Mobile Ticketing for Metro (MTM): An Improved Algorithm for Optimizing Ticket Re-Usability and Validation Techniques

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Abstract— The daily congestion in the metro stations create havoc for the daily passengers. This research paper addresses the problem of congestion and provides a solution for easy and quick commutation by the use of an application in smart phones being used worldwide. The application provides tickets to the passengers by generating barcodes, which are valid for a stipulated period of time to avoid corrupt use of the generated ticket.

Key words: Barcode, Wireless and Cellular Technology, Online Payment, Android Application, Sqlite

I. INTRODUCTION

The long queues people have to face while travelling in metros to a destination is gruesome and tiring. To provide a relaxing journey and an efficient mode of payment, we have come up with the "Quick Commutation System". This system, through an android application on smart phones, will let the passengers select tickets according to their respective destination and enter their bank account pin to pay for the ticket. Once this is done, a barcode will be generated which will be scanned prior to entrance into the platform. The barcode will be deemed invalid when the passenger leaves the metro station. The barcode generation and ticket generation follow particular algorithms which are implemented in the android application using JAVA code. The user can make use wireless networking through its implementation in Wi-Fi or also use the implementation of cellular networking through the use of data cards recharged into their smartphones to make internet access.

II. EXISTING APPLICATIONS

In order to facilitate convenient ways of ticket generation and reduce hassle at metro stations, a number of systems and procedures have been proposed by various companies and researchers, (for example, in US8543813, US20140164161, WO2013021394A1 etc.). But in general, while systems are capable of reducing commotion, they suffer from several significant shortcomings and drawbacks.

A. Shortcomings of the existing applications

- They have not kept any check for validation of the tickets generated.
- Regeneration of the same tickets after used by one customer hasn't been looked into. If tickets once generated are not allotted to another customer, it becomes difficult to cater to the large number of customers availing the service.
- The numbers of unique tickets generated are bounded by the unique bar code number (in this case, six). Hence, recycling of the bar codes greatly broadens the customer base.
- Technology related to mobile ticketing has not been implemented on currently used, mobile OS.

III. PROPOSED METHOD

A. The Design

Our proposed method requires:

- Access to the internet(via Wi fi or data card)
- A smart-phone which has the Mobile Ticketing for Metro (MTM) App downloaded in it
- A barcode reader(scanner)

1) Access to the Internet:

a) Cellular Network (used technology in Data cards)

A cellular network is a radio network distributed over land through cells where each cell includes a fixed location transceiver known as base station. These cells together provide radio coverage over larger geographical areas. User equipment (UE), such as mobile phones, is therefore able to communicate even if the equipment is moving through cells during transmission. Cellular networks give subscribers advanced features over alternative solutions, including increased capacity, small battery power usage, a larger geographical coverage area and reduced interference from other signals. Popular cellular technologies include the Global System for Mobile Communication, general packet radio service, 3GSM and code division multiple access.

Cellular network technology supports a hierarchical structure formed by the base transceiver station (BTS), mobile switching center (MSC), location registers and public switched telephone network (PSTN). The BTS enables cellular devices to make direct communication with mobile phones. The unit acts as a base station to route calls to the destination base center controller. The base station controller (BSC) coordinates with the MSC to interface with the landline-based PSTN, visitor location register (VLR), and home location register (HLR) to route the calls toward different base center controllers.

Cellular networks maintain information for tracking the location of their subscribers' mobile devices. In response, cellular devices are also equipped with the details of appropriate channels for signals from the cellular network systems

b) Wi-Fi-based positioning system (WPS)

Wi-Fi-based positioning systems (WPS) are designed to support the acquisition of accurate location information with technology other than Global Positioning System (GPS). These systems have the potential to supplement GPS where GPS is unreliable, specifically, indoor environments. Recently, Location Based Services (LBS) have become increasingly popular for many mobile device users. These new mobile devices incorporate various wireless technologies, such as Wi-Fi, A-GPS, Bluetooth, and GSM. While each of these technologies contributes to the integration and development of LBS, Wi-Fi has been most widely employed as an alternative positioning service.

Indoor location uncertainty with Wi-Fi stems from utilizing an unreliable database for wireless router locations and not fully utilizing and correcting received signal strength. Furthermore, database information is often collected using unreliable and unsecure methods.

c) Wireless Sensor Network (WSN)

WSN is an emerging technology, which has revolutionized the data collection in real time from the field (location), which will help to improve the decision making process to a large extent and help user to draw contingent measures in real-time Manner. A wireless mesh network (WMN) can be seen as a special type of wireless ad-hoc network. It often has a more planned configuration, and may be deployed to provide dynamic and cost effective connectivity over a certain geographic area. A wireless mesh network (WMN) is a communications network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may, but need not, connect to the Internet. The coverage area of the radio nodes working as a single network is sometimes called a mesh cloud. Mesh networks may involve either fixed or mobile devices.

d) WI-FI as a part of Location Based System (LBS)

Wi-Fi Positioning System (WPS) uses wireless fidelity network instead of GPS or cell tower systems or location beacons to determine position. This consists of a nationwide access points or network of location beacons used for pinpoint measurement of user's position and is better than satellite positioning system. There are several Wi-Fi positioning software available that uses radio signals emitted from wireless routers to determine the exact position of any Wi-Fi enabled devices including PC, laptop, PDA and smart phone. The operator that provides Wi-Fi services has their own database containing information about every access points in a particular area. So when a user enter into an area then the software search for access points and then calculates the exact position of the user by selecting and comparing them to the reference database. For more accuracy, there needs to be more access points with more Wi-Fi signals.

2) Smartphone with the MTM App

a) Smartphones:

A smartphone is one device that can take care of all of your handheld computing and communication needs in a single, small package. It's not so much a distinct class of products as it is a different set of standards for cell phones to live up to.

Unlike many traditional cell phones, smartphones allow individual users to install, configure and run applications of their choosing. A smartphone offers the ability to conform the device to your particular way of doing things. Most standard cell-phone software offers only limited choices for re-configuration, forcing you to adapt to the way it is set up.

Fig 1: Variety of smartphones in the market

b) The MTM App:

This Application once downloaded acts as the interface for the user to generate virtual tickets for availing the metro. The Application consists of the following components:

- Barcode Generator
- Timer for checking ticket validity
- Database for storing barcodes
- Online Payment Portal

Once the user opens the application, he/she is asked to select the source and destination stations from drop down menus. The application calculates the ticket amount and flashes it on the screen. Accordingly the user selects the correct ticket from another dropdown and proceeds to the payment portal. Once the user has provided the required payment details, the person hits the generate button which completes the transaction.

The barcode, which serves as the ticket, is generated and the timer starts. The timer provides the user with a comfortable amount of time to validate the ticket at the source station failing which the timer stops and the ticket is rendered invalid. At the end of the journey, the ticket is once again scanned at the destination station as an exit pass at the station.

Fig 2: A barcode generated on the phone

c) Barcode Reader (Scanner)

A barcode reader (or barcode scanner) is an electronic device for reading printed barcodes. Like a flatbed scanner, it consists of a light source, a lens and a light sensor translating optical impulses into electrical ones. Additionally, nearly all barcode readers contain decoder circuitry analysing the barcode's image data provided by the sensor and sending the barcode's content to the scanner's output port. Because a barcode reader merely captures and translates the barcode into numbers and/or letters, the data must be sent to a computer so that a software application can make sense of the data. Barcode scanners can be connected to a computer through a serial port, keyboard port, or an interface device called a wedge. A barcode reader works by

directing a beam of light across the bar code and measuring the amount of light that is reflected back. (The dark bars on a barcode reflect less light than the white spaces between them.) The scanner converts the light energy into electrical energy, which is then converted into data by the decoder and forwarded to a computer.

B. Components of the Application

1) Barcode Generator

The MTM application uses a barcode generating activity to serve as an alternative to the paper ticket. When the user wants to generate a ticket, a 6-digit random number is generated using the random function in the activity. The barcode generator simply takes in the randomly generated six digit serving as the ticket code and generates its equivalent barcode using a barcode font file saved in the resources of the application.

In our model of the MTM application, we have used the European Article Number, or EAN (which is a standard European barcode and superset of the American standard, UPC) to allow for a more global perspective.

EAN13 barcode use a 12 digits product code, the thirteenth digit is a control number, which is calculated on the basis of the first 12 digits. Calculation of the control number (digits numbered from right to left) looks like this:

P1 = the sum of even digits

P2 = the sum of odd digits

$Z = P1 + 3 * P2$ (1.1)

R = the number divisible by 10 and greater than Z

Control number = R – Z (1.2)

Next, let's see the EAN13 encoding system: The first 6 digits of the barcode is given by the service provider and is same for all generated barcodes. The first digit is not encoded. Each 6 following digits are encoded according to the first digit.

The 6 last digits are converted by the strict rule:

First digit	Left 6 digits	Right 6 digits
0	LLLLLL	RRRRRR
1	LLGLGG	RRRRRR
2	LLGGLG	RRRRRR
3	LLGGGL	RRRRRR
4	LGLLGG	RRRRRR
5	LGGLLG	RRRRRR
6	LGGGLL	RRRRRR
7	LGLGLG	RRRRRR
8	LGLGGL	RRRRRR
9	LGGLGL	RRRRRR

Encoding for the digits:

Digit	L-code	G-code	R-code
0	0001101	0100111	1110010
1	0011001	0110011	1100110
2	0010011	0011011	1101100
3	0111101	0100001	1000010
4	0100011	0011101	1011100
5	0110001	0111001	1001110
6	0101111	0000101	1010000
7	0111011	0010001	1000100
8	0110111	0001001	1001000
9	0001011	0010111	1110100

2) Timer

Android operating systems allow the interaction between multiple existing applications. Hence, for the purpose of our MTM application, we will be using the inbuilt timer app on the android platform. The ticket generated by the MTM application is allowed a fixed validity period. This is to improve ticket distribution efficiency. If a user purchases his ticket and does not utilize it for a long interval of time, it increases the potential queue of other MTM application users. This due to the unavailability of the ticket because it is held by the current user. The timer prevents the possibility of this logistical error ever occurring. The timer counts down from, say T minutes, at the end of which the inbuilt alarm is sounded which triggers the removal of the barcode (ticket) from the database, allowing regeneration of the ticket.

However, for proper utilization of the ticket, the user simply needs to scan it in at the source station. The barcode scanner then validates the ticket by sending a signal to the user's smartphone device which stops the timer.

3) Database for storing barcodes

The MTM application utilizes a database to store all the codes currently in use as tickets. The application uses the inbuilt database Android OS provides – SQLite, to create the records of the ticket usage. The ticket codes are stored in the database following a simple model:

On receipt of the client's payment of the ticket money, the 6-digit random number is searched for a match in the database. If no such match is made, it means that the ticket with that specific code is yet to be generated for use. In that case, a barcode is generated using this unused random number and the unique number forming that code is inserted into the database. Again, on completion of the ticket's life cycle, i.e. once the user checks out of the destination station by scanning in the ticket, the code is deleted from the database (records) to allow a future, prospective metro user to avail such a ticket (barcode) thus allowing the recycling of tickets.

4) Online Payment Portal

When a customer orders a product from a payment gateway-enabled vendor, the payment gateway performs a variety of tasks to process the transaction.

1) A customer places order on website by pressing the 'Submit ' or equivalent button.
2) If the order is via a website, the customer's web browser encrypts the information to be sent between the browser and the vendor's webserver. In between other methods, this may be done via SSL (Secure Socket Layer) encryption. The payment gateway may allow transaction data to be sent directly from the customer's browser to the gateway, bypassing the vendor's systems.
3) The vendor then forwards the transaction details to their payment gateway. This is another (SSL) encrypted connection to the payment server hosted by the payment gateway.
4) The payment gateway forwards the transaction information to the payment processor used by the merchant's acquiring bank.
5) The payment processor forwards the transaction information to the card association (e.g., Visa/MasterCard/American Express). If an American

Express or Discover Card was used, then the processor acts as the issuing bank and directly provides a response of approved or declined to the payment gateway. Otherwise [e.g.: a MasterCard or Visa card was used], the card association routes the transaction to the correct card issuing bank.

6) The credit card issuing bank receives the authorization request and does fraud and credit or debit checks and then sends a response back to the processor (via the same process as the request for authorization) with a response code [e.g.: approved, denied]. In addition to communicating the fate of the authorization request, the response code is used to define the reason why the transaction failed (such as insufficient funds, or bank link not available). Meanwhile, the credit card issuer holds an authorization associated with that merchant and consumer for the approved amount. This can impact the consumer's ability to further spend.
7) The processor forwards the authorization response to the payment gateway
8) The payment gateway receives the response, and forwards it on to the application (or whatever interface was used to process the payment) where it is interpreted as a relevant response then relayed back to the merchant and cardholder. This is known as the Authorization.
9) The entire process typically takes 2–3 seconds.

Many payment gateways also provide tools to automatically screen orders for fraud and calculate tax in real time prior to the authorization request being sent to the processor. Tools to detect fraud include geo-location, velocity pattern analysis, OFAC list lookups, 'black-list' lookups, delivery address verification, computer finger printing technology, identity morphing detection, and basic AVS checks.

C. The Working Algorithm:

The following is a probable working algorithm for the working of the Quick Commutation System.

STEPS:

1) START
2) Initialize variables by storing the name of the stations in a string array and corresponding distances in a floating array
3) Choose entry station (Source) and exit station (Destination) from drop-down menus
4) When Destination != Source
   a>Display fare amount calculated on the basis of the fare chart given below using suitable sample data.

– If the distance is between 0 -2 kms, then ticket price is 5 INR.
– If the distance is between 2-6 kms, then ticket price is 10 INR.
– If the distance is between 6-12 kms, then ticket price is 15 INR.
– If the distance is between 12-21 kms, then ticket price is 20 INR.
– If the distance is between 21-30 kms, then the ticket price is 25 INR.
– If the distance is between 30-40 kms, then the ticket price is 30 INR.

b> Choose correct fare amount from drop down menu
c>Click on button to proceed to online payment option

5) Enter card CV no. and pin code.
6) Confirmation of payment is displayed. Click on button to generate ticket.
7) The ticket in the form of a barcode is generated and timer (denoting the life of the ticket-from generation to usage) is started.
8) When timer != 0

a> barcode is scanned by barcode reader at entry station.
b>Activate wifi or datacard connection for wireless transmission.
c>Barcode reader transmits signal to phone to mark ticket as active.
d>The database is updated.
e>Turnstile opens

9) 9. Barcode is again scanned by barcode reader at exit station.
10) 10. Reader transmits second signal to phone to mark ticket as used.
11) 11. The database is again updated. Ticket is then recycled for future use.
12) 12. Turnstile opens.
13) 13. END

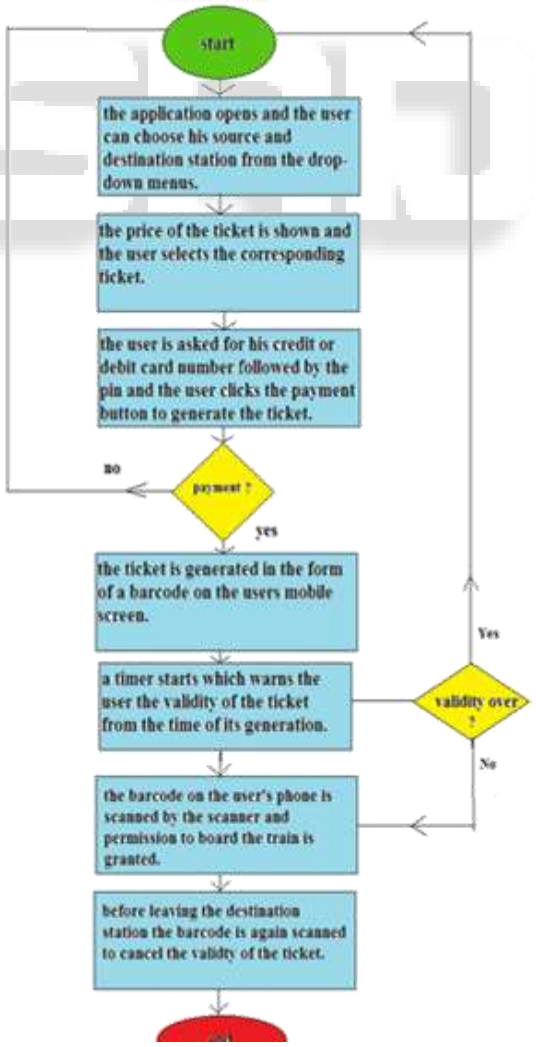

Fig 3: Flowchart for the Working Algorithm

D. Advantages of our proposed system

Our proposed system has several advantages over the existing systems. They are:-

1) Care is taken so that repeated use of a ticket never occurs. For this we use an efficient database, SQLite and also a timer to ensure the validation of the ticket.
2) The flap barriers can be customized with bar code scanning engines to replace the low frequency radio signal tuned configuration in use at present. This approach would exclude the phasing out of the flap barriers - only a simple modification to the machinery is required though it involves addition 9of costs.
3) However, if the high cost involved in the maintenance and future installation of the flap barriers is to be removed from the equation, then the flap barriers need to be phased out and instead be replaced by officials appointed to function as conductors on the trains with handheld scanners(1000-50000)
   One overall advantage with respect to the generation of the tickets, would be saving man power and also elimination of redundant token generating machinery. Elimination of ATVM machines can save up to INR 2 lakhs for each ATVM.

E. Future Scope regarding our application

The MTM utilizes WIFI for communication between the Android application and the barcode reader. Other wireless communication formats like Near Field Communication (NFC) can be used to make the ticketing process hassle-free. The large, clumsy electronic barcode readers can be phased out in favour of NFC scanners attached to the entrance of the trains which validate the ticket of anyone entering the train in a fashion similar to a metal scanner. Security measures to reduce fraud and duplication can be introduced like 'locking' a particular to the corresponding so it cannot be forwarded to any other device. Larger databases to handle personalized accounts and monthly ticketing tabs could be implemented.

IV. CONCLUSION

The major problem faced by daily passengers is standing in long queues to purchase metro tickets causing delay and consequent unnecessary hassle. Our designed system addresses this issue allowing ticket generation easily and without wastage of valuable time. We have taken care that, fraudulent practices if adopted would be detected instantaneously due to the inclusion of the timer which validates the ticket. We hope our system proves to be effective to the passengers as well as the Metro Railway Transit System (MTRS) under the authority of the Indian Railways.

ACKNOWLEDGMENT

The authors of this paper would like to thank their parents for their constant encouragement and support. We would also like to thank the various resources and our university for providing ample information needed for our research. The authors also express their gratitude towards anonymous reviewers and editors.

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