Card Based Fare Collection System: The Case of Addis Ababa Public Transit System

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Abstract

Our life is based on travel and nowadays it is highly unlikely that a day goes by without any of us using some kind of transit system. This paper explores the current public transit system of Addis Ababa and experiences of other cities around the world to come up with a card based fare collection system that is open to any standard payment card solution. Different people were selected through subjective sampling for interviews in addition to observation and case studies through literature reviews.

The existing transit system causes inconvenience for commuters by creating long queues to buy tickets hence wasting valuable time. It also has logistics issues for the transport service providers because it involves ongoing ticket printing and making the system easily susceptible to fraudsters. The proposed solution will remove the problem by allowing customers to pre-pay for their travel using their existing banking cards which is then authenticated when trying to board a bus or a train through a POS machine that will communicate with a fare gate to allow or deny entry based on the customer's balance.

The system will be deployed at stations through POS devices while all the transactions will be monitored and customers' information is handled through a back office system. In addition, the system will allow easy fare adjustments and the customer will be charged only for his/her travel distance discarding any pre-determined fare charge allowing flexibility for payments.

Keywords: Transit; Commuters; Card; Fare; Transaction; Payment; POS

1. Introduction

Smart card fare collection systems are being used more and more by public transit agencies. While their main purpose is to collect revenue, they also produce large quantities of very detailed data onboard transactions. These data can be very useful to transit planners, from the day-to-day operation of the transit system to the strategic long-term planning of the network [1].

Smart card fare collection systems are now widely implemented all over the world. The concept is well advanced in Europe, especially in France, the UK and Italy. In the United States, there are implementations in New York, Washington, Chicago, San Francisco and in more than ten other metropolitan areas. The smart card is also popular in Asia and is increasingly used in South America, for example, in Santiago, Chile [1].

A smart card is a device that includes an embedded secure integrated circuit, like an NFC (Near Field Connection) chip. The card connects to a reader with direct physical contact or with a remote contactless radio frequency interface. Some smart cards have the ability to securely store large amounts of data, carry out their own on-card functions (e.g., encryption and mutual authentication) and interact intelligently with a smart card reader [2].

In public transit, the use of smart cards for payment requires the existence of a corporate information system, which makes it possible to validate the use of the card through the network while storing transaction data for its financial accounting process [1].

In recent years, the technology and processes for open standard bankcard payment systems have reached the point where they can meet the needs of transit systems. Such systems enable transit authorities to focus on their core competency – transportation - and get out of the costly business of processing payments [2].

The biggest enticement of open bankcard payments is the notion that a transit authority can vastly reduce the infrastructure it has in place to support issuing and managing its own expensive closed loop card and paper ticketing systems. The goal is to allow consumers to use debit, credit and prepaid cards that are already in their wallets to directly pay for rides on a transit system, rather than using cash or those cards to buy another card sold by the transit authority [2].

As of today there is no smart way of payment for public transportation in Ethiopia which is starving the country of all the benefits mentioned above. This paper attempts to come up with a System Requirement Specification (SRS) document and System Architecture Document (SAD) as well as a prototype of a card based fare collection system which is open for "Open bankcard standards" for payments which are set by the world's most common financial networks, including Visa and MasterCard [2].

2. Related Work

Even though electronic smart cards for payments have been in use throughout the world for decades, it is still challenging and a work in progress for many. But this is not to say there haven't been success stories. Among these successful implementation are NOI Card Dubai, MTA New York City Transit and Los Angeles County Metropolitan Transit Authority (LA Metro) [3]. The NOI card is an electronic smart card that enables commuters to pay for the use of various RTA transport models in Dubai (UAE) with a single card. There are 4 types of NOI Cards available to meet travel requirements. In addition to paying for transport, the card can also be used to pay for parking fees. As other card based systems, NOI has benefits such as commuters no longer need to carry cash or worry about the correct change while enjoying low cost fares and flexible transfers across different modes of transport. Commuters also have the ability to add credit to account and the card will automatically deduct the correct fare based on usage.

The MTA New York City Transit (NYCT) began Phase 1 of a pilot program in partnership with MasterCard and Citibank in 2006. The trial was intended to test the viability of accepting standard contactless bank-issued smart cards to pay transit fares directly at the point of entry without the need to purchase the fare media. The participants' PayPass device functions as a credit or debit card, depending on the individual customer's relationship with Citibank. When a participant passes through a fare gate, s/he would tap the card or fob against a reader. However, his/her account is not charged at this point. Instead, a preliminary approval verifies the card's legitimacy and processes a pre-auth for $15. A cardholder's first transaction would always be allowed even if his/her account was not in good standing. The account status would be checked later when a series of fares were aggregated and submitted as a single transaction.

Another success story is that of LA Metro which began a 25,000-person pilot program in 2008 in conjunction with Visa and Ready Credit Corporation to offer special Visa payWave contactless cards that also incorporate the transit system's Transit Access Pass (TAP) fare application. These dual-use prepaid cards allow riders to pay their fares and purchase fare products using their Visa account, while also allowing cardholders to make purchases anywhere Visa debit is accepted.

Generally transport systems in different countries offer different kinds of payments for their transport systems. One of the common options is electronic card that is rechargeable. These cards are contactless and customers will only need to tap at gates to enter. Customers can recharge these cards at kiosks or stations using unattended machines. Customers will

insert or put the card on the machine and choose amount to recharge and insert that amount in cash into the machine. Transit system providers offer discounts for users of these cards. The problem with this and similar cards is since the value or available balance is stored offline (inside the card) it is difficult to recover when the card is either stolen or damaged. Another type of electronic card is also contactless but this one is not rechargeable and can only be used for few times. These cards compared to the rechargeable cards are expensive. The system will authenticate the cards within 1 to 2 seconds in most cases. People who want to use these cards can get them at stations or other kiosks. Most transit systems offer a third option for those who don't want to use electronic cards. Here they will need to use token disposing machines. Customers will need to insert cash into the machine and the machine will then dispose tokens based on the inserted amount. The problem with this is that it takes time compared to using cards to get authenticated and allowed entry. Another problem is the disposing machines are easily damaged and become out of order because of misuse and unfit cash being inserted to it.

In some countries customers are able to use their bank cards for transport payment services. The cards have to be contactless and have an offline capability. These cards also have limits so they can only be used up to a fixed amount. It took many years and many obstacles for many cities to integrate electronic payment into their transit system costing them billions of dollars through time. But the advantage of being a late developer is that we can learn from both the mistakes and successes of other countries and introduce electronic payment for our transit system that suits the city of Addis Ababa.

3. The Proposed Solution

Transportation is one of the necessities of our day-to-day life. This transportation needs a modern way of handling its commuters. This card based fare collection system will be able to provide this and play a major role in creating awareness of using electronic payment methods.

The proposed system consists of a central station and many POS terminals with card reading and network communication capabilities deployed at different entry and exit points of the transit stations. The central station will be responsible for customers' registration, transaction processing, terminal management, fare and tariff management as well as topping up of customer's credit. The POS terminals located at stations are used to accept cards of customers and process them by communicating with the central station.

Qualities Attribute Consideration and Architectural Decision

The following are system requirements and objectives that have some significant impact on the architecture and design of the system.

a. Technical Platform: The system application will be deployed onto a Windows platform.

b. Communication: The system will use TCP Server to handle incoming and outgoing connections. The POS system will use built-in communication libraries to handle its communication. The POS communication will handle both Ethernet and GPRS communications. Communication between remote components outside the LAN of the central station will be via VPN to be implemented by ethio telecom.

c. Security: The system must be secured because it is storing customer's card number information. Basic security behaviors are stated below.

- Every user is assigned an access level.
- *Authentication*: Login using at least a username and a password and a user's account will be automatically disabled after three wrong attempts.
- *Confidentiality*: Sensitive data must be encrypted and must not be shared with

third parties without prior agreements and security clearances.

- *Safety*: All the data must not be kept at a local database. It should be backed up every day.
- *Data Integrity*: Data sent across the network must not be modified by a middle person.
- *Auditing*: Every sensitive action must be logged and be audited.

d. *Reliability/Availability*: High availability is required since there are monetary issues related to system availability. When the system is not available, POS system will work offline and settles the transactions when the system with central station is back on. When there is a problem of Ethernet connectivity, POS will automatically revert to GPRS connectivity. Ethernet connectivity is much faster than GPRS connectivity hence priority is given to Ethernet. Targeted availability is 18 hours a day 7 days a week while maintenances and system updates are done after midnight.

e. *Performance:* Transit systems are very critical of the time it takes for a customer to use his/her card and enter into the transit medium. With that in mind, the system will respond in less than 3 seconds. The response time is calculated beginning from once the customer inserts or swipes a card at the POS located at the stations, send the transaction to central station and receive the transaction response and passes it to the fare gate.

f. *Extensibility:* Initially the system is designed mostly taking consideration of the Addis Ababa Light railway transit system. The system with some modification can be transferred into other modes of transit systems like busses and taxis. The system is also open to handle and connect with customer's bank account and also accept contactless cards in the future.

4. Prototype

4.1. Overview

A prototype was developed to test that the proposed solution meets the requirements set in the Requirement Specification document and the design goals and quality attribute considerations set in the System Architecture Design. The programming language used to develop the PC side of the system is C# with SQL server 2008TM. For the POS side to be deployed at stations, C programming language is used. The general objective of this paper is to come up with a card based fare collection system that is open to any standard payment card solution while using the current infrastructure implemented in the country. The system is based on a Client Server architecture that addresses the research problems and shows the constraints of the existing transit fare collection system in Addis Ababa. The Home Page is shown in Figure 1.

In the new system customers will take advantage of the modern fare collection system by going to registration stations with their existing bank cards (expired or not expired) and get enrolled with the system. This is a one-time process unless they want to change cards at a later time. The customers will top up or credit their balance. To use the system any customer will swipe or insert his/her card at the entry of the stations. If the customer has positive balance then s/he will be allowed entry if not a declined response is received. While departing the station the customer will again swipe/insert his/her card at the station and the system will again communicate with the central server and will deduct the fare amount from the customer's existing balance. In addition customers of the Addis Ababa public transit system will be able to recharge (top up) their available balances remotely using POSs found in designated stations. There is a system in place to set Fares between two stations. In the current public transit system in Addis Ababa the customer has to pay the whole price of the travel even if s/he gets off at the next stop and this forces the customer to pay extra

fare for the ride. The proposed solution solves this problem as it only calculates the number of stations the commuter traveled in. Transit authorities will be able to monitor real-time transactions, disable, edit or delete a particular customer's account, manage and settle disputes based on available transaction reports

4.2. Implementation

In order to implement the proposed system and put it to use different hardware and software components need to be in place. As shown in Figure 2, which is the high level deployment diagram, these are RS232 Cable used to connect and transfer data from the POS device to the PC, TopUp or customer registration POS which is used to either enroll/manage customer accounts or credit customer's balance and is connected to the system user's PC via RS232 Cable or remotely using Ethernet cable and GPRS. In addition to the above components LAN Switch is used to connect devices in a Local Area Network while TCP Server is used to handle incoming TCP connections and transactions. SQL Database Server is used to store customers and transaction data with ADSL router providing remote access together with ethio telecom's VPN connection. Transaction POSs are deployed in every station and they are used by commuters to pay for their ride using their cards.

The proposed solution uses a TCP application server that handles incoming transactions originating from POS terminals whenever a customer swipes/inserts his/her card and performs account balance checking and debiting the customer's account by calculating fare. The application server is also responsible for responding with the appropriate message which is then sent to the POS devices located at the station. The database system is based on SQL Server. The POS system handles card reading and transaction sending and receiving as well as topping up of customer's balance. The POS can accept any standard bank issued card whether it is credit card or debit card.

Figure 1: Administration Home Page of Card Based Transit Fare Collection System

5. Conclusion and Future Work

Even though we are seeing progress in infrastructure and digitalization we are yet to see any modern way of payment for our public transit system in Addis Ababa. Our transit system uses the same methods it has been using for decades with only

minor changes. This is causing disadvantages for customers as well as the management of these transit companies or authorities. In the current Addis Ababa Public Transits system, customers will have to wait on queue to buy their paper based tickets and waste time while deciding how much the transit might cost. The cashiers that work nearby stations often don't have changes when customers come with larger notes. This paper tried to address these issues and come up with a modern system for handling transits.

The new system will be able to give administrators abundant data on the day-to-day transit. The generated data/report can be used in identifying key places for improvements and assigning more transport vehicles when there is too much queue in some areas. The reports can also be used by security officials to track down criminals that could be using the public transit system.

The developed system can be deployed and be used as it is but the following future works need to be added to get the most out of the system. As Ethiopia is currently working on a national switch with ATM interoperability already in action, the integration of the system with the actual available balance of the customer's bank account when the POS interoperability is completed is required. In addition to that currently all cards available in the country are either EMV contact or magnetic stripe only. The system has to support contactless cards when they began to come into the country's electronic payment environment.

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