"Tap-&-Pay"
A Universal Transport Billing System Using RFID Smart Card

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Abstract— **It is the era of technology, people are highly dependent on carrying out their business (money) transactions through internet based services. Most of the fairing/billing systems are now available with online support. Hence to integrate all applications in one system we are introducing Universal Transport Billing System Using RF-ID (Radio Frequency Identification) card. In public transportation system at present we use paper tickets which are printed by a small machine with a key pad. In this system we don't know the details of passengers who are using the public transport. The system requires user details in order to provide security during identification process. The details are also required in order to provide notifications via SMS to the user. In our proposed system, automatic ticketing is done with the help of RF-ID technology. The RFID card can be used for billing of systems like buses, petrol, toll and parking. The amount is deducted from passenger's account according to the mode selected by passenger as traveled respectively. Thus, users will not have to carry cash and the system becomes more convenient. The main advantage of the system is that the transaction & fare calculation is automated and secured. The total system mainly acts to bring out the consistency in the public transport system that will conclude in uniform access of passengers in daily rides through an automated server being updated every single time the passengers travel by carrying the RFID based tickets.**

Index Terms— **EM-18, RFID, RFPro.**

I. INTRODUCTION

In megacities, there are various transport services available for public travelling all over the city such as buses, cabs, etc. Among these transportation system, most of the transport services use paper based ticketing. This type of services leads to chaos among public, system loss, corruption and most of all traffic jams that is responsible for wastage of time, money and environmental loss. Again having no government authority to take control of keeping an eye on public as well as private transport services, leads to autocratic raise in fairs, corruption is possible or might occur.

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Current transportation services need some changes for satisfying the general public. These services are either operated by state run authorities or private organizations. Both public and private organizations are not concerned about the detail information of passengers, transportation used by individuals as well as location travelled by the passengers respectively. These all aspects are necessary in order to keep a track on activities performed by individuals.

The Universal Billing Transport System using RF-ID card proposed by us ensures for ticketing system that can be merged to solve above problems. We have proposed this system through RF-ID based tickets for low cost, easy operations, portability, durability, reliability and being much more user friendly. Also the high speed of RF-ID tags and detectors make the tracking system of any transport system merely a child's play.

Public carrying RF-ID based electronic tickets will have access to any transportation system within entire city by only by specifying source and destination location to the system. The data will directly be transferred to the server's main database and the equivalent credit will be stored in the corresponding system account. By using this automated system we will save time, have a higher authoritative inspection and reduce chaos and confusion on roads.

II. LITERATURE SURVEY

R.Daniel, P.Prudhvi Kiran and Sk.Nagoor [4] explained hardware interfacing for "Messages" in regulation of Attendance. But only verification was explained, working of RFID was not explained. The major issue was security which was also not explained. Piyush Chandra, Prakhar Soni and Rakesh Kumar Keshar [1] explained how to overcome issues of current conventional bus systems and better monitoring for buses. But it didn't explained hardware part that is interfacing techniques with the software. The part of mapping of software with hardware was not stated. S.Archana Mala and Mrs.N.Leela [3] explained notification given by GPS when destination reached and the interfacing techniques. Mainly focusses on hardware implementation. Shilpa Rai and Ankan Priya [6] stated benefits over virtual financial transaction and ability to provide last transaction details. But the e-receipt was mailed, and not notified. V.Venkatakrishnan, R.Seethalakshmi [2] explained wireless technology which provided powerful management transport engine and sophisticated bus tracking through GPS. But it was applicable to Bus Transportation Systems only, implementation & working of Zigbee was not provided.

2.1   LIMITATIONS OF EXISTING SYSTEM

Existing systems are not automated completely that is there is a high level of dependency on the operator [4]. People wait in queue for hours to get monthly or yearly pass for public transportation systems like Bus, Train and Metro [5],[6]. Existing system do not store user's credentials or user's last transaction history. Existing systems use Paper for displaying the transaction process which is not at all Eco-Friendly [3], [7]. The problem of hard cash flow (that is Uneven Fare Rates in turn leading to Change Disputes) is commonly seen in existing systems [6], [8]. In countries with population similar to India, it is practically difficult to manage all the commuters travelling through public transports like bus, trains, metro etc. [6], [9].

III.   PROBLEM DEFINITION

To proposed Universal Transport Billing System using RFID that can be used for the billing of different transport systems like Bus, Parking Systems, Toll Collection Booth & Petrol by adding automation in the existing system for fare calculation and transaction providing e-tickets via messaging stating the status of transaction.

IV.   DEVELOPMENT APPROACH

The main approach for development of overall activities was the agile methodology. Agile provided us with several chances to access direction throughout development lifecycle. Regular meetings or "scrums" were held for 2-3 times within a week. Initially what tasks were completed was discussed. If some pending work was remaining then within a specified time, the task had to be completed. The next thing to be discussed was what task had to be further commenced and executed. Thus, further workload was discussed and scheduled to each group member. One member of the group was responsible for resource gathering. Thus for a specific requirement associated with a task to be achieved, others discussed and gave the requirement written to the member to avail the resources. There was retesting and reanalysis every time a task was completed for avoiding issues. When the expected results were achieved we moved on to the next task. Thus agility proved to be the major software building methodology. Agile approach was not only applied in designing but also during the actual implementation of the modules, both hardware and software. The module development phases were eventually divided and gradually modules were developed.

V.   PROJECT SCOPE

The project scope includes the website product as well as the hardware product. It also states the abilities of the product that it will accomplish. The scope also defines the activities which would not be performed by the system. Considering all facts, the scope can be stated as:-

i. The software product is the Tap-&-Pay website. Users register their details through the website. The website will help them get information about the usage of the card, topping up of the card, help services, etc.

ii. The hardware product is the RF-ID Card & Reader. The card will help the commuters in billing purposes while the reader only fetches the data from RF-ID tag.

iii. The system can keep records of transaction and provide it to the user if requested.

iv. The system also does not tend towards tracking of devices nor vehicles through the Global Positioning System.

v. Also there is no presence of the dynamic scheduling of the devices.

VI.   SYSTEM FEATURES

The system features specifies the functional and nonfunctional requirement. Functional requirements are the requirements which are given by the client. The client expects that all the given requirements are implemented in the system. The client may be an expertise or invoice client or organization. Hence, there are some factors which are to be considered in the system irrespective of the functional requirements. These requirements are given by the development team and they are termed as Non-functional requirements.

6.1 Functional Requirements

Functional requirements are the requirements given by the client (organization) for development of the product. With respect to our system, they can be listed as:-

1. **Website.**
   Purpose: - User Registration.
   Tool: - Dreamweaver.
   Programming Language Used: - PHP.
2. **Smart Card.**
   Purpose: - Identification.
   Technology: - Radio Frequency Identification.
3. **Card Reader.**
   Purpose: - Reading of RFID Tag / fetching the user data for identification.
4. **Database of User.**
   Purpose: - Maintain a record of transactions.
5. **Fare Calculation.**
   Purpose: - To calculate fare after user travels through transport mean
6. **Transaction.**
   Purpose: - To deduce balance from user account after the tap of the card. When transaction is successful message will be displayed as "Transaction Successful!"
7. **Notification.**
   Purpose: - To notify the user the status of transaction when it ceases at a particular   point (whether it has been successfully processed or halted at any point).
   Tool: - SMS through GSM Sim 900.
8. **Exception Popup.**
   Purpose: - Popup or notify for following exceptions:-
   •Balance falls below appropriate levels.
   •Identification unsuccessful.

9. Error Messages.

Purpose: -To know the type of error occurred during transactions.

Following error messages will be displayed:**-**

1. "Balance Low….!!!Please Recharge."
2. "Invalid User"

6.2 Non Functional Requirement

Non Functional requirements are the requirements specified by the development team irrespective of the requirements submitted by the client. These are the requirements which are supposed to be subjected on the system in order to guarantee other factors which are not considered.

They include:-

a) Performance Requirement

Higher performance will be gained if better and efficient readers are installed along with compact databases (at server side) with continuous, fast working internet, as well as user support in timely recharging of the card.

b) Safety Requirements

Validity of the system will be satisfied at any situation at any time provided the conditions of the system hold good. If the card is misplaced, then user has to first contact and register a complaint about the misplaced card. He/she will then apply for a new card. The balance will be checked for last transaction and the remaining balance will be transferred to the newly applied card.

c) Security

Security is required while identification process. If there is a loss of card, damage to the card, the card can be immediately blocked by contacting a care center or calling a help service. For this purpose, a PIN number will be provided. Website security is provided by using appropriate protocols like HTTPS. Also the website programming language plays a major role in which it is developed. Considering this, programming language used will be probably PHP.

d) Software Quality Attributes

Availability will be achieved if there is availability of the card readers at billing points as well as there is care centers for any kind of help, within vicinity.

6.3 Analysis Models

1. Class Diagram.

In fig 1, the class diagram includes several classes with respective class functions. The register class has the get info function which helps in taking the user data in database. Next we have the Login class to complete the registration process. After exchange of packets through sockets there is identification, in which database values are matched with values in RFID tag. Then the fare calculation class is implemented for fare calculation and finally there is transaction. After the transaction there is a notification class which helps to know the transaction status.
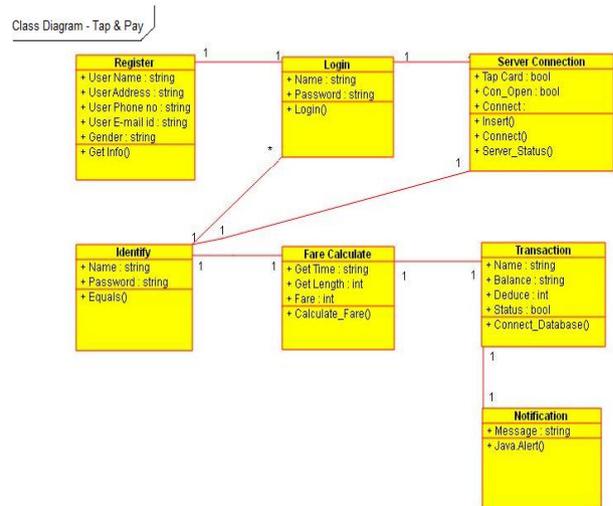

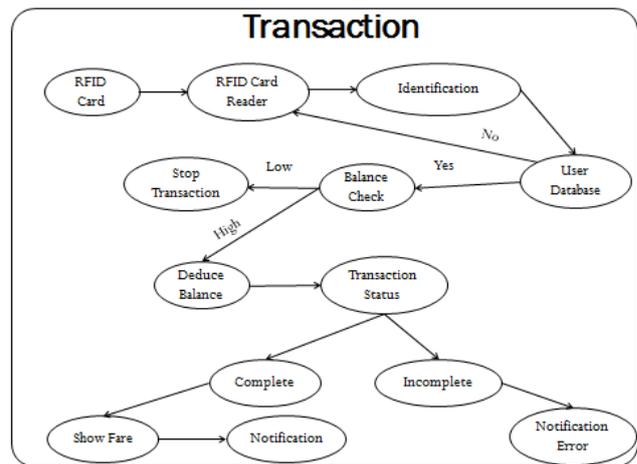Fig. 1 Class Diagram – Tap-&-Pay

2. State – Transition Diagram.

Fig. 2 State Transition Diagram – Transaction

Fig 2 explains that initially, state of the system is ideal. User taps the card on the reader. The card is then recognized and client - server communication is processed. The identification with the help of database record is done. If this succeeds then further processing will be done else user is requested to tap again. Then fare calculation is done. If the balance is greater than the minimum amount required, then the fare is deducted and details of transaction are notified to the user. Hence this is the final state of the system.

VII. SYSTEM DESIGN

The system design architecture includes the architecture of the system which is stated by functional block diagram. The fig 3 explains several entities that will be active as the user places the RFID card on the reader. The reader will then contact the server through internet and then it will be checked for user identification.
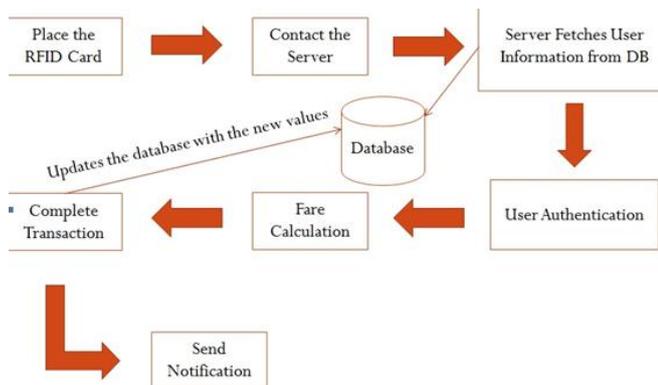
Fig. 3 Basic Functional Block Diagram
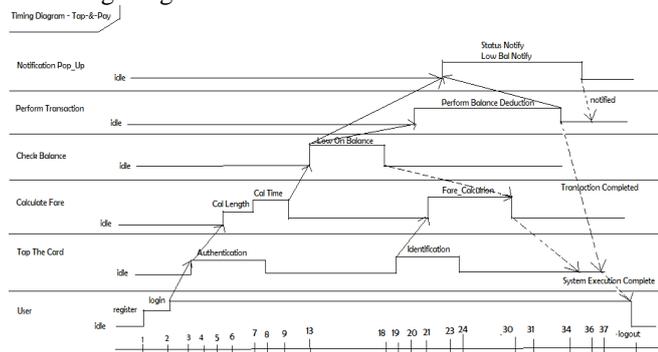
7.1 UML Diagrams

1. Timing Diagram

Fig. 4 Timing Diagram – Tap-&-Pay
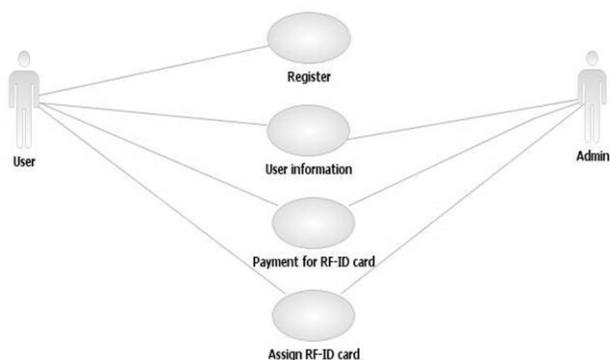
2. Use Case Diagram

Fig. 5 Use – Case Diagram – Registration

VIII.   TECHNICAL SPECIFICATIONS

Basically this project is divided into two sections:-
   i. Hardware Part   **ii.** Software Part

The Hardware components that we have used in the project are 9V 1A Transformer, 2 Pin Mains Cable, IN4001 Diode, 1000µF 16V Capacitor, 470µF 16V Capacitor, IC 7805, 89S52 Microcontroller, 11.0542 MHz Crystal, 16*2 LCD Display, IC Max 232, RFID Reader (EM-18) & Cards, 4*4 Keypad, RF-Pro Modems, Serial to USB BAFO Cable, SIM900 GSM Modem. These hardware parts constitute both sender and receiver circuit.

The Software Part (i.e. GUI of Website) is developed using following technologies:-

i.   PHP for the development of website.
ii. JavaScript for validations.
iii. MySQL Database.
iv. Xampp Server for Localhost Website Testing.
v.   Keil compiler for Microcontroller Code.

8.1 Project Estimate.

The main task is to estimate the cost and establish the budget. Project estimation includes considerations of several resources like software requirements, hardware requirements leading to conclusion of the ultimate budget. Project estimate also gives a rough idea how much longer the code will be i.e. estimated lines of code. To determine cost of project, basically four entities were considered: - Hardware, Networking, Documentation & Estimated lines of code.

Hardware estimation included the designing of circuits. After researching the basic hardware requirements, a list of hardware components was produced The overall hardware budget estimation was calculated as Rs 6000. Networking proved to be important resource during researching on a particular component for both hardware and software. The estimated network budget was calculated to be Rs. 1000. Documentation included hard copies of references, SRS, IJECS Paper, the project report1 and Project Report 2 and other miscellaneous printouts. The estimated budget was calculated to be Rs 1000. The lines of code included coding for fare calculation for several transport systems. It also includes socket programming which will be used for client – server communication. The main part of coding includes the coding of website designing. The overall estimate can be stated as: -

Table 1 Estimated Lines of Code

Sr.no.	Code	Lines Of Code
1.	Fare Calculation	200
2.	Transaction Algorithm	300
3.	Database Connectivity	250
4.	Identification	50
5.	Website Designing and Building	2050
6.	Notification Coding	100
7.	Hardware Coding	500
8.	Estimated Total Lines Of Code	3450

IX.   IMPORTANT MODULES AND ALGORITHMS

1. **Registration –** Here the user will register for the RFID card by entering all the necessary credentials.
2. **Delivery of RFID Card to the user –** After successful registration, user will be provided a unique RFID card.
3. **Using the card for Transaction –** RFID card can be used for ticketing of Bus, Cab, Parking, Toll or Petrol.
4. **User Identification –** After the contact of RFID card with Card Reader, user will be identified.
5. **Balance Verification –** Balance will be verified and if there is appropriate balance, transaction will proceed else it will fail.

6. **Processing of Transaction –** Transaction will be done according to the calculated fare.

1. **Algorithm for Hardware Usage**
   a. Start
   b. User enters details into registration form. Details stored in userdb table on-click of submit.
   c. User amount stored in Tap-&-Pay wallet in amount.
   d. A RFID card with unique id will be allotted to the user.
   e. User taps the card on the EM-18 reader installed at transaction spots i.e. in Buses, Toll booths, Parking stations and Petrol Pumps.
   f. A message is displayed on reader :- "Enter Mode"
   g. User then selects the mode of transport through keypad: 1 for Bus, 2 for Toll, 3 for Parking & 4 for Petrol.
   h. After filling all data, mode of transport|12 bit RFID number | Parameters according to mode which are sent to server.
   i. If User RFID number is not present in the userdb table, a message is displayed "Invalid User".
   j. If amount is not appropriate, a message is displayed on LCD "Low on Balance".
   k. If transaction is completed, fare is send back to the controller displaying message on LCD "Fare Calculated: Rs. XYZ".
   l. Finally the details associated with the record is send in a form a message to the user specifying the details of transaction and user balance in the account.
   m. Stop.

2. **Algorithm for Bus Module**
   a) Start.
   b) User enters mode : 1 (Bus Mode)
      LCD displays message: - BUS MODE
      LCD displays message: - ENTER SOURCE
      User enters source. Example: - 02.
      LCD displays message: - ENTER DESTINATION
      User enters destination. Example:-07.
   c) The MODE|RFIDNUMBER|SOURCEDESTINATION are send to server. These values are stored in database in a table temp table.
   d) Initially it is checked weather user is registered to the system by comparing RFID number with the RFID number from userdb table. Then user account balance is checked, if appropriate, the mode i.e. the first digit in the string is compared. It then enters into toll mode.
   e) Then values are fetched from table into variables. Source is fetched and copied into variable $src and destination value is fetched from table and copied in $src.
   f) $fare1 = ($dest-$src/2)+8;
   g) $fare is then sends to controller to be displayed on LCD.
   h) From wallet exact amount is deducted and database record is updated.
   i) The updated record details are sent to user via a SMS using GSM 900.
   j) Stop.

3. **Algorithm for Toll Module**
   1. Start.
   2. User enters mode : 2 (Toll Mode)
      LCD displays message: - TOLL MODE
      LCD displays message: - ENTER VEHICLE TYPE

User enters what type of vehicle they are travelling in. Example: - 04 (For Heavy Vehicles).
LCD displays message: - ENTER JOURNEY TYPE
User enters journey type weather he wants to have a single or return journey. Example:-01.
3. The MODE | RFIDNUMBER | VEHICLETYPE | JOURNEYTYPE are sent to server. These values are stored in database in a table temp table.
4. Initially it is checked weather user is registered to the system by comparing RFID number with the RFID number from userdb table. Then user account balance is checked, if appropriate, the mode i.e. the first digit in the string is compared.
5. Then values are fetched from table into variables. Vehicle type is fetched and copied into a variable $t_vehtyp and journey type value is fetched from table and copied in $t_jourtyp.
6. Based on the values received, corresponding values are deducted. Example. If Vehicle Type is Car i.e. 01 and it is return journey i.e. 02, then Fare Calculated is Rs. 50. Fare calculated is stored in $fare
7. $fare sends to controller to be displayed on LCD.
8. From wallet exact amount is deducted and database record is updated.
9. The updated record details are sent to user via a SMS using GSM 900.
10. Stop

4. **Algorithm for Parking Module**
   1. Start.
   2. User enters mode : 3 (Parking Mode)
      LCD displays message: - PARKING MODE
      LCD displays message: - ENTER VEHICLE TYPE
      User enters what type of vehicle they are travelling in. Example: - 01 (For Bikes)
   3. The MODE|RFIDNUMBER|VEHICLETYPE are sent to server. These values are stored in database in a table temp table.
   4. Initially it is checked weather user is registered to the system by comparing RFID number with the RFID number from userdb table. Then user account balance is checked, if appropriate, the mode i.e. the first digit in the string is compared.
   5. Then values are fetched from table into variables. Vehicle type is fetched and copied into $t_vehtyp.
   6. Based on the values received, corresponding values are deducted. Example. If Vehicle Type is Bike i.e. 01, then fare calculated is Rs. 10. Fare calculated is stored in $fare
   7. $fare sends to controller to be displayed on LCD.
   8. From wallet exact amount is deducted and database record is updated.
   9. The updated record details are sent to user via a SMS using GSM 900.
   10. Stop.

5. **Algorithm for Petrol Module**
   1. Start.
   2. User enters mode : 4 (Petrol Mode)
      LCD displays message: - PETROL MODE
      LCD displays message: - ENTER AMOUNT
      User enters amount. Example: - 300.

3. The MODE|RFIDNUMBER|AMOUNT are sent to server. These values are stored in database in a table temp table.

4. Initially it is checked weather user is registered to the system by comparing RFID number with the RFID number from userdb table. Then user account balance is checked, if appropriate, the mode i.e. the first digit in the string is compared. It then enters into petrol mode.

5. Then values are fetched from table into variables. Amount is stored in $petrol. The $petrol value is copied into $fare. The $fare is deducted or reduced be $fare value from user wallet.

6. $fare sends to controller to be displayed on LCD.

7. Database record is updated and details are sent to user via a SMS using GSM 900.

8. Stop.

X. EXPERIMENTATION

10.1 Assumptions

1. The reader-machine (EM18–Reader Module, 89S52 Microcontroller Circuit along with RFPro Modems) are installed at every spots where are required.

2. For transferring RFID data from a remote transaction point to main server, several RFPro modems are installed.

3. Within a radius of 1.5 Km, there is at least one office for carrying out activities like Top-up of card in offline mode, getting transaction status, reporting for thefts, card damage and so on.

4. Maintenance service is available 24 hours in case a machine breaks or other such hardware/software maintenance issues occur.

5. Helpline Service is available 24 hours for customer support.

10.2 Experiment Steps

Following experimentation steps were carried out:-

1. GUIs were built page by page. During building of GUIs, there was a huge discussion about how the database should be designed and what tables should be created.

2. After completion of GUIs we integrated the pages and developed our databases.

3. Then the website was partially completed as there involved a dependency of hardware data in one of the table. Hence, the work of website was successfully completed.

4. Then came the part of building of hardware. All the necessary components were mounted and corresponding PCBs were designed.

5. The sender part was mounted and connected and testing only on sender was done. After successful results, work of receiver circuit was implemented. It was tested too and finally the task of mapping was remaining.

6. After mapping of hardware with software the overall testing was performed.

7. The card was tapped on the EM18 reader. The reader recognized the data and sent it to receiver or server. The RFID data was identified and balance check was performed according to designed code.

8. After balance check, fare was displayed on LCD and fare value was deducted. The database was updated and a message was received to a particular registered user describing transaction details.

XI. SOFTWARE TESTING

Software Testing is an investigation conducted to provide stakeholders with information about the quality of the product or service under test. Software Testing can also provide an objective, independent view of the software to allow the business to appreciate and understand the risks of software implementation.

9.1 Screenshots of Test Cases

1. Test Case T01

Fig. 6 Test Case 01

2. Test Case T03

Fig. 7 Test Case 03

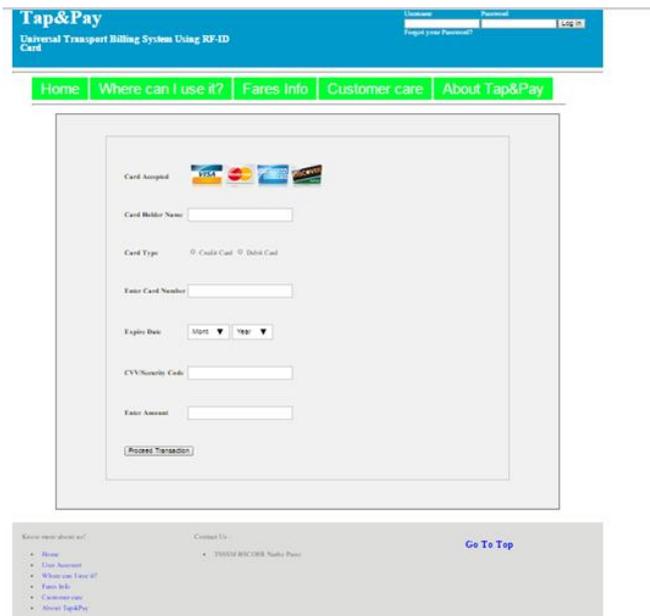## XII. RESULT & SNAPSHOTS

1. Screenshot - Gateway

Fig. 8 Screenshot – Gateway
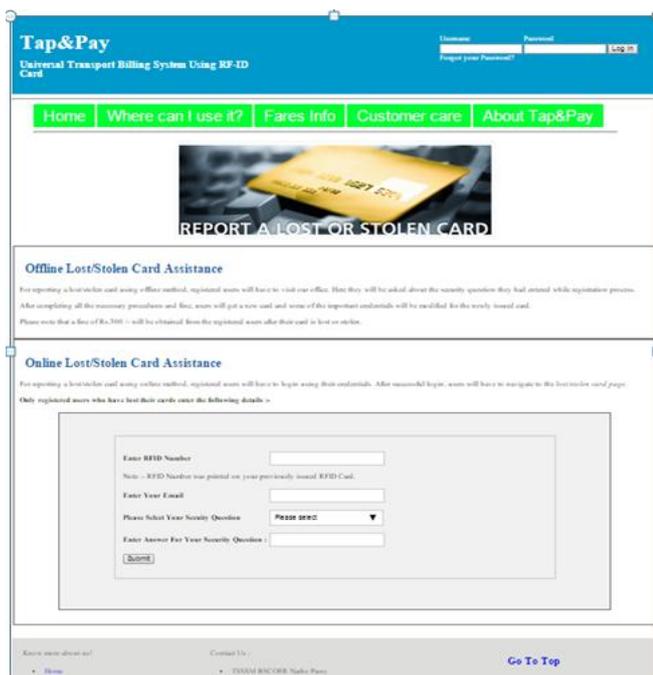
2. Screenshot - Lost or Stolen

Fig 9. Screenshot – Lost or Stolen

Above screenshots include the gateway page and the stolen or lost page. The gateway page specifies gateway for online transaction where user pays amount through online mode and gets registered to the system. The second screenshot specifies what user should do if their card gets damaged, if it gets stolen or if it is lost. In such a case user has to immediately register a complaint at Tap-&-Pay website. They will have to pay a small fine in order to get a new card. During, this process, user's current balance is transferred to new card.

Correspondingly, database records are updated.
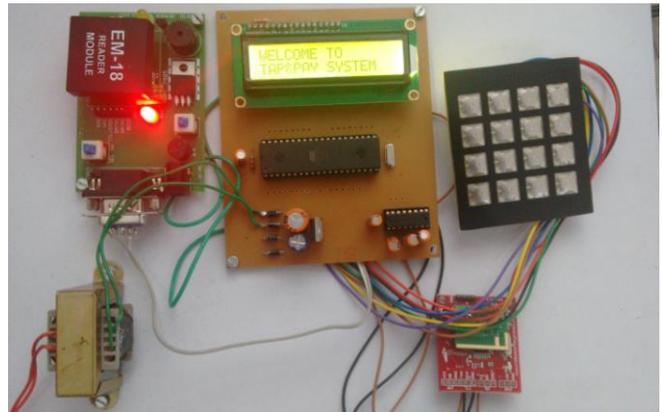
3. Hardware Circuit – "Welcome To Tap-&-Pay System"

Fig. 10 – Welcome to Tap-&-Pay System
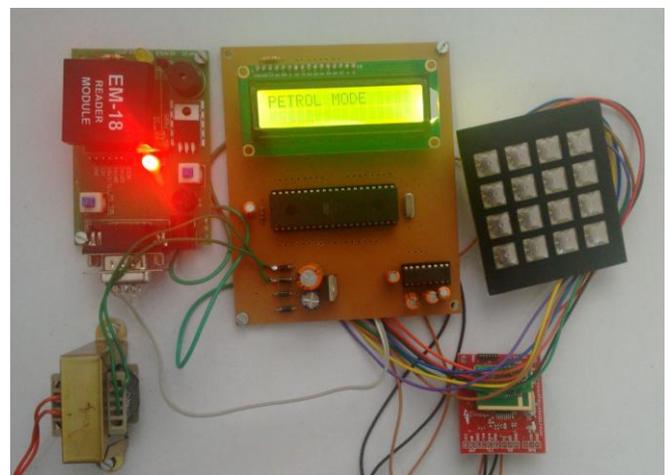
4. Hardware Circuit – Petrol Mode.

Fig. 11 – Petrol Mode

XIII. CONCLUSION

Using the Tap-&-Pay Card commuters will have to carry just one card for the transaction of transport services like bus, toll, parking & Petrol. Our proposed system provides fully automated process of transaction. User can simply register into our system and recharge their account, view transaction history, modify their account, ask for a new card when their card has been stolen. Our system provides SMS based notification. This SMS Notification displays all the transaction details along with the date and time. Also note that some of the exceptions messages will also be sent via SMS. The system can be accessed from anywhere and using any device that can allow internet access. Hence users can top-up their account from anywhere. Security is provided at every stage of the system. From Registration, Payment to Lost/Stolen Card Stage, the system is secured with Payment Gateway and Industry Standard Protocol. Registered users who have either lost or stolen cards can report their card loss to us and after completing the fine procedures, users will be provided with a new card. Note that the balance will be carry forwarded to the new card also.

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