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A Study on Digitisation of Zambian Intercity Bus Based Public Transport Support Services

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Abstract This research study investigates the digitisation of booking and payment services of Zambian of Intercity Bus Transportation Sector to address the inconvenience faced by passengers due to manual ticketing processes. It aims to understand the details for deprived service and how digitisation can enhance customer experience. The study involves stakeholders like bus operators, customers, and local authorities, with data collected through interviews and online questionnaires. It walks through the solution and deduces the sample size based off a few variants to gain 95% confidence in the proposed solution. The proposed digitisation includes developing an integrated online system accessible via web and mobile applications. Overall, the study seeks to improve efficiency, convenience, and satisfaction in intercity bus travel in Zambia through digitisation.

Keywords Zambia, Digitisation, Booking, Reservation, Payment, Public Transport, Integrated Online System, Services

1. Introduction

Transportation is essential for providing mobility to the people, and for movement of goods. Transportation facilitates a broad spectrum of opportunities for an individual for desired activities. Though transport is not an end in itself, it is the means to many ends. Efficient transportation results in economic, social and political advantages [1]. Public Transport transportation is a system for taking people from one place to another, for example, using buses or trains [2]. Buses are the widely used mode of transport by the public to move from one town to another town. Big buses depart Lusaka from Intercity Bus station to towns such as Kapiri-Mposhi, Livingstone, Ndola and to neighbouring countries like Zimbabwe, Botswana, Malawi, Tanzania and more. Schedules can be obtained and bus tickets by going to Intercity bus stop in advance. Tickets are also purchased on the day of travel [3]. Public transportation has become an important part of urban life in many African countries and especially for fast growing cities. As cities expand rapidly, concerns about the effectiveness of within and outside city movements of people are becoming a source of worry and an important policy issue for many governments on the continent. This is because urban public transportation has important linkages with economic growth, productivity, social change and general well-being of the urban population. For many African countries public transport experienced a transformation especially following liberalisation of most economies in the 1990s, moving from public run systems to include private sector participation. This transformation did not leave out Zambia. The period after 1991 was characterised by an influx of private passenger vehicles into the country leading to an exponential growth in the number of public transport operators. In general, this improved the availability of public transport within and across cities making it relatively easier for people to connect between places compared to before [4].

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2. Literature Review

In the contemporary era, the demand for convenient and budget-friendly intercity travel solutions has surged. Traditionally, purchasing bus tickets involved enduring long queues at bus terminals or navigating through multiple carrier websites and apps, causing confusion and consuming time [5]. However, the advent of e-ticketing systems has revolutionized ticket purchasing by offering round-the-clock accessibility and eliminating geographical constraints, thereby enhancing traveller convenience and enabling service providers to monitor traveller behaviour effectively [6]. Zambia's mobile connectivity landscape reflects a significant opportunity for the development of online systems accessible to a large user base across the country [7]. While industries like hospitality and air travel have successfully integrated online booking systems, the intercity bus sector remains predominantly offline [8]. The integration of information and communication technology (ICT) in transportation holds immense potential to enhance mobility, safety, and efficiency. Technological advancements such as travel information systems and online

booking platforms cater to evolving consumer preferences for comfort, safety, and speed [9]. Previous studies indicate that various companies and transport agencies, including DotCom Zambia and Mazhandu Family Bus Services, have embraced e-ticketing and reservation systems to streamline operations and enhance customer satisfaction [10]. However, challenges such as low internet penetration and system maintenance issues have hindered widespread adoption. The emergence of smartphone applications has further transformed consumer behaviour, facilitated seamless online transactions and fostered closer company-customer relationships [11]. E-ticketing systems in public transport not only serve as payment methods but also process vast amounts of data, offering opportunities for improved management and integration of pricing structures [12].

The suitable flow of the system will be construed after the conducting the research on digitisation of public transport on the case study of intercity bus booking and reservation services. Bus Reservations Systems allocate available seats by employing the algorithm or formular below:

Availability = Capacity – Current Occupancy – Requested Guest

- Capacity is the maximum number of guests the reservation system can accommodate.
- Current Occupancy is the current number of guests already booked for the requested date and time.
- Requested Guests be the number of guests for the new reservation.

If Availability ≥ 0, it means there are enough slots available to accommodate the new reservation. Otherwise, there is not enough capacity, and the reservation cannot be accommodated. This formula provides a simple way to check whether a reservation slot is available within the capacity limit of the system.

The system should allow users to check seat availability, book seats, cancel bookings, and view current reservations. Below is a basic flow chart for implementation of such a system:

1. **Start:** The initial stage where the user begins their interaction with the system.
2. **Member Page**: The user is presented with a member page that likely requires login. This page also offers several options:
3. **Schedule:** The user can view the bus schedules. Select the date of date and time of departure.
4. **Price:** The user can check the prices for different routes or services.
5. **Booking:** The user can make a booking for a bus trip.
6. **Booking/Registration:** This decision stage directs new users to registration while returning users proceed to booking. If the user is not logged in, they will need to register.
7. **Login:** The user must log in to access their account and make bookings.
8. **Login Found**: A check is performed to verify if the login details are found in the system database. If not found, the process presumably redirects to registration or denies access. If found, the user proceeds to the next step.
9. **Booking:** This decision point asks if the user wants to make a booking. If no, the flowchart leads to "Logout." If yes, the user selects the bus and schedule.
10. **Select Bus:** The user selects the desired bus service.
11. **Select Schedule:** The user selects the preferred travel schedule.
12. **Save Data:** The booking information is saved to the system.
13. **Show Data:** The system displays the booking data to the user for confirmation.
14. **Finish:** If the user is done, they can log out or finish their session.
15. **Logout:** The user logs out of the system [13].

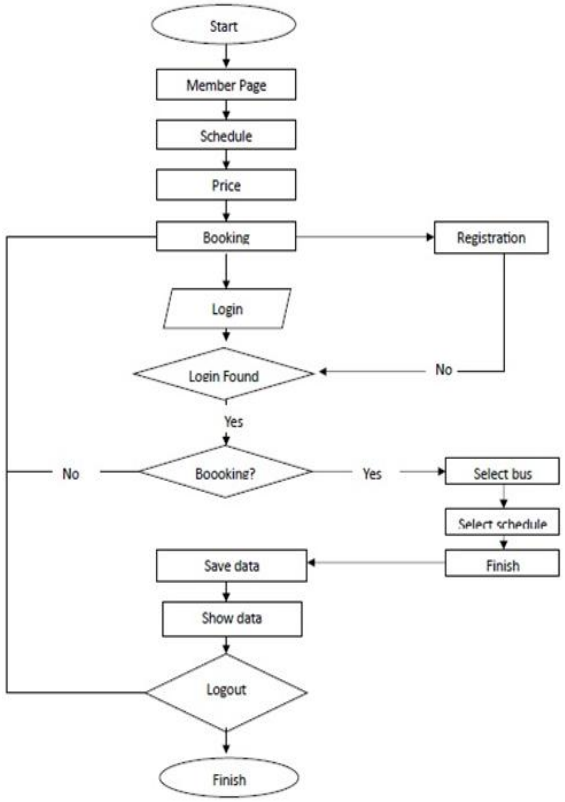

Figure 1. Flow chart diagram of online booking system

For an online Bus Reservation System to be successful, it is needs an online Payment Gateway. In simple terms, a payment gateway is a piece of software that collects and sends payment data from customers to acquirers, and then sends payment acceptance or rejection back to the customers [14].

The success of the system hinges on the functionality of its key modules, which include a payment gateway for processing online transactions like Airtel Money, MTN Money, Zamtel Money, and bank card payments, prevalent in Zambia and the SADC region. Additionally, the system incorporates a mobile application compatible with Android and iOS, leveraging the convenience and accessibility of

mobile phones. Another critical component is the web application, which users can access through any web browser on a computerized device. The development of this system primarily utilized Python as the programming language, with GitHub for version control and collaboration. This structure ensures a comprehensive, accessible, and user-friendly system.

3. Methodology

The research focuses on developing an Online Bus Reservation and Booking System, specifically targeting the engineering domain. It employs a qualitative research design, emphasizing interview-based and observational study approaches. This method is chosen due to its suitability for exploring the predominantly manual, paper-based systems currently in use for intercity bus operations. The qualitative approach is ideal for gaining deep insights into user experiences, preferences, behaviours, and the factors influencing the adoption of online reservation systems. The study targets the public using intercity buses in Lusaka city, including stakeholders like bus operators, conductors, the council, and bus owners. Lusaka, being a central hub for intercity and international bus services within the Southern Africa Development Community (SADC) and Common Market for Eastern and Southern Africa (COMESA) regions, presents an ideal setting for this research.

The Sampling technique suitable for this research study is Simple Random Sampling. Simple random sampling is a statistical method in which everyone in a population has an equal chance of being selected into a sample. The sample represents a smaller and more manageable portion of the people that can be studied and analysed. It's a fundamental technique to gather data and make inferences for a finite population.

Sample Size for this research study was deduced from the target Population Size of 15,000 participant, Confidence Level of 95% and Margin of Error of 5%. Sample size is the number of observations in a sample. It is commonly denoted n or N. Confidence/risk level is the degree to which an assumption or number is likely to be true. That is the probability that a random variable lies within the confidence interval of an estimate. The margin of error represents the range within which the true population parameter is estimated to lie, with a given level of confidence, based on a sample from that population [13]. The Sample Size for this study has been calculated using mathematical and python programming language in code shown below.

(i) Mathematical Sample Calculation

$$n = \frac{N \cdot Z^2 \cdot p \cdot (1-p)}{E^2 \cdot (N-1) + Z^2 \cdot p \cdot (1-p)}$$

Where:

n = sample size.

N = population size.

Z = Z-score (the number of standard deviations from the mean).

p = estimated proportion of the population (typically 0.5 if unknown).

E = margin of error.

Given the parameters:

N = 15000

Confidence level = 95%, so Z = 1.96

Margin of error E = 0.05

p = 0.5 (as a conservative estimate)

We shall now proceed to input the provided values into the given formula.

1. Calculate Z^2:
   $Z^2 = (1.96)^2 = 3.8416$
2. Calculate $p \cdot (1-p)$:
   $p \cdot (1-p) = 0.5 \cdot 0.5 = 0.25$
3. Calculate the numerator:
   $N \cdot Z^2 \cdot p \cdot (1-p) = 15000 \cdot 3.8416 \cdot 0.25 = 14406$
4. Calculate the denominator:
   $E^2 \cdot (N-1) + Z^2 \cdot p \cdot (1-p) = 0.05^2 \cdot 14999 + 3.8416 \cdot 0.25$
   $0.0025 \cdot 14999 + 0.9604 = 37.4975 + 0.9604 = 38.4579$
5. Calculate the sample size:
   $n = \frac{14406}{38.4579} \approx 374.5$

(ii) Python Programming Calculation

```
population_size = 15000          # Total population
confidence_level = 0.95          # Confidence level
margin_of_error = 0.05           # Margin of error (E)
z_score = 1.96                   # Z-value for 95% confidence level
p = 0.5                          # Assuming maximum variability, P (proportion of population with the characteristic)
q = 1 - p                        # Q = 1 - P
# Calculate the sample size using the formula with finite population correction
sample_size = ((z_score ** 2) * p * q) / (margin_of_error ** 2)
sample_size_corrected = sample_size / (1 + ((sample_size - 1) / population_size))
sample_size_corrected
#Result
```

374.5914363498786

This Sample Size is 375. To achieve a confidence level of 95% with a margin of error of 5% for a population size of 15,000 the calculated sample size, after applying the finite population correction, is approximately 375 individuals. This means you would need to include 375 participants in your study to ensure that your survey results are representative of the larger population with the specified confidence level and margin of error. The dataset reviews responses from a

survey regarding intercity bus usage in Zambia, focusing on variables like gender, age, occupation, bus usage frequency, favourite operators, and reservation practices. It also examines user satisfaction with the current reservation process, the challenges faced, and the time in advance that tickets are booked. Moreover, it explores payment methods, user satisfaction with these methods, and the factors influencing service choice. The dataset also gauges the overall convenience of the bus reservation system, awareness of online systems, the probability of recommending such systems, and the desired features in an online reservation system. This comprehensive dataset is essential for understanding current trends and identifying areas for improvement in the intercity bus service domain. Here below are the results from the collected data.

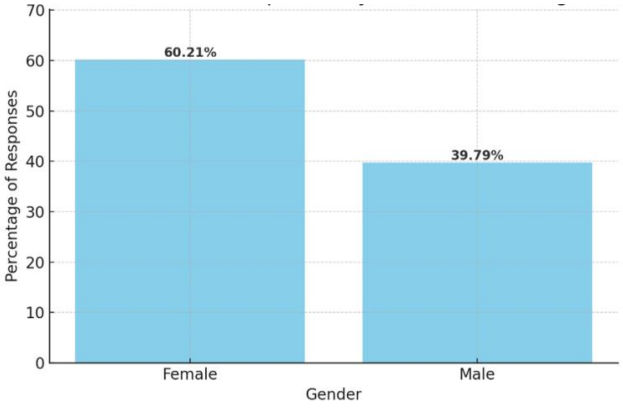

Figure 2. Gender distribution of intercity bus customers

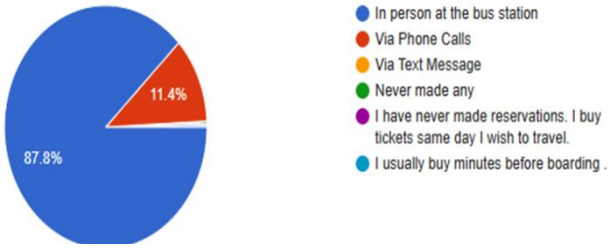

Figure 3. Methods used for making reservations of bus tickets.

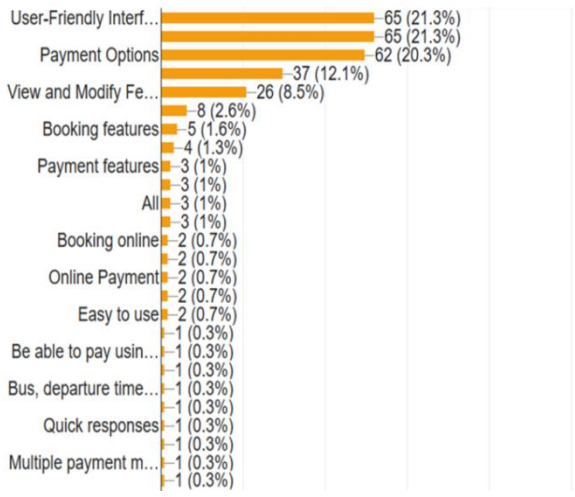

Figure 4. Desired features for the online bus ticket reservation and payment system

The visualizations provide a comprehensive overview of the current state of intercity bus usage and reservation processes in Zambia, as captured from the survey responses.

1. **Frequency of Intercity Bus Use**: The chart shows varied frequencies of bus use among respondents, with a significant portion using buses monthly or rarely. This indicates a diverse customer base with different travel needs and patterns.
2. **Methods of Making Reservations**: Most respondents currently make bus reservations in person at the bus station. This traditional method dominates, suggesting that digital reservation options either are not widely adopted or available. This could point to an opportunity for enhancing digital access and convenience.
3. **Satisfaction with the Reservation Process**: Satisfaction levels vary, with a notable number of respondents expressing dissatisfaction or neutrality. This variability suggests that there is room for improvement in the reservation process, potentially through the introduction of more user-friendly and efficient digital systems.
4. **Payment Methods Used for Bus Tickets**: The data show that the majority of passenger use cash as form of payment method in Zambia.

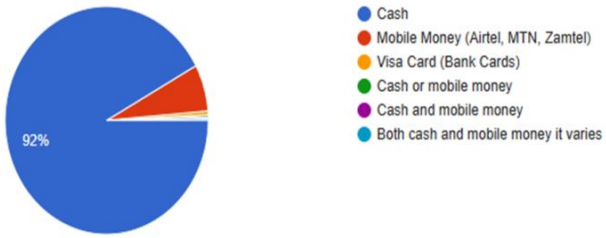

Figure 5. Payment methods used for buying intercity bus tickets

The majority of bus operators are using manual system like shown below in the pie chart. This is the analysed data from excel sheet.

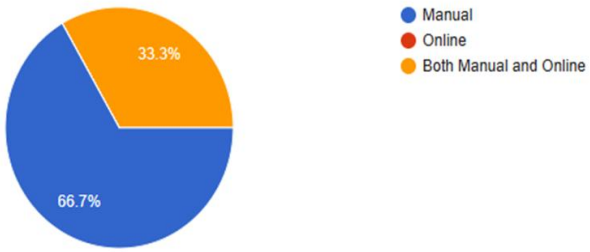

Figure 6. Current booking system at Intercity Bus Station

These insights could guide the development of an online bus reservation system, emphasizing the need for user-friendly interfaces, multiple payment options, and broad accessibility to cater to the diverse needs of bus passengers in Zambia. An online system could potentially streamline operations, improve customer satisfaction, and accommodate a broader range of user preferences.

Systems development is the process of defining, designing, testing, and implementing a new software application or program. It could include the internal development of

customized systems, the creation of database systems, or the acquisition of third party developed software. Written standards and procedures must guide all information systems processing functions. The organization's management must define and implement standards and adopt an appropriate system development life cycle methodology governing the process of developing, acquiring, implementing, and maintaining computerized information systems and related technology [15].

Agile methodology is applied for this study because it is predictable and values rigorous software planning and architecture. Agile methodology is a project management approach that prioritizes cross-functional collaboration and continuous improvement. It divides projects into smaller phases and guides teams through cycles of planning, execution, and evaluation [16].

Figure 7. Agile methodology diagram

1. **Plan:** Define research objectives, scope, and stakeholders. Create a detailed research plan.
2. **Design:** Develop research methodology, system framework, and prototypes.
3. **Development:** Implement research methodology, collect and analyse data.
4. **Test:** Test research findings and system design with stakeholders.
5. **Deploy:** Pilot the system, gather feedback, and make necessary adjustments.
6. **Review:** Evaluate system effectiveness, document lessons learned, and make recommendations.

This is achieved with the use of Adaptive Software Development (ASD) of Agile Methodology. Adaptive Software Development (ASD) is a direct outgrowth of an earlier agile framework, Rapid Application Development (RAD). It aims to enable teams to quickly and effectively adapt to changing requirements or market needs by evolving their products with lightweight planning and continuous learning. The ability to adapt allows teams to align with organizational goals. The ASD approach encourages teams to develop according to a three-phase process: speculate, collaborate, learn [17].

Here below is the overview of the overall system:

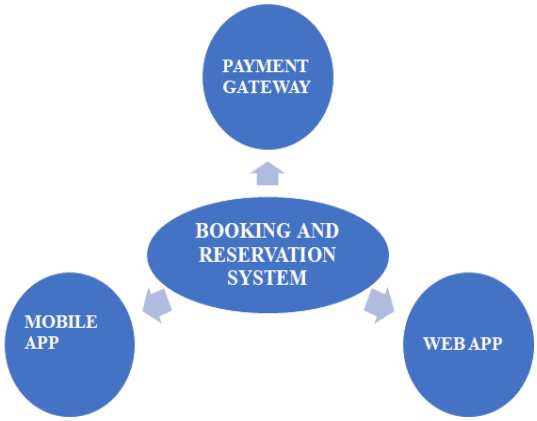

Figure 8. Reservation System Overview

The success of the system hinges on the functionality of its key modules, which include a payment gateway for processing online transactions like Airtel Money, MTN Money, Zamtel Money, and bank card payments, prevalent in Zambia and the SADC region. Additionally, the system to incorporates a mobile application compatible with Android and iOS, leveraging the convenience and accessibility of mobile phones. Another critical component is the web application, which users can access through any web browser on a computerized device. The development of this system primarily to utilise Python as the programming language, with GitHub for version control and collaboration. This structure ensures a comprehensive, accessible, and user-friendly system.

With the widespread adoption of mobile devices and applications, ensuring data security has become a paramount concern, especially for applications handling sensitive user information and financial transactions. In the context of this research, which focuses on bus reservation and payment systems, the security of data obtained from mobile apps (both Android and iOS platforms) is of critical importance. One of the fundamental security measures is the implementation of encryption techniques to safeguard data during transmission and storage. Secure communication protocols, such as HTTPS, should be employed for all network interactions, ensuring that data exchanged between the mobile app and the server is encrypted and protected from eavesdropping or man-in-the-middle attacks. Furthermore, incorporating two-factor authentication mechanisms can add an extra layer of security, reducing the risk of unauthorized access to user accounts. Integration with secure payment gateways is also crucial for handling financial transactions, ensuring that sensitive payment information is processed and stored in compliance with industry standards and regulations.

In addition to technical security measures, it is imperative to comply with relevant data protection regulations in Zambia, such as the Data Protection Act, which governs the handling and processing of personal data. Failure to comply with these regulations can result in significant legal and financial consequences for organizations operating in the country.

4. Findings and Discussion

Findings indicate that there is a significant engagement with intercity bus services customer, operator among various stakeholders. Intercity bus customers, frequently use these services, predominantly booking their tickets through traditional, in-person methods at bus stations. Notably, approximately 59% of these customers are aware of online reservation systems, and there is a high level of receptiveness towards adopting digital solutions. The potential benefits of an online bus reservation system as identified by customers include increased convenience, time savings, and enhanced transparency in scheduling and fare pricing. The demand for user-friendly interfaces and flexible payment options highlights the importance of customer-centric designs in the development of new technologies. Operators recognise that online booking systems can lead to improved operational efficiency, better record-keeping, and enhanced customer service. However, they also express concerns regarding the costs of implementation and the adaptability of their current workforce and customer base to new technologies. Government perspectives underscore a strategic commitment to enhancing public transportation through digitalization. The support from government initiatives is seen as crucial for overcoming the significant infrastructural and financial challenges associated with such transitions.

The integration of digital solutions in the Zambian intercity bus reservation system presents a significant opportunity to enhance service delivery and operational efficiency. However, this transition requires careful consideration of the following factors:

1. **Market Readiness:** There is clear evidence of market readiness for digital solutions, as stakeholders across the board express interest and willingness to adopt new technologies. The development of these systems must align with user needs and local market conditions to ensure high adoption and sustained use.
2. **Government Involvement:** Active government participation is essential not only in terms of funding and policy support but also in facilitating the necessary regulatory frameworks that encourage innovation while ensuring consumer protection and fair competition.
3. **Customer Experience:** Digitisation offers a pathway to significantly improve customer experiences, but this requires the deployment of systems that are accessible, reliable, and easy to use. Addressing the digital divide and ensuring inclusivity in access to new technologies will be crucial.
4. **Operational Challenges:** Implementing digital systems involves addressing several challenges, including the initial financial outlay, the integration with existing infrastructure, and the training of both staff and customers. These issues require strategic planning and phased implementation strategies.

5. Conclusions

In conclusion, the Online Bus Reservation and Payment System marks a significant step forward in modernising public transportation, offering benefits to both customers and operators. By leveraging technology, the system addresses many of the challenges traditionally associated with bus travel, paving the way for a more efficient, accessible, and user-friendly public transportation ecosystem. As adoption grows and technology advances, the system has the potential to transform public transportation into a more attractive, convenient, and sustainable option for travellers.

Future Recommendations

To improve the digitisation of Zambia's Intercity Bus Booking System. Implementation of a confirmation step and grace period to address wrong bookings and checks to detect and warn users of duplicate bookings is ideal. Development real-time seat inventory management to prevent overbooking and add safeguards to resolve duplicate payments promptly. Enhance the refund management system for efficiency and transparency. Continuously refining the user interface and developing of web and mobile application will improve accessibility. Integrating customer support within the platform will provide prompt assistance. Strengthening data security measures and implementing analytics and reporting tools will monitor performance and user behaviour. These steps aim to enhance user satisfaction, operational efficiency, and system reliability.

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REFERENCES

[1] S. Ponnuswamy and D. (Late) D. J. Victor, Introduction. McGraw-Hill Education, 2012. Accessed: Dec. 30, 2022. [Online]. Available: https://www.accessengineeringlibrary.com/content/book/9781259002731/chapter/chapter1.

[2] 'Public transportation definition and meaning | Collins English Dictionary'. https://www.collinsdictionary.com/dictionary/english/public-transportation (accessed Jan. 02, 2023).

[3] 'How to Navigate Transport in Zambia'. https://theculturetrip.com/africa/zambia/articles/how-to-navigate-transport-in-zambia/ (accessed Jan. 02, 2023).

[4] Consumer Unity & Trust Society 2016 'Understanding Challenges and Opportunities for Implementing 'Route Allocation' in Lusaka's Bus Transport System'.

[5] M. K. Shaikh, S. Palaniappan, T. Khodadadi, S. Ali, F. Ali, and F. Ali, 'Using eBus Services Solution, Book Anywhere to Save Time', ICISCT 2020 - 2nd Int. Conf. Inf. Sci. Communication. Technology., no. January 2021, 2020, doi: 10.1109/ICISCT49550.2020.9080024.

[6] S. Mangai, D. S. Mador, and H. Isaac, 'Criteria for Online Booking/Ticketing for Bus Transport Companies in Nigeria', no. October, 2016, [Online]. Available: https://www.researchgate.net/publication/364695807.

[7] 'Digital 2022: Zambia — DataReportal – Global Digital Insights'. https://datareportal.com/reports/digital-2022-zambia (accessed Jan. 25, 2023).

[8] T. Adam, 'Automated Bus Ticket Reservation System for Ethiopian Bus Transport System', IOSR J. Comput. Eng., vol. 21, no. 3, pp. 22–27, 2019, doi: 10.9790/0661-2103022227.

[9] C. Technology, 'Faculty of Information and Communications Technology (ICT) development of an e-ticketing system "A Dissertation submitted in partial fulfillment of the requirement for the Bachelor' s Degree in Computer Science" Sinyinza Musyani Student Number 004-16', no. 004, 2019.

[10] A. Al-Ani and A. Taa, 'Mobile – Based Bus Ticketing System in Iraq', Eur. J. Comput. Sci. Inf. Technol., vol. 3, no. December 2015, pp. 42–55, 2015.

[11] K. Oloyede, M., Alaya, S., & Adewole, 'Development of an Online Bus Ticket Reservation System for a. Computer Engineering and Intelligent Systems', vol. 5, no. 12, pp. 9–18, 2014.

[12] S. Jamshed, 'Qualitative research method-interviewing and observation', J. Basic Clin. Pharm., vol. 5, no. 4, p. 87, 2014, doi: 10.4103/0976-0105.141942.

[13] E. S. Soegoto, R. Setiawan, and R. Jumansyah, 'Impact of E-Ticketing Application on Bus Transportation in Bandung', Proc. Int. Conf. Business, Econ. Soc. Sci. Humanit. – Econ. Bus. Manag. Track (ICOBEST-EBM 2019), vol. 112, pp. 25–28, 2020, doi: 10.2991/aebmr.k.200108.008.

[14] J. Patel, 'Secured and Efficient Payment Gateways for eCommerce', Int. J. Res. Publ. Rev., vol. 2, no. 7, pp. 575–582, 2021, [Online]. Available: www.ijrpr.com.

[15] S. Development, 'FCA Essential Practices for Information Technology Based on Industry Standards and FFIEC Examination Guidance', pp. 1–5, 2007.

[16] Agile Methodology in Project Management. Available at: https://www.wrike.com/project-management-guide/faq/what-is-agile-methodology-in-project-management/ (Accessed: 25 May 2024).

[17] Adaptive Software Development (ASD). Available at: https://www.productplan.com/glossary/adaptive-software-development/ (Accessed: 25 May 2024).