credit card instead of smart cards. Also can use GPS module to transmit bus location to the bus terminal so that the user can find the correct location of the bus and also can't find when the next bus will arrive. Further GSM can be adding to find the location of bus via sms.

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