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A THREE-TIER INTEGRATED QUEUE MANAGEMENT SYSTEM: OPTIMIZED SERVICE DELIVERY FOR LAND TRANSPORTATION CLIENTS

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ABSTRACT

Optimization of client satisfaction and faster services are the main goals of any service-oriented government organization. However, the land transportation agency in Eastern Visayas Region of the Philippines experience challenges in the management of its flow and processes, as the methods applied are static and traditional. This study aimed to streamline these challenges encountered by clients and employees through the implementation a three-tier queue management system utilizing the agile model incorporating iterative phases of planning, design, development, and testing, with inputs from users' feedback. The evaluation comprises 115 participants composing supervisors, information and communication technology experts, staff, and service clients; mixed quantitative surveys with qualitative usability feedback for user-centric improvement using technology acceptance model and ISO-9126-4 frameworks. The results showed a consistently high score on key criteria, namely, perceived ease of use, structure & layout, relevance, functionality, interactivity and completeness with scores ranging from 4.65 to 4.80, which falls into the highly effective level. Findings represent the strength of the system and design strategy toward reduction of wait times, enhanced transaction flow and processes, and improved transparency. Further findings showed that the three-tier queuing system is beneficial to land transportation agency in fine-tunning their operational processes and increasing revenue.

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I. INTRODUCTION

Like many government agencies, Land Transportation hold the responsibility of providing quality services to people in various types [1] including issuance of licenses and permits that involves long queuing in the clients' arrival area. And, this has been a major issue faced by the Land Transportation Districts in Eastern Visayas, Philippines for several years due to prolong waiting time or queuing and the absence of transaction tracker display for the clients. These concerns cause customer dissatisfaction, overcrowding, resulting in backing out from the services, and revenue loss [2]. Such reasons inspire the researchers to conduct a study intending to resolve this major issues choosing LTO – San Juan District as the initial focus of the study.

The best queue should have shorter queues while serving the clients per unit of time because mismanaged queue becomes more challenging and causes dissatisfaction especially as data volume rises [3], [4]. Additionally, Robas et. al., found out that an effective queue management makes the customers feel better; thus, resulting in good service feedback [5]. Moreover, the LTO also uses non-flexible approach of monitoring transactions by giving paper tickets; and if misplaced risk of losing their spot is another concern. The queue system is used for having a systematic and faster process in transacting business because service clients who experience poor service delivery, especially when it entails waiting in long queues could result to departure without availing the services [3], [6].

And the speed of service, which is a major problem in the Philippine government, reflects how efficient the system is by which affects customer satisfaction [2]. The core aim of every institution is not to lose customers or clients by providing with the services that will satisfy their needs [3]. Adding unique features to a queuing application like automation of steps in the workflow through generation of automatic ticket identifiers [5], employee workstation, and client electronic display tracker boost transparency and accountability. Clients' experience in the queue such as ineffeciencies becomes a determining factor of their first impression of the organization and therefore can result to substantial losses [7]. Thus, reducing the unnecessary queuing time became a critical issue for the restaurant owners to promote customers' satisfaction [8]. Developing the three-tier queue management system has a main goal of linking the 3 systems namely client registration, employee workstation and client display.

This implemented system has the intention of reducing wait times, solving the dissatisfaction of service clients, streamlining employees' work performance and the use of resources, and providing a display tracker for the service clients to monitor the status of their requested services in the LTO – District Offices. Queueing system is influential to the supervision and the service quality which lead to revenue management strategies of an organization [9], [10]. Thus, this transformation addresses the increasing demand of the service clients particularly on transparency and wait time reduction. Moreover, queuing provides the cornerstone of efficiency as they assist employees and managers in tracking, prioritizing, and ensuring the delivery of services and transactions [7], [11]. Specifically, it sought to achieve the following objectives:

1. To assess the existing approach of servicing Land Transportation clients;
2. To propose possible enhancements in the existing strategy;
3. To solve the challenges encountered by the service clients and employees during license or permit applications from the service request to completion phases.

II. THEORETICAL REFERENCE

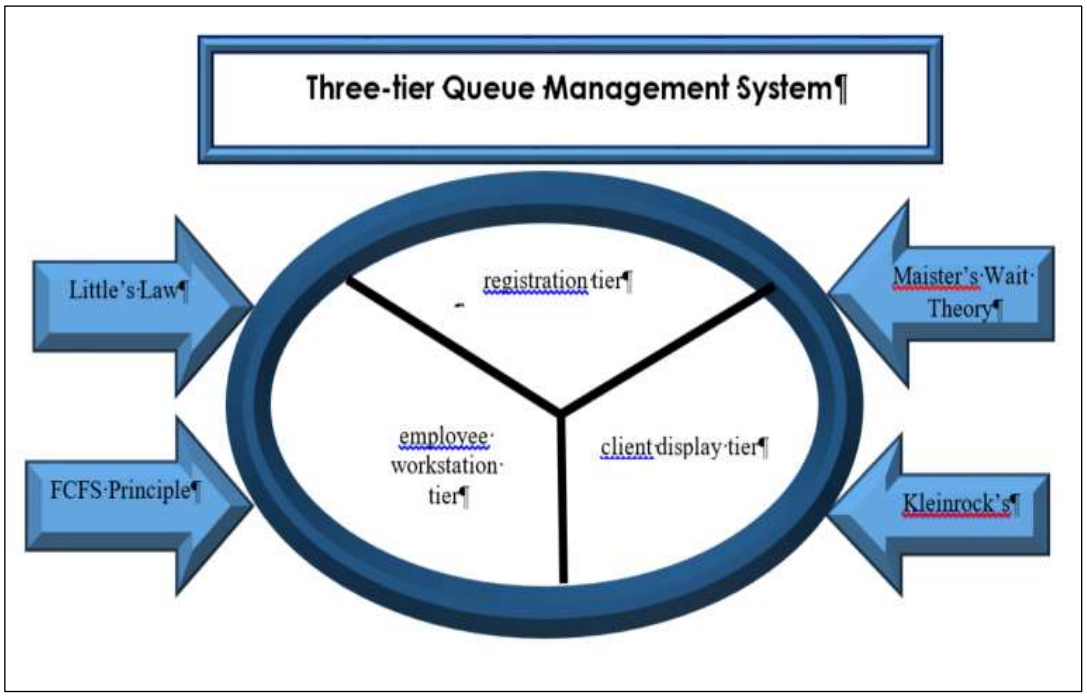

Figure 1: Theoretical Framework.
Source: Authors, (2026).

The three-tier queue management system was structured developed focusing the registration tier during the client's arrival for the selection of the service type and the issuance of the queue number an approach of minimizing bottleneck in the service area; employee workstation tier, and client display tier. In the case of the Land Transportation Districts of Eastern Visayas, Philippines, some of the customers or clients in the case of the Land Transportation leave without receiving the service maybe because they are tired of waiting the line [12] and status of their transaction cannot be tracked by the service clients.

Thus, Little's Law states that the average waiting time and the average number of items or clients (in the case of land transportation application) are important measurements in the decision making of the district supervisor [13]. First-Come, First-Serve Principle is also utilized in this system to ensure fairness by serving customers in the order they arrive or introduces and thereby promotes flexibility for exceptional situations or priority situations such as (Kleinrock, 1975) priorities to tasks or customers-based urgency or value. Moreover, the Service Quality and Perceived Wait Theory of Maister (1985) emphasize perceived waiting times and customer satisfaction are essentials for designing modern queuing systems [14].

The three tiers of the queue management system is implemented to manage service client's transaction's flow, promote quality service, and enhance client experience. Also, effectively controlled clients can avoid overcrowding and thus, the efficiency of the queue model may include important factors such as arrival time in the queue or server, average service time, average waiting time, and queue structure [8-10]. Transparency and real-time tracking of transactions through the display tier thereby enhancing customer satisfaction and ultimately improving overall operational efficiency.

III. MATERIALS AND METHODS

The development of the three-tier queue management system followed the agile model (see Figure 1) and occurred in two primary phases: development and evaluation. Development was iterative process that included: plan, design, develop, test, deploy, and review. This methodology was used because of its operational appropriateness, speed and the capability of adapting to the changing needs of the service clients and the personnel in the Land Transportation Offices (LTOs). In the planning stage, consultation with the key informants from Land Transportation District of San Juan, Southern Leyte, Philippines, District Supervisors, and Regional Administrators was held to elicit service clients' requirements. The consultation made it necessary to have a improved queue system for the Land transportation district offices to replace the traditional physical single-server waiting line to a three-tier queue management system to ensure efficient and fair government service delivery by reducing wait times in a queue lines, and thus, streamlining processes. This input and the fruits of extensive literature reviews shaped the goals for the system development including user-friendly graphical interfaces and a more structured approach to client service delivery. Prototyping in evolutionary refinements to increase scalability and usability was also conducted. Core functionalities include organization and management of clients' flow, minimizing wait times and improving the overall client journey across the different interactive touchpoints. These have been built and evolutionarily improved with the help of modern technology and agile development methodologies from stakeholders' feedback.

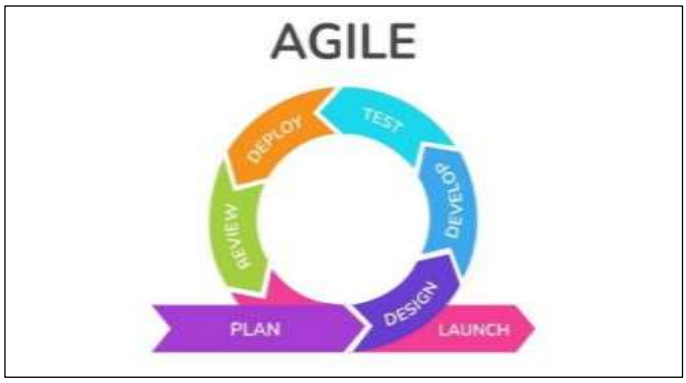

Figure 2: System development model.
Source: Authors, (2026).

On the other hand, the assessment phase used appropriate and detailed frameworks, including the TAM and ISO 9126-4 which laid a basis for assessing the system-based on a criterion that involved perceived ease of use, structure and layout, relevance, interactivity, functionality, and completeness. This phase involved 115 participants, including administrative officer, district supervisors, ICT experts, staff, and randomly selected service clients from LTO – San Juan district and other 19 district and satellite offices in Eastern Visayas, Philippines who completed a 20-item questionnaire adapted from Davis and Elling [15], [16]. According to Isaac et. al., [17], a sample size ranging from 100 to 200 is typically considered adequate for descriptive studies to characterize a population's attributes. To complement this quantitative data, usability testing, and feedback sessions offered qualitative insights into the system's performance. A month after the system's turnover, feedback was solicited to facilitate further enhancements and improvements.

IV. RESULTS AND DISCUSSIONS

A. System Development of the three-tier queue management system

Ease of doing business and efficient government service delivery are the bases of the researchers in identifying the activities involved in all the stages of system development and implementation. Identification of development models, management, hardware, software, graphical user interfaces, online forms and menus for integration were included. Streamlining processes, optimization of wait times, avoiding congestion, and efficiency in the delivery of government service are the intentions of this development. Hence, the queue management system provides simplified, centralized, and enhanced throughput derived analytically particularly to the land transportation service clients making it ready to address a range of real-world application [7].

This also allows the system administrator to monitor every stage, specifically in securing the queue number, status of the transactions in every service counter and up to the completion stage of permits or license application. The system was developed using various programming tools, including Visual Studio Code as source code editor, PHP and Rust programming languages for dynamic scripting, Rust with Tauri as framework for its frontend, Laragon for testing, CSS and Bootstrap for designing and lay outing of the elements and background, JavaScript for creating interactive and dynamic webpages, and MySQL for database, storing user/admin credentials and transaction details; TV/Monitor for the system's real-time display including queuing numbers and their corresponding counter locations; touch screen Monitor for transaction display and a thermal paper use for printing the queue numbers.

Figures 3 and 4 depicts the system architectures, explaining the technical setup of the three-tier queuing management system both for the service client and the employee assistant. These figures describe the entities and how they interact and communicate between the three-tier systems, employees and the service clients and all interface modules. The diagrams show smooth for diverse user groups such as system administrators, touch point employees, and clients because the system is scalable and robust. It also shows a straightforward working and also explains how the application supports real-time flow of processes, enhanced operational efficiency and interactivity.

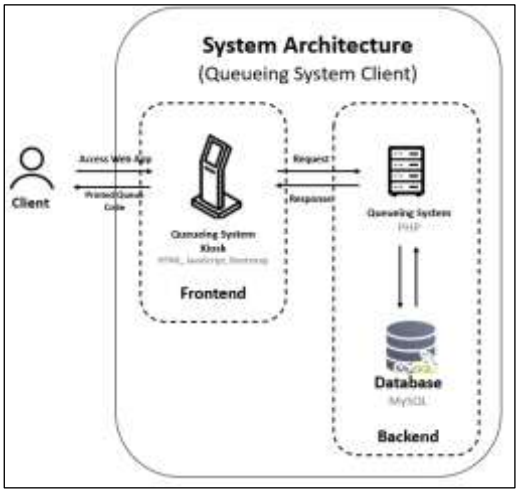

Figure 3: System Architecture for the Client.
Source: Source: Authors, (2026).

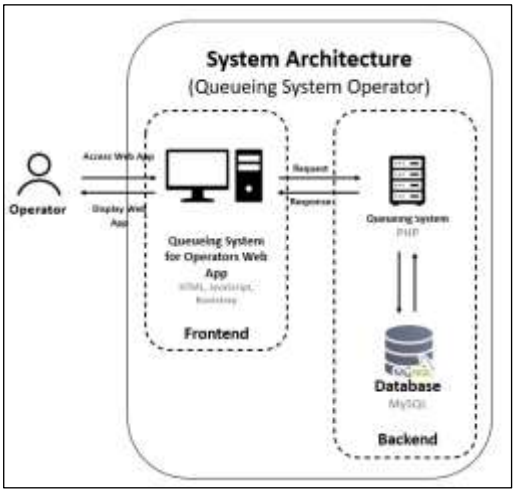

Figure 4: System Architecture for the Employee Assistant.
Source: Authors, (2026).

The interaction process between the service clients accessing the system and the step-by-step flow of the three-tier queue management system is demonstrated in Figure 5 where the service area has a digital kiosk that categorizes the services into Registration, Licensing, and LETAS. Fast printing speed and low maintenance are two major reasons of choosing a thermal printer connected to the kiosk for the generation of a queue number after the client's selection of the service type. Any previous data and information will be cleared for privacy reasons in the registration tier. Correspondingly, all the requested services with the queue numbers are dynamically posted and updated in the second and third tiers of the system called personnel workstation, display tier respectively. A series of rounds of tests were done to ensure that all the touch points were functional and usable.

These various testing operations were divided into three categories, namely: 1) unit testing –where hardware and software were integrated; 2) functional testing- where the LTO – San Juan personnel and service clients were allowed to operate for its functionality if it met their needs and expectations; 3) user acceptance testing- the clients and the employees operates the system to check its completeness and relevance to their needs and expectations; 4) bug fixing iteration where errors in the unit testing phase was noted and the system is revised according to these concerns; running the system is evolutionary until no errors were found. After a month, a review was conducted, where feedback from the personnel and the service clients was acknowledged and resolved.

Figure 6 shows the flow of the personnel tier system that started on the registration providing personal information such as User name-password combinations. The correctness of these information lead to user log in and displays the dashboard that contains number of active workstations, service categories, and personnel users. The transactions in the personnel station is updated in real-time and automatically updates the display tier system. Both audio and visual are the multi channels provided in this three-tier queue management system.

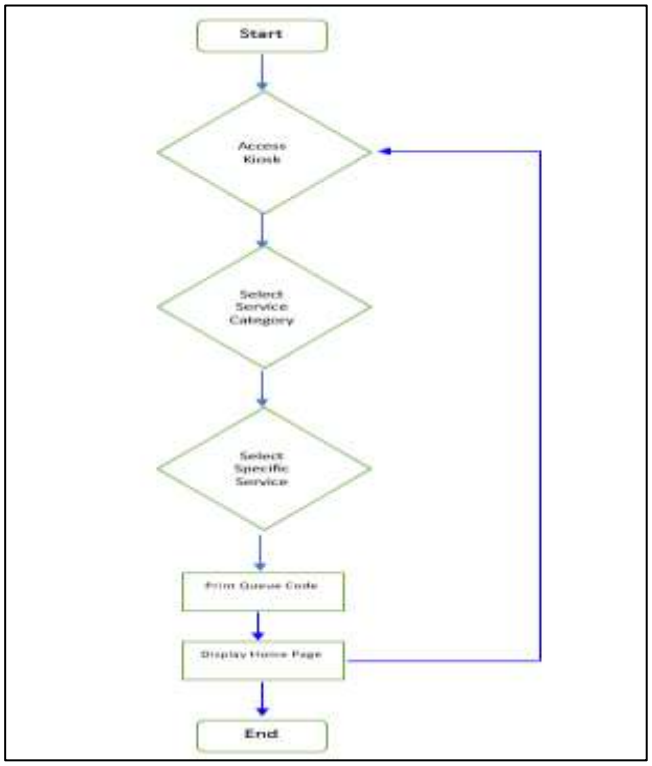

Figure 5: Flowchart Diagram for the Client.
Source: Authors, (2026).

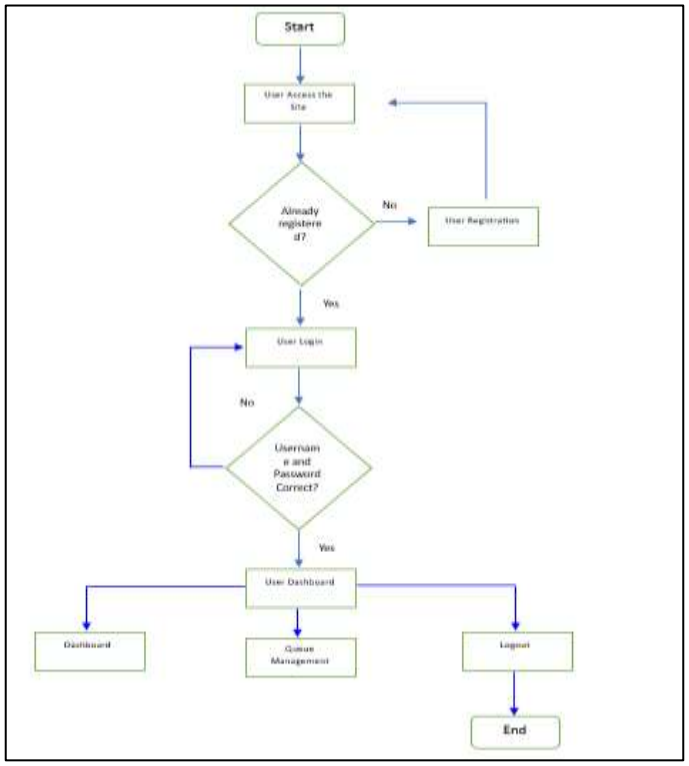

Figure 6: Flowchart Diagram for the Employee.
Source: Authors, (2026).

After the system was operational, it was piloted in San Juan Land Transportation District and in batches to other 19 districts and satellite offices for implementation. The researchers conducted feedback after a month and then scheduled a meeting with the district supervisors, IT experts, and other LTO personnel for enhancements. Hence, user acceptance is the top priority in the initial adoption stage. The final deployment was in full swing after fixing minor errors. This Three-tier Queuing System utilizes a Local Area Network (LAN) - based on web platforms using compatible browsers with interactive interfaces by inputting login credentials. It has limited human intervention, specifically in managing the queues while avoiding line jumpers and alleviating disputes within the queue area, increasing client satisfaction, and providing fast and quality services.

Also, clients feel empowered by being in control of their own time in an automated queuing system, which is directly connected to the quality of services [8], [18]. Waiting for service is a common phenomenon, and customer queuing time has been considered a key factor when evaluating a service-oriented institution, specifically the government [7]. Moreover, using the queuing system significantly affects seventy-eight (78) percent of the quality of service and supervision, considering the utilization rate and average waiting time [9]. Structure and layout of this system meets accessibility standards particularly on the screen reading compatibility of the service clients. Figure 7 displays all the LTO services such as Licensing, Registration and LETAS that are configured and controlled by the admin selected from the personnel appropriately and information technology expert.

The breakdown of these services is handled by the three-tier queue management system including issuance of drivers and conductor licenses, registration and renewal of vehicle, and the issuance of related documents (official receipt, certificate of registration, and other traffic violations). Congestion prevention is one of the most important factors that is considered in the development of this system. Figure 8 is a sample of a unique identification number printed from a thermal printer during the arrival of the waiting area which details the service category that is requested by the client. Also, increasing the number of servers causes a decrease in the average waiting time, thereby increasing service clients satisfaction [19]. However, queue path can be expanded from 1 to 2 with the use of the queue number so that the length of the queue decreases its service time in each service counter [20].

Figure 7: Client transact.
Source: Authors, (2026).

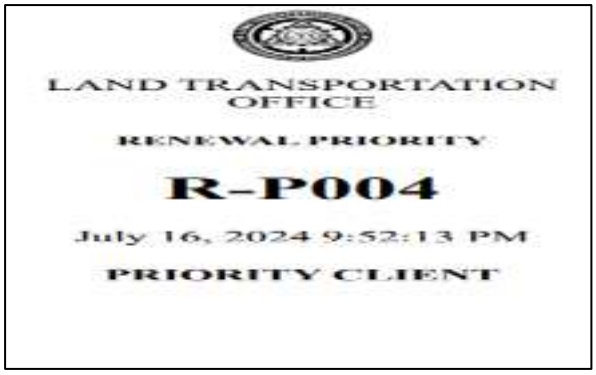

Figure 8: Client Queuing Number.
Source: Authors, (2026).

All operational transactions, namely, number of workstations, the number of active service categories, and the number of personnel users, are displayed in Figure 8 which is the Main Interface of the Queuing System, where each district logs in independently. Each district can navigate the system independently, including Licensing, Registration, and Letas services. In addition, waiting time was minimized from 1 hour per client to 20 minutes. Client satisfaction was noted due to least wait times while maximizing revenue and increasing the productivity among employees [4]. It also enables LTO– -San Juan personnel to efficiently manage clients' flow by getting the queue number and waiting time, monitoring the clients' applications, and controlling the influx of new and existing clients for vehicle registration, paying penalties, and applying for licenses.

Figure 9 is the log in page, where considered entry point of all admin or employee users. It is user-friendly and has a secure authentication method, such as the username-password combination. This serves as the interface where admin or employee users begin interacting with the three-tier queue management system displaying the dashboard offering personalized access to service clients data while ensuring security and management. The functionality of this system prevents unauthorized access as designated by the role-based of the system administrator.

Figure 9: LTO Personnel.
Source: Authors, (2026).

Figure 10: Home.
Source: Authors, (2026).

Figure 11: Transaction.
Source: Authors, (2026).

Figure 10 is the Home page that displays the number of workstations, service categories, and employee users that are updated in real-time. Transaction details, including queue number and station assignment per employee user, are managed and controlled by the system administrator. Each workstation or counter contains a click-enabled button to represent a transaction with corresponding queue number per client that are served, called, forwarded, finished, and discarded. If one counter becomes overloaded, queue numbers will be reassigned to other available counters.

Figure 11 is a sample of the transaction page in the three-tier queue management system containing a real-time and visually enticing interface with which employee users could engage queue controls such as call service clients, forward, finish or complete transactions, discard/cancel and hold or pause service done in multichannel approach such as audio and digital. Queue entries in a specific workstation including complete transaction history can also be accessed to efficiently optimize client services and provides next steps of every transaction for easy re assignment of queue numbers and counters. This design embodies current principles of modern queuing system that is simple and well-organized that are in compliance with data protection regulations.

To ensure an efficient and transparent servicing of the clients, a call interface in the employee workstation was implemented as depicted in Figure 12. This interface notifies the service clients in their turn for service and applies dynamic routing to the correct workstation or counter through audio and display monitor announcements. To optimized transparency and unnecessary inquiries, all active workstations are displayed in the third-tier panel as shown in Figure 13. This display updates transactions in real-time that are called, forwarded, or completed. Also, this panel prevents from the occurrence of a dispute by providing a digital summary visible to service clients**.**

Figure 12: Workstation Call Interface.
Source: Authors, (2026).

Figure 13: Client Display Tier.
Source: Authors, (2026).

B. Evaluation of the Three-tier Management System

In the evaluation phase of the system as shown in Table 1, LTO – administrative officer, district supervisors, ICT experts, staff and the service clients consistently with high ratings across all variables. The mean scores for perceived ease of use, hyperlink, structure and layout, relevance, functionality, interactivity, relevance, and completeness were well at the very high effectiveness level between 4.65 and 4.80. These ratings show the system's performance is very good since it meets the users' expectations in different criteria. Finally, this indicate that the respondents had a high level of concurrence with one another towards the overall effectiveness of this system.

Table 1: Summative evaluation of the three-tier queue management system across different respondent groups.

Variables	Mean	Min	Max	Effectiveness Level
Perceived ease of use	4.65	3.00	5.00	Very high
Structure and Layout	4.65	3.00	5.00	Very high
Relevance	4.80	3.00	5.00	Very high
Interactivity	4.70	3.00	5.00	Very high
Functionality	4.70	3.00	5.00	Very high
Completeness	4.70	3.00	5.00	Very High
Note: 1.00-1.79 Very low; 1.80-2.59 – Low;2.60-3.39 – Average; 3.40-4.19 – Moderately high; 4.20-5.00 – Very high				

Source: Authors, (2026).

All the variables are uniform with minimum and maximum scores ranging from 4.65 to 4.80. This range suggests that the system can provide a good experience to most users while flagging areas for improvement. Relevance is the highest rated with M=4.80, implying that the system can stay in line with what its users need and eventually expect. Similarly, consistency of high rankings in completeness, functionality and interactivity indicates that its necessary modules are practically functioning and fosters dynamic exchange between the user and the systems. Strong scores across all dimensions mean that there has been a robust design and usability of the system in the land transportation's operational transactions. However, perceived ease of use, structure and layout with at least 4.65, mean it should strive at further refinements what could answer some of the evaluation from the users and ensure that the system remains helpful and responsive to diverse clients' need. The findings also suggest system's strengths and offer insights into what needs to be improved to ensure that diverse users have expectations met so that land transportation services it provides are enhanced through innovative digital solutions.

Moreover, the findings also revealed that the customer waiting time is reduced from an hour to 20 minutes and the negative impression was alleviated thereby increases client's satisfaction, fairness and transparency. The development and implementation of this three-tier queue management system is aligned with the mandate and principles of LTO towards fair and transparent services to clients. It also fosters trust and confidence in LTO personnel by reducing clients' conflict and faster services. Lastly, the queuing system enhances the client's ease of accessing the system and solves the challenges encountered by the current traditional queuing approach. More importantly, decreasing the average waiting time of service clients in a queue, increases satisfaction [19], [20]. To have a uniform queuing system for the LTO - Eastern Visayas Region, Philippines, installation and implementation was done to other 19 districts and satellite offices with the approval of the regional director since these offices encountered identical challenges with LTO – San Juan District.

V. CONCLUSIONS

The developed queuing system is very significant to LTO supervisors, personnel and the service clients of the region because it enables them to improve users' satisfaction and enhanced operational efficiency. The reduction of wait wait times from the registration to the completion of the transaction increases employee productivity resulting to more satisfied clients leading to increased revenue. This system provides positive experiences to service clients and word of mouth referrals, thereby stronger agency reputation. Furthermore, the functionality aspect of the system aids the supervisors in having real-time monitoring and reporting. Interactivity of the system interfaces creates an organized communication between the users and the system making all the services fast and functional. Finally, management of the flow of clients' transactions are straightforward, facilitating faster personnel assistance, appropriate allocation of available resources, and streamlining the entire land transportation operations. Finally, this queuing system was developed in a three-tier design for future expansion.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: Ines G. Falcon, Kenneth Jay L. Dugaria and Danna C. Remojo.
Methodology: Ines G. Falcon, Kenneth Jay L. Dugaria.
Investigation: Ines G. Falcon, Kenneth Jay L. Dugaria
Discussion of results: Ines G. Falcon, Kenneth Jay L. Dugaria and Danna C. Remojo
Writing – Original Draft: Ines G. Falcon
Writing – Review and Editing: Ines G. Falcon and Kenneth Jay L. Dugaria.
Resources: Kenneth Jay L. Dugaria
Supervision: Kenneth Jay L. Dugaria and Danna C. Remojo.
Approval of the final text: Ines G. Falcon, Kenneth Jay L. Dugaria and Danna C. Remojo.

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