IMPLEMENTATION OF SECURE USER-CENTRED ARCHITECTURE FOR BUS BOOKING SYSTEM INTEGRATED WITH UNSTRUCTURED SUPPLEMENTARY SERVICE DATA AND WEB PLATFORMS

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Abstract

Globally, lots of people commute to various destinations using road transportation almost on daily basis. Noticeably, purchasing bus tickets has been over the counter at some bus terminals in developing countries including Nigeria. This ticketing procedure is slow and obstinate, resulting to rowdiness at bus parks. Interestingly, previous researches have focused on different challenges that surround booking bus ticket. However, sufficient attentions have not been paid to a secure architecture that offers flexible booking platform and enhance passenger experience. Thus, as its main goal, this study evolved a secure system architecture that is based on three fundamental components namely security, customer experience and dual booking platforms powered by web and Unstructured Supplementary Service Data (USSD) technologies. The secure conceptual architecture, which represents our main contribution, was designed with software engineering tools such as block diagram, use case and flowchart to enable commuters with or without internet service seamlessly book for tickets. Subsequently, the architecture was implemented with Hypertext Pre-processor (PHP), MySQL and Spring application framework. Again, the system was implemented with technologies like QR code, encryption, USSD, eWallet and blockchain. The developed system functioned as designed and its adoption will certainly enhance service delivery, customer satisfaction, security and financial wellbeing of commuters and transport companies.

Keywords: Architecture, USSD, Secure Booking System, User-centred, QR code, Web platform

Introduction

From time immemorial, people have found the needs to move from one location to another. Interestingly, land transportation happens to be the mostly used and cheap means of transportation for commuters. Arguably, vehicle comes to the minds of most low-income travellers, as far as land transportation is concerned. In most developing countries buses are used to transport human and goods within and between rural and urban centres. Therefore, bus tickets are issued by transportation companies to among others, keep records of passengers and maintain financial records. In order to ease the process of booking for buses, electronic ticketing (E-ticket), which allows passengers to reserve and purchase tickets at their convenience is rapidly becoming common de facto (Ceipidor et al., 2013; Skarica, Belani and Illes, 2009).

Unstructured Supplementary Service Data (USSD) is a relatively cheap and real-time communication platform provided by global system for mobile (GSM) network operators. Furthermore, USSD offers service that allows high-speed communication between

subscribers and enterprise applications across GSM network. USSD is session orientated, unlike short message service (SMS), which is a store-and-forward technology, thus turnaround response times for interactive applications are shorter for USSD than SMS (Gupta, 2010). Quick Response (QR) code is a two-dimensional matrix code for storing and retrieving digital contents at high speed. Due to its numerous advantages, such as data security and cost reduction, QR code has become a popular tool to marketing departments of several organizations (Hui, 2017). It is also an effective means to tag and uniquely identify objects (Kaur, 2017). Hence, in security parlance, QR code can serve the dual purposes of object authentication and confidentiality of sensitive digital contents.

Harmony Express is a transportation company own by Kwara State government and has been commuting passengers to several major cities in Nigerian since inception. Interestingly, the company has been in operation for over seven decades. Presently, the Harmony is experiencing rowdiness at bus parks due to increasing number of commuters, which is obviously occasioned by slow booking process at the peak of business hours.

Recently, research efforts in bus ticketing have shown that challenges like rowdiness and corruption in bus transportation company cut across regions, especially in developing countries (Adam, 2019; Alkhaldi et al., 2018; Andhale, More, & Nair, 2019; Gupta et al., 2018). Significantly, the need for a secure and user-centric booking system, which could be accessed by passengers with or without internet enabled devices is desirable in developing countries like Nigeria (Oloyede, Alaya, & Adewole, 2014). To the best of the authors' literature review, the existing researches are yet to propose such a system. Therefore, as its main contribution, this research presents a flexible and secure system architecture with multiple platforms for ticket booking. The proposed architecture was designed with well-known software tools for easy extension or adoption to booking processes in another domains. Certainly, operating a transport company without prior booking schedules in any human settlement could disorganize travelling arrangements for transportation companies and jeopardize commuter satisfactions.

Hence, this study aimed to develop a secure bus ticketing system by incorporating quick response code (QR code), data security algorithms and unstructured supplementary service data (USSD). It is a self-service system that provides both web and mobile platforms for better customer experience. The platforms allow passengers to book bus ticket at any time from the comfort of their various locations and get transaction receipts, either as QR code or unique code generated by the USSD service. Thus, the remaining sections of this article are arranged as follows: section 2 reviews related literatures on the subject matter; section 3 presents the methodology employed in the design and development of the proposed system; section 4 discusses the implemented system; and section 5 concludes the article.

Review of Related Works
For some time now, several researches have been channelled toward improving different aspects of public transport operation like security, customer experience and payment process. Notably, Oudah (2016) and Soegoto and Fadillah (2018) conducted empirical studies to uncover the potentials of technologies like radio frequency identification device (RFID), global system for mobile communications (GSM), global positioning satellite (GPS) and ZigBee to bus ticketing system. For instance, Oudah (2016) opined that building the modules of a ticketing system on these technologies could lead to improved solution in terms of cost, convenience, user satisfaction and future implementation. Unlike Oudah (2016), Soegoto and Fadillah (2018) focused on minimizing error rates of data entry into ticketing system by operators.

Alsmadi, Almarashdeh, Badawi and Alshabanah (2018) analyzed reservation system for Riyadh metro. Subsequently, the researchers implemented a system that reduced human interference in processing and issuance of tickets for an efficient metro management. However, passengers required internet service to book ticket through the system. Relatedly, Oloyede et al., (2014), Baraki et al., (2015), Gupta et al., (2018) and Adam (2019) developed web applications to address specific issues identified with purchase of bus ticket. In particular, Gupta et al, (2018) combined QR code and one-time password (OTP) into web-based system, while Baraki et al., (2015) generated Bus Pass to authenticate passenger and reduce ticket processing time through web application. Unfortunately, all the web-based solutions required internet services.

Also, exploring some laudable features offered by mobile platform, Fitriani and Abdillah (2015), Duraisamy (2018) and Andhale et al., (2019) developed Android based mobile applications to solve various problems associated with reservation and ticketing in transportation businesses. Though, Baraki et al., (2015) and Gupta et al., (2018) presented similar approach to boost user friendliness in bus ticketing, but Gupta et al., (2018) added feature that generates and sends one-time password (OTP) to email account of registered passenger for authentication purpose. Particularly, Fitriani and Abdillah (2015) incorporated general packet radio service (GPRS) into android-based ticket reservation (m-Reservation) to increase customer experience. Therefore, the m-Reservation allows passengers to view departure schedule, check the list of reservations and read the info posted directly via android smartphone and generate ticket for passenger authentication at departure points.

Importantly, security remains another key factor in ticketing system. To this end, Adam (2019) and Gupta et al., (2018) respectively weaved MD-5(Message Digest) and one-time password (OTP) into their proposed systems. Primarily, Smirnov et al., (2014) researched on validation of electronic tickets (e-ticket) for mobile ticketing system that used near field communication (NFC) for transportation companies. The researchers proposed a protocol that operated in peer-to-peer network to validate and check e-ticket. However, the study did not cover payment module of a typical ticketing booking system.

From the foregoing reviews, it is evident that customer's satisfaction, simplified booking process, as well as, security remained the core components of any bus ticketing system. Individually, the reviewed literatures focused on some of these essential components without due considerations to availability of internet service or sophistication of the mobile device owned by commuters. Really, this gap deserves research attentions. More so, considering the low internet penetration and mobile devices with basic functions for calls and SMS that are used by majority of commuters in developing countries like Nigeria. Thus, this gap could possibly be filled by non-internet based, but secured and real time booking system.

Methodology
This section explains design principles and developmental approaches that guide the implementation of the proposed system. Hence, relevant software design tools were used to concretize the conceived system architecture for simplicity and easy development.

Design of the Proposed System
In order to design and implement the proposed bus booking system with realistic scenario, Harmony Express was selected as case study. The rationale its selection not farfetched, the transport company has been in operation for over half a decade. Also, it covers large cities in Nigeria conveying mostly low- and medium-income earners. Actually, the feasibility study conducted revealed that the organization still makes use of a semi-computerized system.

That is, only one staff of the organization operates the system and passengers cannot book ticket through the system. The booking staff captures information about prospective passengers and sells ticket to them over the counter.

Indeed, the proposed system is flexible enough for implementation by other bus transportation companies with minimum configurations. The reason being that, it employed clear-cut software design paradigm layered on topical technologies like electronic wallet, QR code and USSD. On one hand, the QR code is meant to serve as electronic payment receipt for passengers who book through the web platform. On the other hand, the USSD service is incorporated into the system to enable customers without smart phones or internet service to make their bookings seamlessly. Using either the web or mobile platforms, customers can include welfare services such as refreshments and Wi-Fi service, while making their bookings.

System Architecture

The functionalities of the proposed system architecture were broadly encapsulated into two modules, namely the administration and customer modules as shown in Figure 1. The administration module provides key functions for handling system administrative tasks like updating bus availability, updating bus schedule information, managing feedbacks, creating sub administrators and configuring available welfare services for scheduled journeys. In addition, the module is used by administrator to manage available funds for electronic wallets (or over the counter ticket sale).
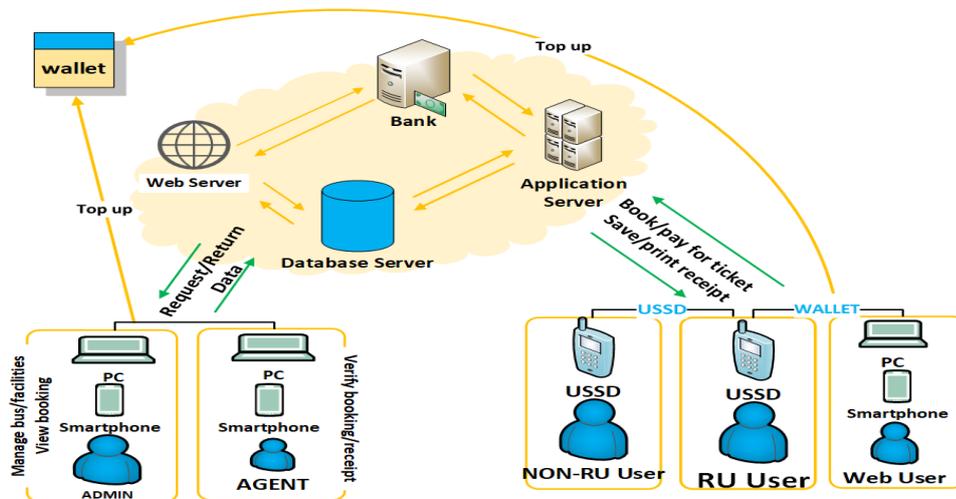

Figure 1: Architecture of Secure Bus Service System

Prior to booking their desired destination and welfare services, the customer module allows commuters to view currently available routes via web or USSD interface. Besides, the module allows passenger to select preferred seat from unallocated seats, choose payment type, add optional welfare services, save or print receipt (QR Code or SMS) etc. Likewise, customers can create web profile through the web interface and can also manage their booking through web and USSD interfaces.

Basically, commuters with internet services are expected to perform all their booking activities through the web platform, though they are at liberty to use USSD platform. Their payments are handled by secured electronic wallet facilities and QR code (e-ticket) would be sent to email accounts of passengers after successful booking exercise. Conversely, clients without internet service or those without smart phones could simply dial USSD code to

manage booking activities. Still, a booking code would be sent to their phones as soon as the booking is completed and necessary payment is made as mandated by USSD workflow.

System Block Diagram

The proposed system is divided into four blocks to easy development namely security, payment, user (both customers and system handlers) information and customer satisfaction as shown in Figure 2. Ab initio, the system design placed strong emphases on security and privacy of commuter information. Hence, security of every financial interaction is managed by existing USSD payment protocols involving passenger's bank, banker of Harmony Express, and telecommunication operators. Thus, the entire financial and none financial components of the system were based on security of information, above all other considerations. For example, the QR and transaction codes received by passengers were introduced into the design to ensure authentication and confidentiality of commuters. Also, secure hash algorithms (SHA-1) was used to hash crucial information like passwords of customer before being saved into the database. Correspondingly, Advanced Encryption Standard (AES) cryptography was utilized to encrypt passenger's financial and personal information.
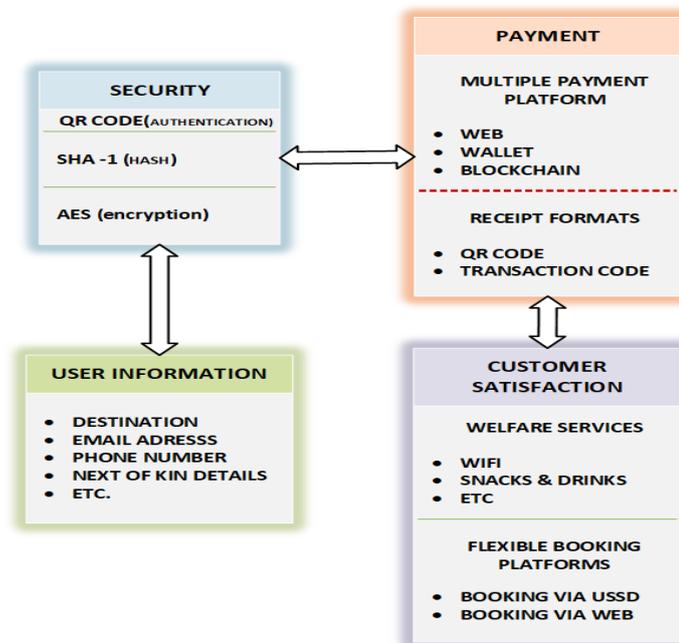
Figure 2: Block Diagram of Secure Bus Service System

System Flowchart and Use Case Diagram

The flowchart of the propose system is shown in Figure 3. As depicted in the flowchart, system administrators and registered passengers are expected to login before using the system after initial registration. Registered passengers are considered to be frequent web or USSD (RU) users whose information are already stored in the system. Whereas, a none register (Non-RU) passengers are first-time users who use USSD to book and provide registration information at the counter upon arrival at the counter for their first usages of the system. Therefore, Non-RU user belongs to category of passenger who do not have internet enable phone. Each of the system user can perform the action shown in the flowchart. Similarly, Figure 4 reveals the actors and their respective actions using Use Case diagram. In addition, the diagram depicts the proposed system boundary and relationships among various actions.
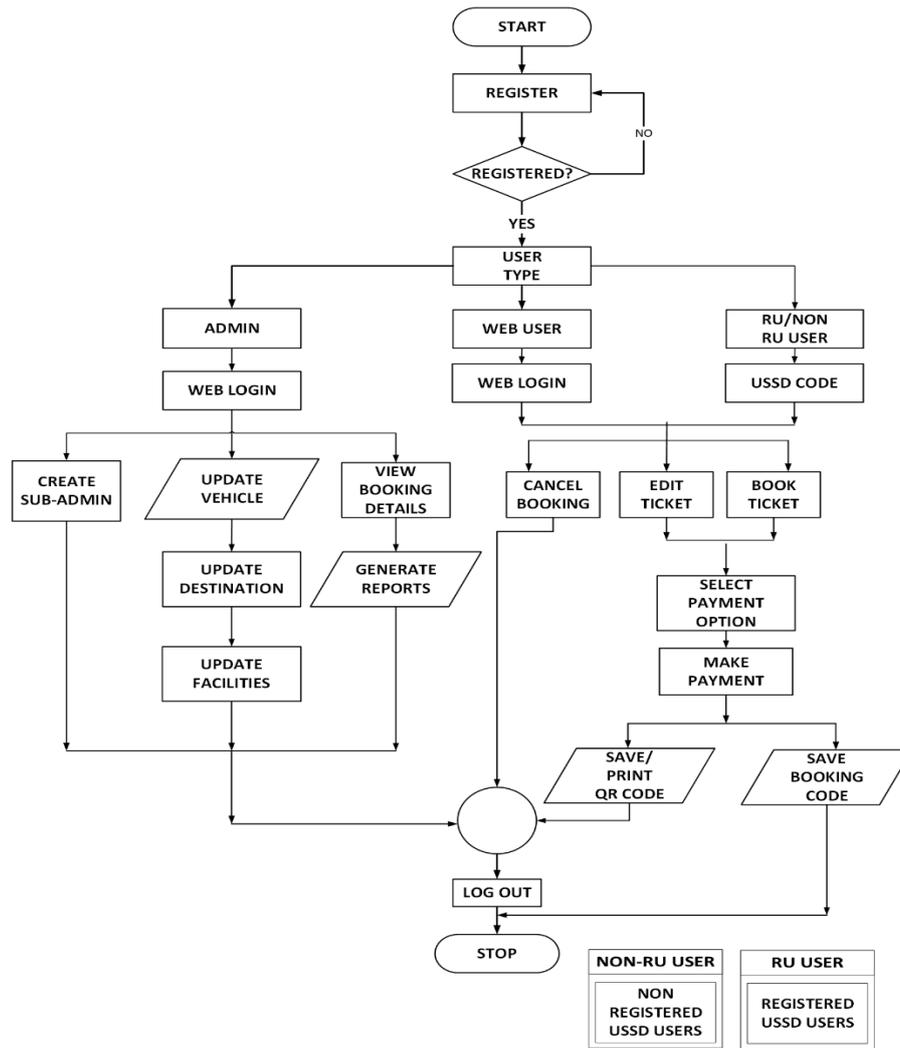
Figure 3: Proposed System Flowchart
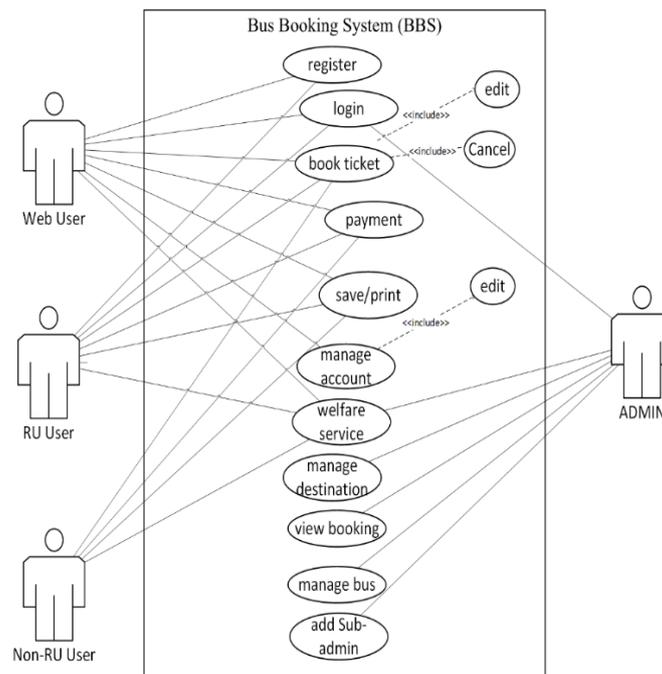
Figure 4: Proposed System Use Case Diagram

System Development

In order to develop the proposed system some software development tools for web application and USSD were employed. Foremost, Hypertext Pre-processor (PHP) which is a server-side scripting language was used to develop the administrator module and business logics for the web interface of registered users. In addition, data model for the system was implemented with MySQL database management system. Also, other web development tools such as JavaScript, cascading style sheet and HTML 5 were used to develop the web interface. Likewise, Spring application framework was used to develop the USSD. Subsequently, the USSD implementation was deployed on Africastalking gateway.

Implementation and Discussion

This section discusses the implementation of core functionalities for the booking system. Therefore, some of the interfaces captured from the system were used to illustrate these functionalities, namely security features, flexible booking platforms and customer satisfactions.

Security features

Figure 5 shows the content of a table in the database that stored basic passenger profile. As noticed in the password field, passenger's password was hashed with SHA-1 algorithm for security purpose. Also, AES encryption was used to secure sensitive data as passengers interact with backend servers from their client devices.

id	firstname	lastname	email	password
1	User	User	example@email.com	7110eda4d09e062aa5e4a390b0a572ac0d2c0220
2	aliyu	abdul	aleeypepe@gmail.com	7110eda4d09e062aa5e4a390b0a572ac0d2c0220
7	ali	dodo	dodo@gmail.com	75d4c9b02467d96bc2ea6d655eb983d5a7a97a9b
8	majeed	ali	dodo111@gmail.com	f7c3bc1d808e04732adf679965ccc34ca7ae3441

Figure 5: User Profile with Hashed Password

Still on security, the interface depicting QR code generated for web user and unique transaction code received by USSD users are shown in Figure 6 and Figure 7 respectively. The codes were used to properly authenticate passengers and to retrieve their profiles for further administrative processes before embarking on their journeys.
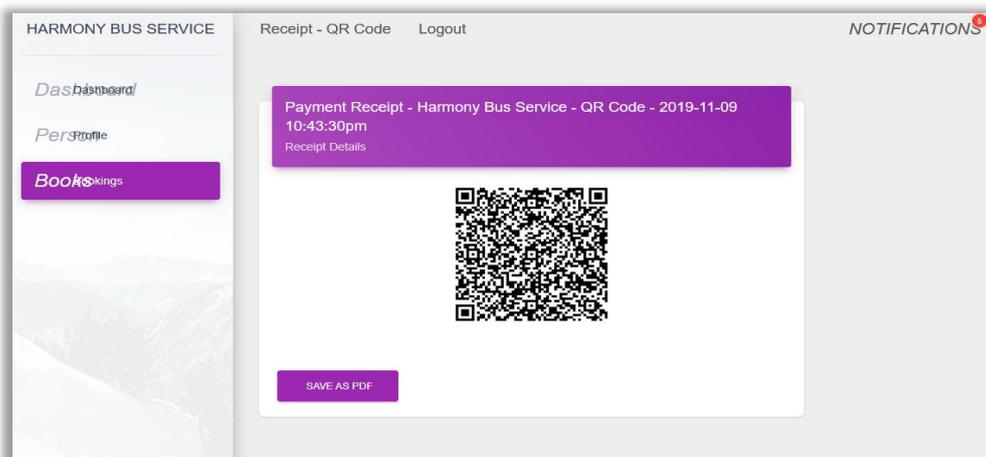
**Figure 6: Web Receipt Containing QR Code**
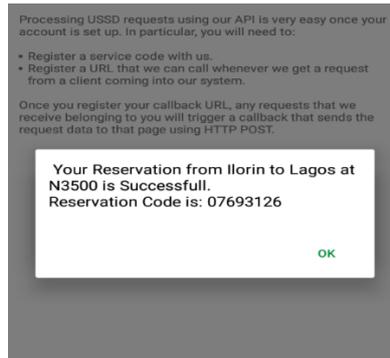
Figure 7: Unique Transaction Code

Flexible booking platforms

Through the USSD platform, passengers can book for tickets and other optional services by dialling *384*428# from any GSM enabled phones as illustrated in Figure 8. Also, the sequentially arranged USSD interfaces will guide users when making payment, entering trip information (Figures 9a to 9d), selecting optional services etc. Likewise, commuters with smart phones and internet service can book ticket from online platform using the web interface shown in Figure 10.
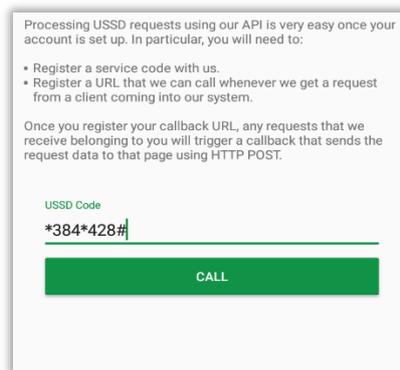
Figure 8: Initiating Booking with USSD Code
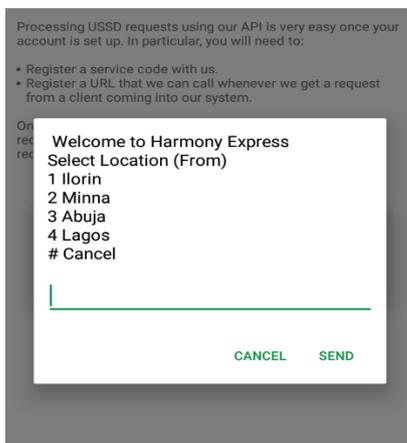
Figure 9a: USSD Location Interface (From)
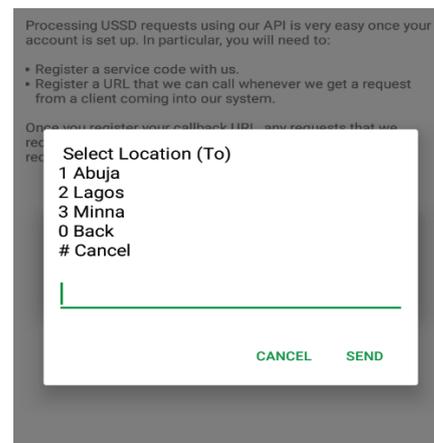
Figure 9b: USSD Location Interface (To)
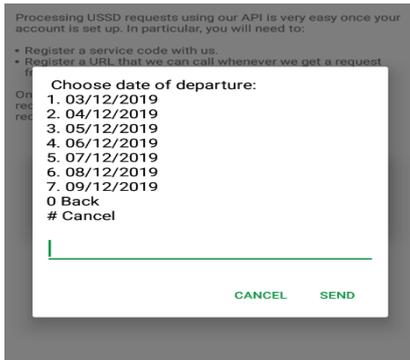
Figure 9c: USSD Departure Date Interface
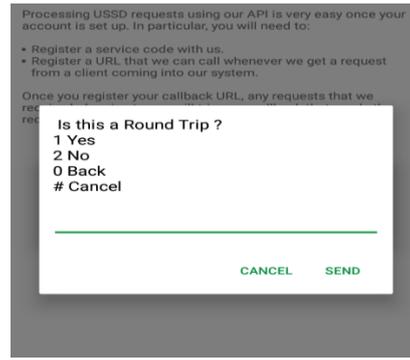
Figure 9d: USSD Trip Type page
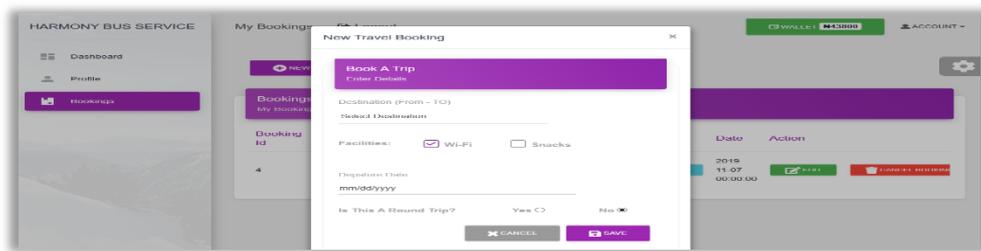
Figure 10: Initiating Bus Booking from Web Platform

Customer satisfaction

Another key function of the booking system is the provision of optional services for differentiated customer experiences through USSD and web platforms. For example, Figure 11a illustrates the services that passengers might include in their booking registration for a pleasurable journey. In addition, user can pay for bus ticket from preferred payment options including commercial bank account, electronic wallet or block chain as shown in Figure 11b. Similarly, passenger could search for relevant information about a trip for well-planned journey.
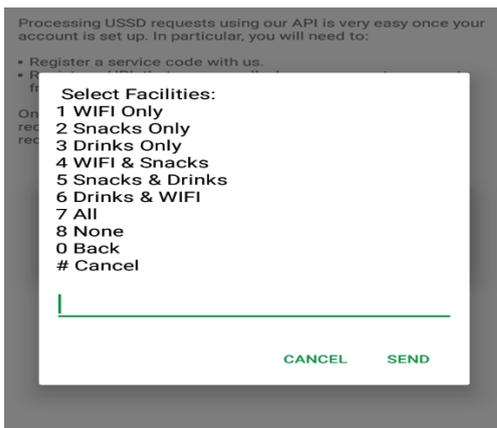

Figure 11a: USSD Interface for Optional Services
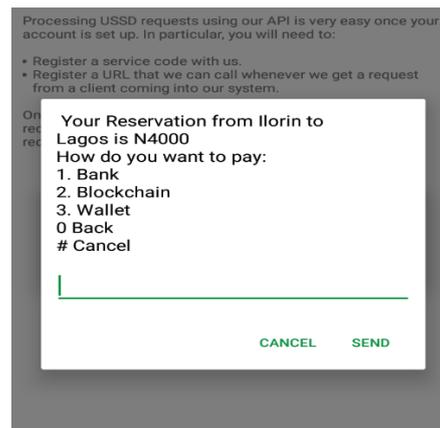
Figure 11b: USSD Select payment type page

System Management

The development of the system also included essential administrative functionalities for effective management of implemented processes and provision of information needed by all users. For instance, Figure 12 presents a web interface that enable system administrator to manage other system users, manage vehicle, setup payment options, manage bookings,

manage trip information etc. More importantly, administrator can easily generate several reports concerning finance, trips, vehicles management etc. to assist management of Harmony Express in decision making processes.

Figure 12: System Administration Webpage

Conclusion

Recognizing the fact that most commuters travel by bus is enough justification to seek better ways to boost passengers experience and secure the information of transport companies. Essentially, the proposed system included USSD and web platforms to enhance booking of bus ticket. Notably, the system could assist organization to internally manage their business processes, minimizing human errors and overcoming issues identified in previous systems. Also, the dual booking platforms and flexible payment options strengthen differentiated commuters' satisfactions. As a matter of fact, the security and simplified payment process, incorporated into the system will sufficiently minimize security breaches and foster financial transparency. More so, the system was designed and developed with proven software techniques and tools to ensure credibility of its operations and to accommodate imminent future extensions and adaptation. Future researches could extend the secured and dual booking platforms implemented in the study to other service delivery companies in developing countries with low income earners and weak internet penetration.

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