

Fare Estimation using Automated Fare Collection System in Buses

Navya Davis*¹, Aiswarya M.R.^{#2}, Ashiya Kareem^{#3}, Mufshana M.T.^{#4}, Vinduja. S. Nair^{#5}

^{*1}Assistant Professor, University of Calicut, Computer Science Department, I E S College of Engineering Chittilappilly P.O, Thrissur, Kerala-680 551, India

[#]University of Calicut, Computer Science Department, I E S College of Engineering Chittilappilly P.O, Thrissur, Kerala-680 551, India

Abstract— Nowadays the public transportation system like the metro are well advanced. Passenger safety, convenience and the need to improve the performance of existing public transportation is driving demand for intelligent transportation system in the market. The paper we introduce, proposes a novel fare estimation technique using Automated Fare Collection (AFC) System and Radio Frequency Identification (RFID) integrated together in public transport buses along with Automatic Vehicle Location System (AVLS) to easily locate the route and track the bus. The contactless smartcard –based end-to-end solution for fare collection and payment that we use here is uniquely designed with the demand of revenue services for modern transit operation in mind. The data from the Origin-Destination (O-D) matrix had been useful to implement the system, thus paving way to the advancement in the area of intelligent transport system.

Keywords — Contactless smartcards, Contactless Fare Media Technology, Automated Fare Collection System, O-D Matrix, Intelligent Transport System

I. INTRODUCTION

Today, everything in the world is smart and digitalized. Many advances have been made in the transportation sector too. However, public transport buses in India have always been an area where such new advances have turned their faces out. Therefore, in this paper, we introduce a Contactless Fare Media Technology and an Automated Fare Collection System (AFC) to up bring the public transportation bus system in India to the world standard along with novel features. The prevailing ticketing system had many malfunction, malicious argument among public, corruption and revenue loss. The project described in this paper aims to reduce fare-related fraud and revenue loss through open standard, secured transaction technology.

Generally, a conductor controls every bus. He collects money from each passenger and issues the ticket. Initially, printed papers or tokens were used as tickets. Nowadays, handheld machines are used to print tickets. However, this system has many disadvantages. The passengers have to carry the ticket until the end of travel, also the conductor

should ensure that everyone has the ticket, the time taken for ticketing is comparatively more and more amount of paper is needed to print the ticket.

In our paper, we propose a public bus transportation system in which there is a bus unit, which has a RFID reader. The reader senses the RF (radio frequency) signals coming from the passenger ID card and thus recognizes the entry, existence and exit of the passenger. Based on when the signals from the card is cut off, the fare of the journey is calculated and is deducted from the passenger's account, which is linked with the bus unit. The system we implement is an end-to-end solution for fare collection, ticketing, and payments that provides secure and faster transactions, more convenience and smooth passenger flow during peak hours, and efficient collection of fare ensuring no fraud takes place.

II. LITERATURE SURVEY

There were many works previously carried out related to the automated bus ticketing system using RFID and case studies has been done related to issues in PTS (Public Transport System). Barry proposed a methodology, which introduced two important assumptions which have been applied in major studies which are based on the fact that the alighting locations are not known but only the origin are known. First assumption is that origin of the passenger journey is the destination of the previous journey. Second assumption is that first daily origin of the passenger is the final daily destination. These assumptions do not hold always, because a passenger may have an intermediate segment of journey between the destination and the origin of the next journey either by walk or by other public transport. Similarly, the passenger may stay in different places in night, thus the second assumption also fails.

There has been a methodology proposed by Trépanier with a database programming approach showing that the first data must be thoroughly corrected prior to the prediction of the destination. Then Gordon proposed an algorithm to predict both the Destination and the Arrival time of the passenger journey. Additional validation was included with respect to the time whether the passenger had sufficient time to transfer in walk or not. All the

previous works are based on the flat fare structure and no attempts have been done to introduce the distance-based fare structure to enhance the accuracy of the inference of destination results.

There is system structure known as Andante System[1] which is an entry-only configuration system with a distance based fare structure. In this system, Zones define the distance based fare structure. System is divided into many geographic zones and the fare depends on the number of zones travelled by the passenger between origin and destination. Also Andante is a time-based system, which allows pay-per-use to make unlimited journeys or transfers in a given period of time.

In some contactless smart card systems, like the system in London, U.K., passengers also have to validate their trips at alighting time. Unfortunately, the more common case is that passengers alight without any sort of fare validation. This makes recording alighting more difficult, because reading a smartcard requires passenger participation, as the cards must be held against a reader antenna at a distance not further than 10 cm. This very short range limitation is imposed by design to avoid access by unwanted parties to the balance stored on the tag. OD trip-desire information can be obtained from direct-interview surveys or estimated from real-time traffic surveillance data. Populating OD-demand patterns from survey samples, however, is a resource intensive and time-consuming process.

Chang and Wu and Chang and Tao and Zhou et al. proposed a multi objective optimization framework to combine available historical static demand information and multiday traffic link counts to estimate the variation in the traffic demand over multiple days. But two classes of demand-estimation problems using vehicle identification data should be distinguished: 1) the estimation of tagged vehicle demand and 2) the estimation of population demand. Population demand using the estimated market-penetration rates.

In brief, the above models require estimating either market penetration rates or identification rates so as to relate the AVI samples to the population demand using a multiplicative structure. The estimation of market-penetration rates or identification rates, however, is a difficult problem in its own right, as these two types of rates are essentially time dependent and location-dependent random variables. Moreover, the inclusion of market-penetration rates and identification rates in the demand-estimation problem could dramatically increase the number of unknown variables and impact the reliability of the final population demand estimate through the multiplicative structure.

The above mentioned paper had focused on the estimation of population OD demand using partially observed AVI counts. To circumvent primary difficulties associated with estimating market-penetration rates and identification rates, this

research samples population OD split fractions from point-to-point AVI counts and extracts OD-demand distribution information, instead of treating OD split fractions as unknown variables, as is the case in several early dynamic OD-estimation models. Furthermore, two OD-demand-estimation formulations are developed to take into account the possible identification and representativeness errors. Between estimated OD-demand flows and the historical demand matrix.

In order to circumvent the difficulties in estimating market penetration rates of AVI tags, the study had utilized probe vehicle data to extract spatial distribution information of trip makers in a traffic network. But that is not at all enough to overcome all the faults and follies that the system has. The system had many estimation errors related to link flow and link-to-link flow proportions from the DTA program, which can be further caused by inconsistency in DTA assumptions on the route choice behavior, traffic-flow propagation, as well as input data errors related to traffic control and information strategies. Because the split fractions only carry information on OD demand distributions, it is necessary to combine other information sources that describe OD population demand volumes in order to estimate a complete OD matrix.

To overcome the demerits of the above-mentioned system, a Freight Origin Destination Estimation Based on Multiple Data Sources was proposed by Yinyi Ma, Prof. Henk van Zuylen, and Dr. Roelof Kuik. Freight origin-destination (OD) [8] information is increasingly important for understanding the influence of transportation on network congestion. Traditional OD estimation methods based on a single data source, usually loop detectors, are not easily transferred to freight OD estimation. Currently, there exists no simple and direct method of obtaining information of OD matrix of all freight transportation in a network. Transportation data are sometimes collected by statistics offices by means of surveys. But these survey-based estimates of freight OD matrices are static, generic and costly to produce. And they present a huge administrative burden to logistics companies.

Also, errors of the differences between observed flow and estimated flow could be generated either by observation devices or by traffic simulation. The first type of error is named as observation error which is resulted from the disruption of the devices, for instance. The second one is from route choice mapping. The inconsistency of shortest path in traffic assignment and real travel behaviour in the road network, not following shortest path for instance, leads to the difference between observable flow and expected flow.

Later, Keemin Sohn and Daehyun Kim introduced a Dynamic Origin–Destination Flow Estimation Using Cellular Communication System [6]. But it

introduced several methods for tracking the position of cell phones in a mobile cellular network, which are described as the signal profiling technique, the angle-of arrival technique, and the timing measurement technique. It is impossible to rule out location errors entailed in location data obtained by the time-based approach using cell phones.

Then, a methodology for estimating the destination of passenger journeys from automated fare collection (AFC) system data was described by Antonio A. Nunes, Teresa Galvao Dias and Joao Falcao e Cunha. It proposed new spatial validation features to increase the accuracy of destination inference results and to verify key assumptions present in previous origin–destination estimation literature. The methodology applies to entry-only system configurations combined with distance-based fare structures, and it aims to enhance raw AFC system data with the destination of individual journeys. This paper described an algorithm developed to implement the methodology and the results from its application to bus service data from Porto. The goal of the methodology was to enrich raw AFC system data into complete Origin-Destination (O-D) passenger journey data sets depicting individual travel patterns. This required high precision from the estimates and resulted at maximum disaggregation level, so the methodology favoured accuracy over the percentage of inferred journey destinations.

R. Daniel, P. Prudhvi Kiran and Sk. Nagoor explained hardware interfacing for “Messages” in regulation of Attendance. 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 explained how to overcome issues of current conventional bus systems and better monitoring for buses. But it didn’t explain 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 explained notification given by GPS when destination reached and the interfacing techniques. Mainly focused on hardware implementation. Shilpa Rai and Ankan Priya 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. Seetha Lakshmi 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.

Thus, the system we implement is to estimate the passenger destination and hence calculate the corresponding fare. This is done by integrating the AFC, AVL and RFID systems. Our system thus compensates all the follies of the prevailing and

previously existing systems. Here are some of the demerits of the existing systems.

A. Demerits of the Existing Systems

The Andante System was an entry-only AFC system with a distance-based fare structure that covers the metropolitan area of Porto. It was not based on the exit of the passengers and alighting locations were not recorded. So flat-fare structures were implemented based on these assumptions. The assumptions or predictions of the destination estimation were inferred from the AFC data. The AFC data was not much accurate as it was not smart or digitalised. The estimation of O-D matrices was not reliable. Hence the fare system was not appropriate. The data was gathered based on a survey which was time consuming and tiresome. OD trip-desire information can be obtained from direct-interview surveys or estimated from real-time traffic surveillance data. Populating OD-demand patterns from survey samples, however, is a resource intensive and time-consuming process, and conventional survey methods cannot provide up-to-date dynamic demand inputs required by online Advanced Traffic Management Systems (ATMS) and Advanced Traveller Information Systems (ATIS) applications.

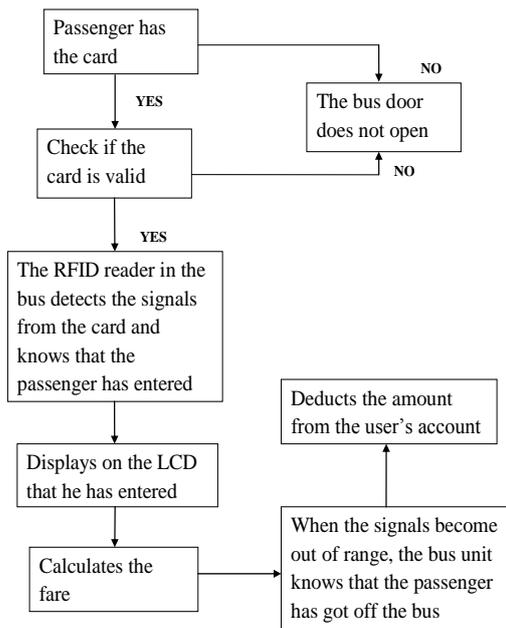
Existing systems are not automated completely. That is, there is a high level of dependency on the operator. Existing system do not store users’ credentials or users’ last transaction history. Existing systems use paper for displaying the transaction process which is not at all eco-friendly. The problem of hard cash flow is commonly seen in existing systems. 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. The conductors have to deliberately reach each one of the passengers and ask them to give money. This is a very tough process when the bus is jerking while passing through humps and gutters. The standing passengers also feel greater difficulty to take out the money from their bags with one hand while the other hand is tightly grabbing the support. If there is a lot of crowd in the bus, the conductor finds it very difficult to penetrate through the passengers to collect the fare. It is also not necessary that the person be able to collect money from all the passengers. He will miss two or three passengers for sure at least in such cases, leading to greater revenue loss when this situation frequently repeats. The fraudsters in the bus make use of this situation and get down from the bus without paying the amount.

III. PROPOSED SYSTEM

The proposed methodology, which we introduce in our paper, makes new contributions. First, it proposes new endogenous spatial validation rules at the disaggregate level. These additional validation

rules deal with the number of zones or stages in a travel card, which is specific to distance based fares, and with the existence of duplicate transaction records. The second contribution relates to improved reliability of estimation results. The methodology refines the existing system by distinguishing between journey stages and complete journeys and subsequently not inferring the destination of the last stage of single daily passenger journeys with multiple stages. It is effective to estimate the destination of journeys at disaggregate level and to detect instances where the candidate destination obtained from the application of key assumptions is likely incorrect. When a passenger travels at least twice in the same bus, his journey's ends will be saved too. So the next time he boards the bus from the same stop, the bus automatically knows where he has to get down. In other cases, the fare will be calculated based on the existence of wireless signals coming from the user identity card. We have taken great care to overcome almost all the black marks that are present with the prevailing system.

A. Working of Proposed System



B. Advantages of the proposed system

This paper aims to develop a new approach for the estimation of dynamic origin–destination (O–D) flow and thus correctly calculate the journey fare of the passengers. The system is fully automated, reliable, transparent and convenient. This can also be used in vehicle on highways, their toll payment and in the bus ticketing system with small modifications. The cards being reusable, they are much more convenient compared to the paper based ticketing system. The card is to be used as a universal travel pass card that will allow any transportation on any route. Initially the RFID system was made operative

with Pi. Then the control over door handling with the use of RFID tags and reader are made possible. A GPS service was added for the distance measurement. Secondary inputs, origin and destination switches can also be used for the same purpose. Programs for the above steps were integrated into one program. The system takes into consideration both the entry and exit. That is, it is purely a distance based fare structure. Fare collection is made automated using the AFC system. Therefore, there is no need of any liquid money to be carried out always. Paper ticket system is replaced with smart card, which removes the difficulty of the passengers in storing the ticket and the trees being harmed to make these paper tickets. There is no need of any conductor, supervisor or any other external agent to preside over the money transactions and ensure that everyone has paid. It reduces the fare related fraud and revenue loss through open standard, secured transaction technology. The system improves efficiency and reduces operating and maintenance cost of fare collection for transit operators. Automated Fare Collection System using RFID card is ease-of-use for commuters, hence it increases the passenger flow in and out of stations and transit vehicles. It also provides reliable and uninterrupted operation for train, bus road toll and retail applications etc. Moreover, it opens up proactive marketing opportunities. Multi-application capability and interoperability enables effective targeted pricing, loyalty programmers, cross-marketing with other services etc.

IV. IMPLEMENTATION

Here we illustrate the way the project is implemented and also its working. The transformation from theoretical designs to working system is done in this stage. Developed package of system is tested with simple accurate data, error identification and then through proposed change from the user, training to the user etc. In order to implement a new system, the choice of a processor with average possible speed is made.

Bit transmitter transmits bits to make bus unit aware that a particular bus stop has reached. The passenger will be having RFID card, the bus unit also detects it, and the door of the bus will be opened for that passenger who have the RFID card. After boarding the bus, the passenger presses the origin switch indicates that the passenger has entered into the bus and the LCD displays the welcome message. The minimum fare will be charged to the person who enters into the bus and the fare is added for each stop and in the implementation, the LCD shows the calculation of fare also.

When the desired stop is reached, the door opens, the passenger gets down from the bus and the total fare will be calculated and deducted at the moment when the radio frequency waves are cut. In the

implementation, we have included a destination switch for the passenger to get down from the bus before reaching the desired stop and the LCD displays thank you message.

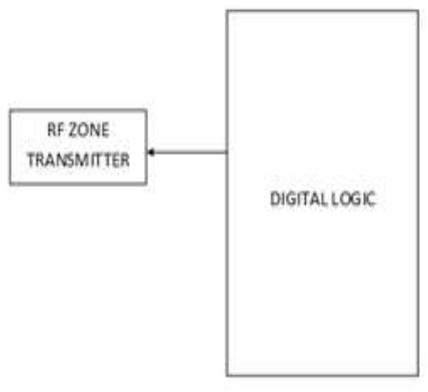
Opening and closing of the door is been shown with the help of a motor that is used in the setup. This system consists of an RFID reader which is used to identify the passenger, a control unit which uses the database to monitor factors like account balance, ticket charge etc. The system also includes a distance-measuring unit, which uses the GPS to find leaving place and arriving place to calculate distance. An RFID system consists of a tag, basically a microchip with an antenna and an interrogator or reader with an antenna.

B. Bus Unit

Arduino is the software used to code the Embedded C Language that is used in this project. Arduino is an open source, computer hardware and software company, project, and user community that designs and manufactures microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world.

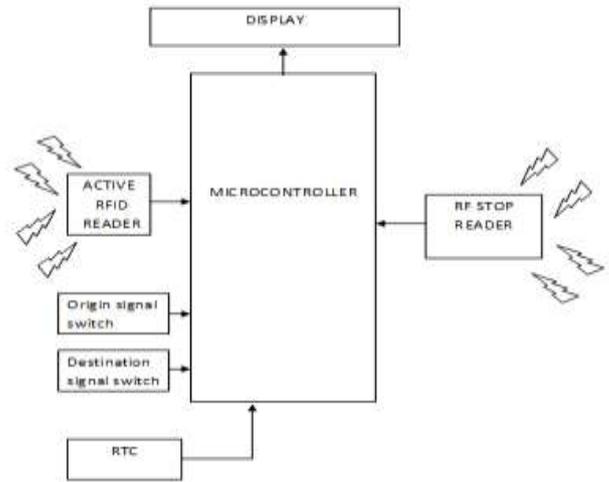
V. SYSTEM IMPLEMENTATION

A. Bus Stop Unit



VI. CONCLUSIONS

Here, we proposed the automated fare collection system in buses using radio frequency identification card. The system is expected to be fully automated, reliable, transparent and convenient. Any unwanted events can be avoided as all the person carrying RFID tickets are monitored every time they travel. By implementing this project as real time project, many disadvantages in ticketing system is rectified and fare is debited from RFID tag where tag is rechargeable one. The manual fare collection system has many issues which are overcome by our proposed system. Automated fare collection system for public transport is an innovative idea, which reduces manpower. The ultimate goal makes the life



of the passengers easier and good development of transport system.

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