European Journal of Computer Science and Information Technology, 12 (6),1-14, 2024
Print ISSN: 2054-0957 (Print),
Online ISSN: 2054-0965 (Online)
Website: https://www.eajournals.org/
Publication of the European Centre for Research Training and Development -UK

Development of Models for Ticketing in Public Transportation System in Nigeria

Folake Akinbohun (PhD)
Computer Science Department
Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria
Email: folakeakinbohun@yahoo.com/folakeakinbohun@gmail.com

doi: https://doi.org/10.37745/ejcsit.2013/vol12n6114 Published September 08, 2024

Citation: Akinbohun F. (2024) Development of Models for Ticketing in Public Transportation System in Nigeria, *European Journal of Computer Science and Information Technology*, 12 (6),1-14

Abstract: *Transportation is a system that humans use to carrying out their day-to-day activities. In the bid to do activities, transportation by any means has to be used. In the public transportation system, they use the manual or traditional method to process ticketing. This causes many flaws such as long queues, communication gap, miscalculation of tickets, improper records of commuters' information etc. For commuters to gain a convenient platform for bus reservations, real-time information updates, and a smoother experience; and for the companies to benefit from automated reservations, improved communication, and data-driven insights for better decision-making, there is need to develop a model for ticketing in public transportation system. The models for ticketing in urban transportation system have methods that involve pricing algorithm and route algorithm where scaling factors and user capacity planning models are calculated. With the introduction of the ticketing model in transportation system, existing challenges in urban mobility are revolutionized. The intersection of technology and transportation are positioned in such a way that the model seeks to enhance the overall commuter experience seamlessly by integrating reservation processes, real-time updates, amount payable, time and date of travels and communication between branches. The study envisions a shift towards a more accessible, efficient, and user-centred urban transportation system. It represents a transformative catalyst in transportation system especially by land/roads which are being used by automobiles (buses, cars, tricycle etc).*

Keywords: model, average time, route optimization, transportation

INTRODUCTION

Transportation can be defined as movement of people or goods from one place to another by means of vehicles, ships, aircrafts, trains and animals. Transportation can be classified into three basic types: land (road, rail, and pipeline), water (shipping), and air; each of these means with its characteristics. The essence of transportation is to achieve mobility (Adamec, 2011). In the use of

roads, vehicles, motorcycles, tricycles, bicycles can be used to convey people and goods from one place to another. If transportation is by the air; airplanes, helicopters, airbuses and jets can as well be used for transportation. If transportation is by water (marine transport) in forms of rivers or seas; boats, ships, canoes, yachts, hydroplanes, submarine can be used for transportation. If transportation is by rail, trains can be used (Igwe, 2013). In alignment with these developments of means of transportation, the ticketing model in transportation system seeks to revolutionize the ticketing experience with the objectives of providing comfort, hospitality and enhanced profitability.

The societies we are living today are busy with various activities necessitating the conveying of people from one place to another. In the process of using any means of transportation, ticketing model is paramount (Rosati and Greg, 2011). Ticketing in transportation system is a way of modeling a means of transportation by issuing ticket of amount to be paid, based on the distance covered. Moving from one place to another has to be in a lively atmosphere without stress.

There are flaws and challenges when using the manual method. The challenges exhibit human errors which includes miscalculations in ticket prices and inaccuracies in recording passenger data; inability of front officers to multitask efficiently during the peak periods which results in bottlenecks in the check-in process, lack of real-time overviews or reports of the ongoing business which makes it difficult for the transportation companies to assess the past and current performance.

In the study by Xiong et al. (2018) the challenges being faced by travel agents in recording the booking information when there are high customer traffic were examined. The impact of inefficient booking information leads to queuing and extended waiting times. The study highlighted the importance of streamlining the automated systems so that operational efficiency and improve customer satisfaction could be enhanced.

Overbooking problem has been one of the challenges when it comes to travels. It leads to managing a limited number of seats. The overbooking could be attributed to staff stress and over workload (Ab Majid et. al.,2014). The flow of communication between the branch offices and head offices for customer inquiries about availability of schedule updates, seat availability and reservation-related information could be delayed due to geographically dispersed travel agencies (Fleischer et al., 2012)The operational constraints affecting reservation availability in a manual setting by restricting reservations to on-the-spot bookings during specific time frames is another problem during transportation system especially by land. This manual means of ticketing may not cater for the diverse customer needs and preferences (Behzad et al., 2014).

The manual method of ticketing in transportation system is not calculative enough; there may be lengthy queues and accessibility problem between the passengers and transportation entities. To overcome these challenges, there is need for a solution in form of models of ticketing in

transportation system. To adopt the models, web technologies can be used to carry out the system. This model smoothly combines advanced technology with what people need in today's city life. The purpose of using the models of ticketing in transportation system is to help the passengers or commuters to get their calculative ticket so that they can have accessible and smooth experience in public transportation either by trains, buses or cars etc (Hsu et al., 2022)Shivaji (2010) pointed out the adoption of electronic systems to manage passengers and vehicle records. This is becoming more important, thereby creating a more efficient and error-free transportation system.

The model for transportation system is helpful in cities and institution environments where gates are quite far from the main offices or lecture rooms. For cities and organizations/institutionsto be lively in busy urban life, efficient transportation system cannot be overlooked. The model makes it easy for users to calculate between the initial and final destinations of commuters, to check if there are tickets available, buy them and pay online.

The ticketing model in transportation system is a technology that makes use of conveyance of people from one place to another in the cities, towns etc in which certain amount has to be paid. To calculate the amount passengers or commuters need to pay, the ticketing model is useful. It provides a solution that focuses on the user, making it efficient and easy to use. As technology changes how we interact with transportation, this model is a significant move toward a new way of getting tickets for different types of travels. It brings together technology, convenience, and the lively atmosphere of city living in a complete approach to urban transit.

Payment for tickets has to be made through various means. It is important to note that electronic payment systems rely on a number of transfer options. Today, there exists a wide variety of electronic payment systems: Smart card, online payment, mobile application payment, electronic cheque payment (Okifo, 2015; Kim et.al, 2016; Harish et. al., 2019).The ticketing model for public transportation system is aimed to provide a unified, real-time, and mistake-free way of handling reservations. The system is modeled into three parts to make the overall experience better for commuters. It allows users to check if seats are available, reserve tickets easily, and cancel tickets (Sad, 2012).

There are functionalities of the ticketing model in transportation system which includes reservation processes, real-time information updates, communication between branches, amount payable, available time and dates of travels, generation of tickets and enhanced decision-making information for management. The proposed system leverages on web-based technologies, incorporating a web platform application to ensure accessibility for users.
The objectives of the new proposed paper are to model, design and implement ticketing in transportation system

REVIEW OF RELATED LITERATURE

In the realm of transportation services in Nigeria, the expanding business of bus travel grapples with challenges associated with the manual bus reservation system. Hence, there is need to design a model for ticketing in transportation system. Below are the reviews of literatures that tailored towards the new proposed system.

Online Bus Ticket Reservation System was developed by Oloyede et al. (2014) where reservation process was streamlined for users to facilitate seamless checking of bus availability, ticket purchases, and online transactions. The online bus ticket reservation system is positioned as a solution by providing a convenient and effective platform for users to conduct bus-related transactions.The research conducted by Adekola et al. (2021) centers on developing an Online Road Transport Booking System to automate traditional road transport ticket booking processes. Web technological tools were used for the design. The study analyzed the road network patterns for urban growth.The study of Subramaniyan et al., (2021) focused on integrating smart technologies into public transportation systems. With the application of technologies such as Radio Frequency Identification (RFID), GSM, infrared (IR) sensor and face recognition, the researchers highlighted the revolutionary impact of technological advancements on public welfare, particularly in transportation. Wee (2007) proposed the online ticketing system to solve the problems of having physical reservations, limited times for reservations, and possible mistakes via the use of manual ways of seat reservation. The system (Wee, 2007) makes it convenient for customers to buy and ask about vehicle tickets anytime but also makes it easier for staff to sell tickets at counters.

METHODOLOGY

The models for ticketing in transportation system is developed taking into consideration the computational service. The computational service serves as the engine or brain of the proposed architecture system as depicted in Figure 1. The computational engine involves the combination of routing algorithm and capacity algorithm that produces the pricing algorithm. The development of models for ticketing in transportation system is described as follows:

COMPONENTS OF TICKETING IN TRANSPORTATION SYSTEM

The models for ticketing in transportation system can be deployed on online ticketing in transportation system. The deployment or design is to ensure scalability, reliability, and efficiency. A client-server architecture is preferred because of a robust backed server handling core functionalities and a user-friendly front-end interface accessible to passengers and administrators.

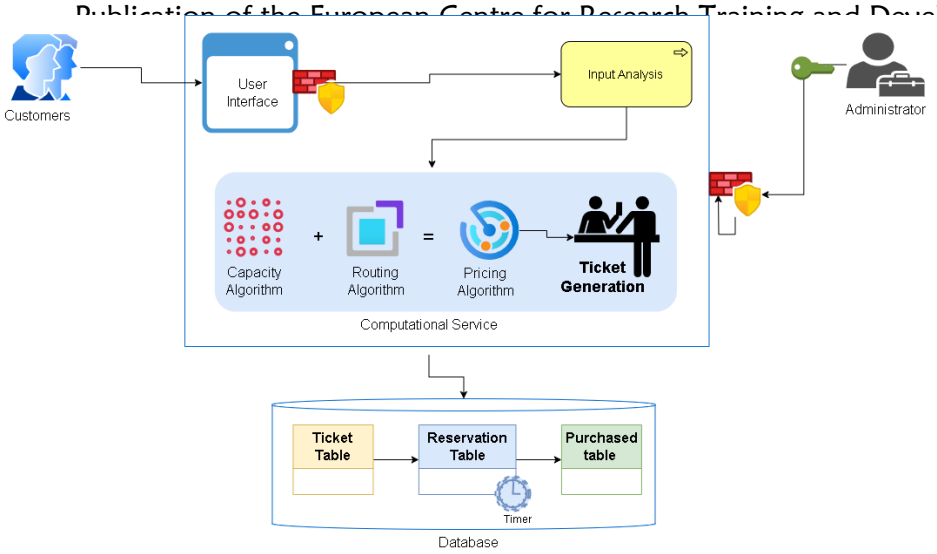

Figure 1: Ticketing in Transportation System

The ticketing model in public transportation system in Figure 1 is built to have various components: user interface, input analysis, capacity algorithm, routing algorithm, pricing algorithm, ticket table, reservation table and purchased table. Each subsystem of the proposed system is described as follows:

1. User Interaction: Users interact with the system through a user interface, which could be a website or app.
2. Administrator Management: Administrator oversees and manages the system. He ensures smooth operations and addressing any issues that may arise.
3. Database: The database stores essential information in structured tables, such as ticket details, reservations, and purchases.
4. User Interface Modules with Firewall: The user interface modules serve as the entry point for users. A firewall ensures secure communication and protects against unauthorized access.
5. Input Analysis: An input analysis component examines user-provided data, extracting relevant details about travel plans and preferences.
6. Capacity Algorithm: A capacity algorithm dynamically calculates the system's ability to handle user demand, preventing overload and ensuring optimal performance.
7. Routing Algorithm: The routing algorithm determines the most efficient travel route based on real-time factors like traffic patterns and user preferences.
8. Pricing Algorithm: The pricing algorithm derived from the capacity and routing algorithms, computes the cost of a ticket based on various factors like distance, time, and demand.
9. Ticket Generation: The ticket generation process involves creating a virtual ticket for the user, incorporating all relevant details for their journey.

European Journal of Computer Science and Information Technology, 12 (6),1-14, 2024

Print ISSN: 2054-0957 (Print),

Online ISSN: 2054-0965 (Online)

Website: https://www.eajournals.org/

Publication of the European Centre for Research Training and Development -UK

MODELS FOR TICKETING IN PUBLIC TRANSPORTATION SYSTEM

The following which are the pricing algorithm, ticket generating and routing optimization algorithm are developed; putting the scaling factors into consideration to develop ticketing in transportation system as follows:

a. Pricing Algorithm

The pricing strategy is formulated using a dynamic pricing model which considered various factors such as distance, time, and demand. The algorithm allows for real-time adjustments and competitive pricing. Discounts and promotions are calculated based on predefined rules, and by offering users personalized incentives.

Let:

- D is the distance of the journey
- T is the time of the journey
- P is the base price for the journey
- D_{factor}, $T_{factor}$and $Demand_{factor}$ is scaling factors for distance, time and demand respectively.
- $Discount_{rule}$is a function that calculates discounts based on predefined rules.

The pricing algorithm can be expressed as follows:

$$Ticket\ Price = P + (DxD_{factor}) + (TxT_{factor}) + (DemandxDemand_{factor}) - Discount_{rule} \quad (Equation\ 1)$$

Where

- P represents the base price, providing a starting point for the calculation.
- DxD_{factor} adds a component based on the distance traveled, scaled by the distance factor.
- TxT_{factor} adds a component based on the time of the journey, scaled by the time factor.
- $DemandxDemand_{factor}$adds a component based on demand, scaled by the demand factor.
- $Discount_{rule}$ subtracts any discounts calculated based on predefined rules.

The scaling factors D_{factor}, T_{factor}, and $Demand_{factor}$ are introduced to provide a mechanism for adjusting the impact of each factor (distance, time, and demand) on the final price. These factors allow one to fine-tune the influence of each variable based on the business considerations, market conditions, or other relevant factors.

The rationale behind using scaling factors:

i. **Distance Factor** (D_{factor}): This factor allows you to control how much the distance traveled contributes to the overall price. For example, if you want to emphasize longer distances in pricing, you might set a higher value forD_{factor}

ii. Time Factor (T_{factor})**:**Similar to the distance factor, the time factor allows one to adjust the impact of the time of the journey on pricing. If you want to encourage travel during off-peak hours, you might set a higher $T_{factor}$for peak hours.

i. **Demand Factor** *(*$Demand_{factor}$*)***:** The demand factor helps to account for fluctuations in demand. During periods of high demand, one may choose to increase prices to balance supply and demand. The demand factor allows one to control the sensitivity of pricing to changes in demand.

b. User Capacity Planning Models

In the context of the ticketing model in transportation system, user capacity planning is crucial to ensure what the system can efficiently handle at varying levels of demand. The formula for calculating user capacity is as follows:

$$User\ Capacity = {}^{Total\ Processing\ Capacity}/_{Average\ Ticket\ Generation\ Time} \quad (Equation\ 2)$$

Where:

- **User Capacity** is like figuring out how many people a system can serve efficiently.
- **Total Processing Capacity** is how much work the system can handle in a specific time. It is a kind of system's workload-handling ability.
- **Average Ticket Generation Time** is how quickly the system can create one ticket.

If you want to know how many people a ticketing system can help at the same time, consider how much work it can do (Total Processing Capacity) and divide it by how long it takes to make one ticket (Average Ticket Generation Time). In simpler terms, the equation 2 explains how many users the system can serve smoothly and quickly. If the number is high, it means the system is good at handling a lot of users without slowing down, which is what we want for a smooth online ticketing experience.

c. Average Wait Time for Ticket Generation

The average waiting time for ticket depicts how long people must wait to get their electronic tickets when they use an online ticketing system. This metric evaluates the efficiency of the system in processing ticket requests and delivering the electronic tickets to users. Equation 3 is the average wait time for ticket generation:

$$Average\ Wait\ Time = {}^{Total\ Ticket\ generation\ Time}/_{Total\ Number\ of\ Ticket\ Requests} \quad (Equation\ 3)$$

Where:

- **Total Ticket Generation Time:** The cumulative time taken by the system to generate tickets for all users.
- **Total Number of Ticket Requests:** The total count of ticket requests made by users.

The Average Wait Time is just the total time it took to make all the tickets divided by how many times people asked for tickets. If the Average Wait Time is low, it means people don't have to wait too long for their tickets, which is good! But if it's high, it might mean the system is taking a bit longer to generate tickets, and users might have to wait more. It ensures how efficient the system is at making tickets quickly and giving them to users without making them wait too long.

d. Route Optimization Algorithms

In the models for ticketing in transportation system, there is a smart way to figure out the best route for one journey. If a passenger/driver plans a trip, and he/she wants to know the fastest and most efficient way to get from where he is to where he is going to. Equation 4 is stated to indicate the route optimization.

Optimized Route = CalculateOptmalRoute (StartLocation, EndLocation)

(Equation 4)

Where:

StartLocation: The starting location specified by the user.

EndLocation: The destination specified by the user.

This optimized route is not just for someone's convenience; it is also a crucial piece of the pricing puzzle. The distance of your journey (D) is one of the factors used in the pricing algorithm. So, the more accurate and efficient the route, the better the system can calculate someone ticket price based on the distance travelled.This algorithm dynamically calculates the optimized route based on user input and it determines the distance *D* of the journey – one of the parameters for the pricing algorithm.

In essence, the system is a coordinated network of subsystem/modules and algorithms that collaboratively manage user interactions, analyze input data, optimize capacity and routing, determine pricing, and ultimately generate tickets. It's a streamlined and automated process that ensures a seamless experience for both users and administrators.

The flow of information within the vehicle ticketing model in public transportation system shows the representation aided in understanding data processes, inputs, outputs, and interactions between different components as depicted in Figure 2.

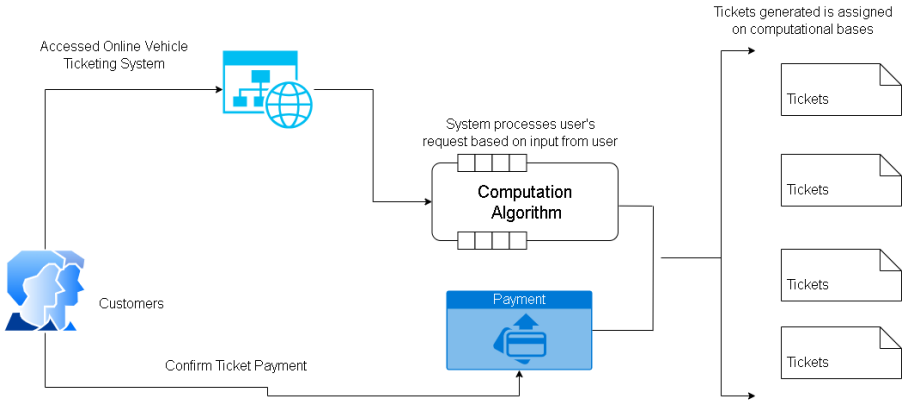

Figure 2: Flow of the ticketing model in public transportation system

As shown in Figure 2, the online ticketing transportation system is depicted in two primary flows. The two primary flows include (i) customer interaction and (ii) online ticketing transportation system.

A Customer Interaction Flows

The customers interacts with the system

i. User Input Flow: Customers initiate the process by providing inputs such as route preferences, travel details, and personal information. These inputs form the initial flow into the system, triggering computations and interactions within the online vehicle ticketing system.

ii. Feedback Loop Flow: Simultaneously, there exists a feedback loop where customers receive information, updates, and confirmations based on their inputs. This flow ensures continuous communication and engagement, keeping customers informed about their bookings, payments, and other relevant details.

B Ticketing models in transportation system Components:

This core component encompasses the computation algorithm, serving as the system's brain. It processes customer inputs, calculates ticket prices, payment, manages bookings, and ensures a seamless user experience from input to output.

i. Customers: Representing the external entities initiating interactions, customers play a pivotal role in providing input and receiving feedback, shaping the entire ticketing process.

ii. Computation Algorithm: The computation algorithm housed within the online vehicle ticketing system performs essential calculations. It considers factors like distance, time, and demand to determine ticket prices, optimizing the overall ticketing process.

iii. Payment Module: Handling the financial aspect, the payment module ensures secure transactions. Customers input payment details, and this module processes the information, completing the transaction and facilitating a smooth payment experience.

iv. Ticket (Overall Output): The ultimate output of the system is the ticket. Once computations, payment, and booking processes are completed, customers receive their electronic tickets, containing all relevant travel details and confirmations.

C Database Design

A relational database model was employed to store and manage data efficiently. Tables were designed to capture essential information, such as user profiles, transaction details, vehicle schedules, and route data. Normalization principles were applied to minimize redundancy and maintain data integrity.

The database section of the architecture I Figure 1 maintains and stores the data of the following:

i. **Customer Selects Dates and Location:** The customer initiates the ticketing process by entering their desired travel dates and departure location on the ticketing system.
ii. **System Checks Availability:** The system retrieves data from the database to see if there are tickets available for the requested location and dates.
iii. **System Presents Options:** If tickets are available, the system presents the customer with various options, likely including different vehicle types, classes, or routes. The customer selects their preferred choice from the available options.
iv. **Customer Enters Information:** The customer enters their personal information required for the ticket purchase, such as name, contact details (if applicable).
v. **System Confirms Ticket:** Once the customer confirms their information and selection, the system creates a ticket record in the database and assigns a unique ticket ID.
vi. **Confirmation and Payment:** The system sends a confirmation email or displays a confirmation screen with the ticket details, including the ticket ID, travel date, departure location, vehicle information (if applicable), and the total ticket price.
vii. **Payment Processing:** The system collects payment information at this stage for the ticket purchase. The system likely processes the payment and stores the details in the database.
viii. **Ticket Issued:** Once the confirmation and payment processing are complete, the ticketing process is finalized. The customer receives a confirmation email or printout with the ticket details for reference (e.g., e-ticket or mobile ticket).

SYSTEM IMPLEMENTATION OF MODEL FOR TICKETING IN TRANSPORTATION

The mathematical models and algorithms developed in the equations above are integrated into the system implementation of ticketing models in public transportation system, having used PhP, HTML, CSS, and JavaScript to create responsive and interactive interfaces accessible through web browsers and mobile devices for the front end development. Laravel 7+, a PHP programming language framework and vue 3 js are for the back end development. MySQL is selected as the backend database.

Having used the programming tools, the interfaces generated from the proposed system are landing page, vehicle schedule, admin login and dashboard, find schedule, vehicle management, schedule list, location list and booked list. Only few interfaces are depicted in Figure 3, 4 and 5

i. Find Schedule

This interface allows users to find vehicles scheduled for their picking and destination points as shown in Figure 3.

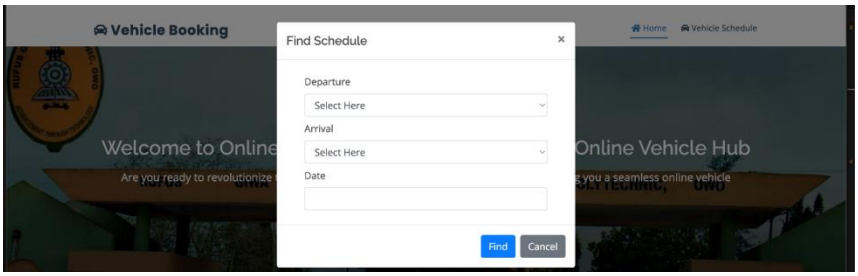

Figure 1: Find Schedule

ii. Book Ticket

This interface provides the users with functionality of booking for vehicles scheduled for their route. It allows the user to pick vehicle of choice, picking and destination point. Upon successful booking, a ticket containing reference id is generated as depicted in Figure 4.

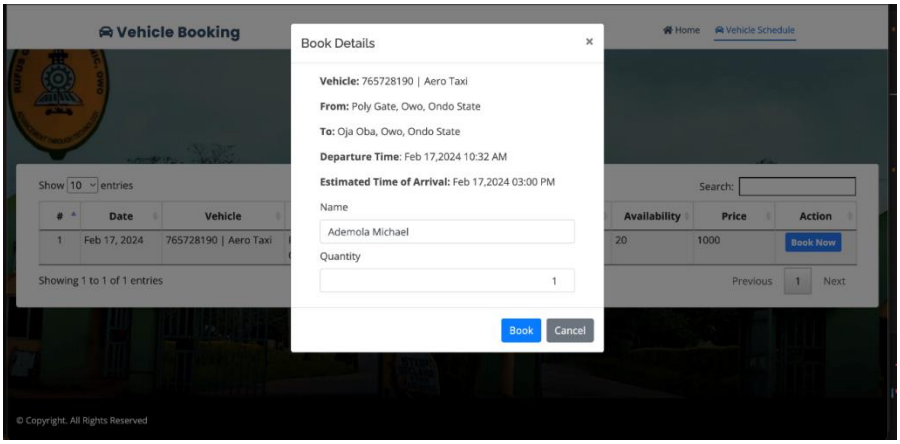

Figure 2: Book Ticket

iii. Booked List

This interface contains details of all booked vehicles and the users that booked them. It enables the administrator to manage all bookings and allows easy confirmation of booking payment.

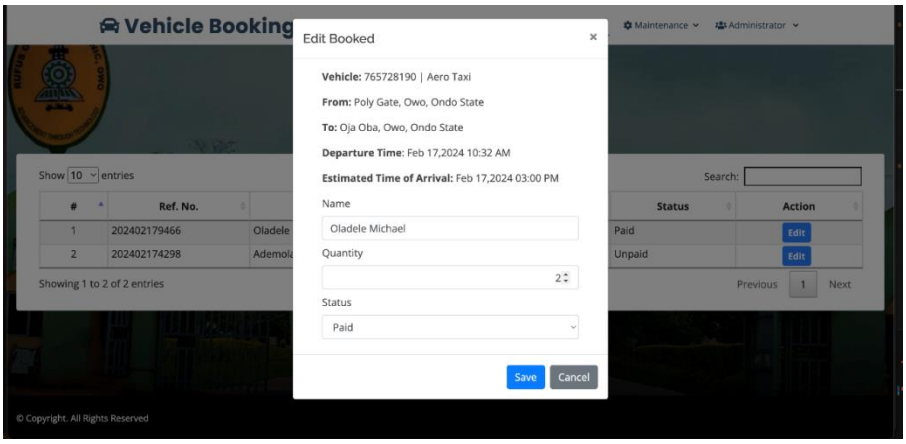

Figure 5: Booked list

CONCLUSION

The development of models for Ticketing in transportation system is to eliminate human errors, overbooking issues, communication challenges, limited reservation availability, and a lack of information for decision-making processes. The proposed models for ticketing address these challenges by providing an integrated reservation system that enhances efficiency in information updates, reservation handling, and ease of use.

The study recognizes the importance of adopting models for calculating the capacity, route and pricing algorithms to improve the overall transportation experience. By embracing web and mobile technologies, the Online Ticketing Model could be designed to eliminate the inefficiencies associated with traditional ticketing systems, making it convenient for both commuters and transportation entities. The transportation system such as bus, train and other public vehicles could deploy the proposed system for use.

REFERENCES

Ab Majid, R.; Mohamed, N.; Haron, R.; Omar, N.B.; & Jomitin, B. (2014) Misappropriation of Assets in Local Authorities: A Challenge to Good Governance. *Procedia Soc. Behav. Sci.*

Adamec, D. A. (2011). Transport and Its Role in Society. *Transactions on Transport Sciences*

Adekola, O. D , Mensah, Y , Maitanmi, S. O., Akande, O., Kasali, F. A, Omotunde, A., Ajayi , W. and Ajiboye, O. (2021). An Online Road Transport Booking System. *Asian Journal of Computer Science and Technology*. Vol.10(2), pp.1-5

Behzad, M.; Sana, A.; Khan, M.A.; Walayat, Z.; Qasim, U.; Khan, Z.A. & Javaid, N. (2014) Design and Development of a Low-Cost Ubiquitous Tracking System. *Procedia Comput. Sci*., 34, 220–227

Choi, Y., Hickerson, B. & Kerstetter, D. (2018) Understanding the Sources of Online Travel Information. *Journal of Travel Research*, 57(1), 116-128

Fleischer, P.B.; Nelson, A.Y.; Sowah, R.A. & Bremang, A. (2012) Design and development of GPS/GSM based vehicle tracking and alert system for commercial inter-city buses. In *Proceedings of the 2012 IEEE. 4th International Conference on Adaptive Science & Technology (ICAST)*, Kumasi, Ghana, 25–27; pp. 1–6

Harish, M.; Karthick,R.; Rajan, R. M. & Vetriselvi, V. (2019). A New Approach to Securing Online Transactions—The Smart Wallet; *Springer: Singapore.* Volume 500, ISBN 978-981-13-0211-4.

Hsu, K-T, Lu W-C, Jheng, H-Y, Hung, Y-T, Chen, X-Z, & Chen, W-P (2022). Integrated System for Official Vehicles with Online Reservation and Moving Path Monitoring. *Applied Sciences*, 12(9):4777.

Igwe, C. O. (2013). A Review: Nigeria's Transportation System and the Place of Entrepreneurs. *Journal of Sustainable Development Studies*, 2201-4268.

Okifo, J. & Igbunu, R. 2015 Electronic Payment System in Nigeria: Its Economic Benefits and Challenges (*Journal of Education and Practice*), 6(16), 56-62

Kim,Y.H.; Park,Y. & Choi, J. (2016). The Adoption of Mobile Payment Services for "Fintech". *Int. J. Appl. Eng. Res.* 2016, 11, 1058–1061

Oloyede M. O, A. S. (2014). Development of an Online Bus Ticket Reservation System for a Transportation Service in Nigeria. *International Institute for Science, Technology and Education (IISTE)*, 5(12).

Rosati, Tony, and Greg Zaverucha (2011). "Elliptic curve certificates and signatures for NFC signature records." *Research in Motion, Certicom Research*, 10

Sad, A.A., Ayad, M.J. & Hayder, N.K. (2012). Design and Developing Online Iraqi Bus Reservation System Using Unified Modeling Language. *International Journal of Scientific Knowledge*

Shivaji. Varma. (2010). Bus reservation system. Retrieved from [http://shivajivarma.wordpress.com/2010/09/20/dbms-project-bus-

reservation](http://shivajivarma.wordpress.com/2010/09/20/dbms-project-bus-reservation) Accessed 19th December 2023

Subramaniyan J., Senthil Kumar P., Sripriya, S., Jeganb C. & , Jenny M. (2021). Smart Ticketing System for Public Transport Vehicles. *Recent Trends in Intensive Computing*. Pp 906-910. doi:10.3233/APC210301

Wee, K.I. (2007). Bus Ticket Reservation System. Available at: http://library.utem.edu.my/index2.php?option=com_docman&task=doc_view&gid=3237&Itemid=113 Accessed: 18th December 2023

Xiong, C, Zhu, Z, Chen, X, & Zhang, L 2018 Optimal travel information provision strategies: an agent-based approach under uncertainty *Transportmetrica B: Transport Dynamics* 6(2), 129-150