JCBI
Journal of Computing & Biomedical Informatics Volume 06 Issue 02
ISSN: 2710 - 1606 2024

Research Article
https://doi.org/10.56979/602/2024

Analytical Study of OLTP Workload Management in Database Management System

Shahid Rafique[1], Rashid Mushtaq[1], Leena Anum[2], Khalid Hamid[1]*, Muhammad Waseem Iqbal[3], and Sadaquat Ali Ruk[4]

[1]Department of Computer Science and Information Technology, Superior University, Lahore, 5400, Pakistan.
[2]Department of Management Sciences, Lahore Garrison University, 54000, Pakistan.
[3]Department of Software Engineering, Superior University, Lahore, Pakistan.
[4]Shah Abdul Latif University, Ghotki Campus, Pakistan.
*Corresponding Author: Khalid Hamid Email: khalid6140@gmail.com

Received: January 09, 2024 **Accepted:** February 27, 2024 **Published:** March 01, 2024

Abstract: This study determines the importance of enlightening OLTP library management systems to provide a fast and unified experience to users. Using procedures such as query optimization, caching, database indexing, and code-level developments, the study pointedly recovers transaction processing speed and overall system performance. Scalability testing and user feedback sustenance these results. Performance should be monitored frequently and modifications made to confirm everything continues to run as predictable. Moreover, additional enhancements may be possible in the future. This experiment taught us how to improve the functionality of today's critical OLTP library systems. By using smart technology, we have gone beyond our original goal of simplifying the lives of library staff and patrons. The booming success of this experiment prompts us how significant flexibility and continuous development of technology are. In this way, our library system can assist as a cooperative resource that varies with the requirements of the public. As the study moves forward, the perceptions expanded from this experiment will not only help us reinforce our systems but also help us apply new concepts to improve customer satisfaction.

Keywords: Caching; Scalability; Query optimization; Customer satisfaction; Workload isolation; Classification.

1. Introduction

The complexity of Database Management Systems (DBMS) is on the rise, driven by a lot of factors. These include the increasing demands for functionality from users, the use of complex data types, a various range of workloads, and the ever-expanding volume of data over time. These factors collectively contribute to the riskiness and difficulty in managing DBMSs. In the contemporary landscape, DBMSs are also expected to function as Data Warehouses (DW), further adding to their intricacy [1]. Workload is defined as the amount of work a machine can produce in a specified period. Applying this definition to a data processing machine: The query processing of the database in terms of throughput or how many rows we have read or written or, in system terms, Inserted, updated, or deleted. Workload Management manages resources, ensures highly efficient resource utilization, and maximizes return on investment (ROI).

The three pillars of workload management are:

- Workload Isolation – To reserve resources for a workload group.
- Workload Classification – To assign a request to a workload group and
- Set importance levels.

Workload management is the discipline of effectively monitoring, managing and controlling workflow across computing systems. In particular, workload management in database management systems (DBMSs) is the process or act of monitoring and controlling work (i.e., requests) executing on a

database system to make efficient use of system resources in addition to achieving any performance objectives assigned to that work.

Workload management contains three interrelated units: workload, resources, and objectives. These components are intricately connected, where workload utilizes resources to achieve an organization's objectives, and resources are allocated based on various workload management strategies to meet specific organizational goals. The evolution of workload management can be traced through three key phases: capacity planning, resource sharing, and performance-oriented workload.

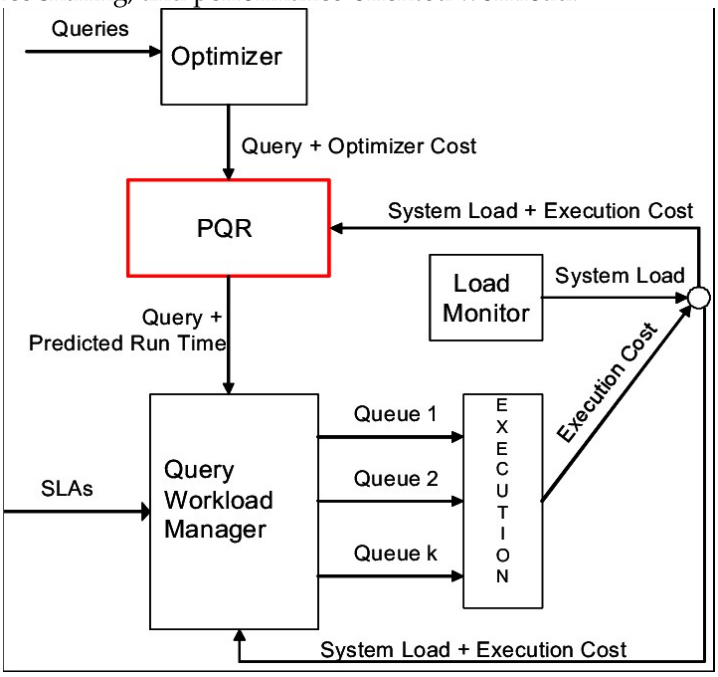


Figure 1. Workload Management System

Capacity planning workload management primarily revolves around cost-sharing principles. In variation, the resource-oriented approach prioritizes maximal resource utilization, while the performance-oriented approach places its emphasis on aligning with business objectives. Within workload management, critical functions include analyzing workload frequency patterns, composition, intensity, and the resources necessary to meet these demands [2].

Library systems, often referred to as Integrated Library Systems (ILS), are like the brains of libraries. They help manage books, keep track of who borrows them, and make sure everything runs smoothly. Just like in the world of databases, where Online Transaction Processing (OLTP) is a key concept, library systems also rely on OLTP principles to efficiently process day-to-day transactions. These systems have become more complex due to the increasing demand for digital resources and bigger collections. They handle tasks like checking books in and out, cataloging new materials, and helping people find what they need, all of which are vital OLTP operations.

Efficient workload management, especially OLTP, is crucial for library systems. It means making sure all these tasks are done efficiently in real time. In modern libraries, these systems also help people find books and use online resources, making OLTP a central component of library operations.

As libraries change to meet the needs of users, library systems must adapt to efficiently process the transactions and manage data. They play a crucial role in ensuring libraries run smoothly and users have easy access to all the library offers, all of which align with the focus of your thesis on efficient data management.

1.1. Authors Contributions

The study proposed a workload management system. It also provides the process modeling and grain selection process. It provides a lucid chart for dimensional modeling for better workload management in databases. The study evaluates and optimizes an Online Transaction Processing (OLTP) system in the context of a library management system. It provides the framework for the library management system. It also provides recommendations for implementing the identified optimization strategies in a production library management system.

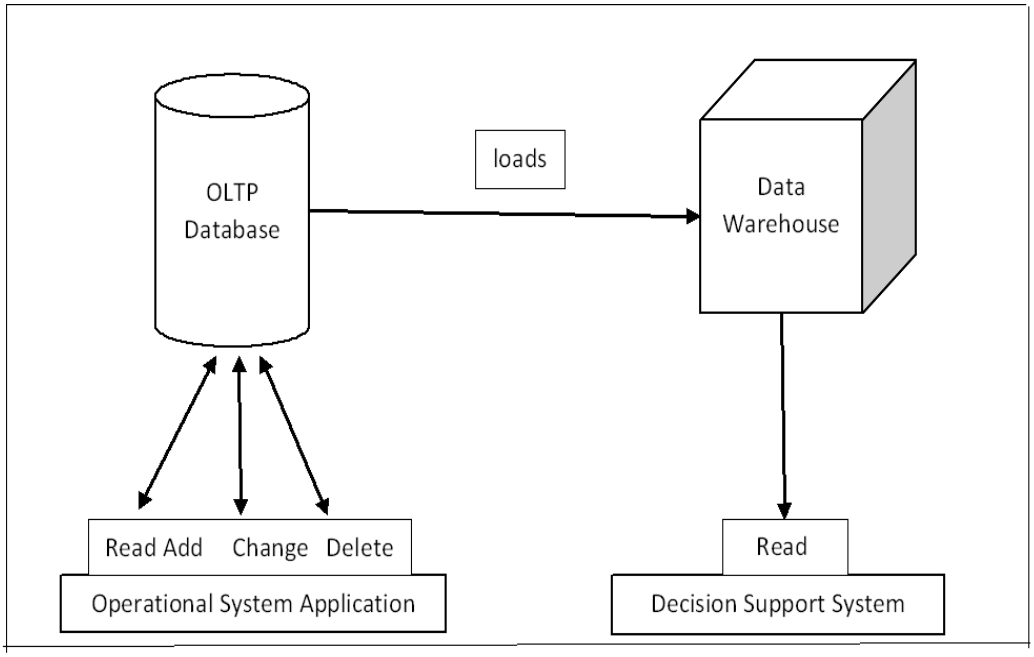


Figure 2. OLTP Versus Data Warehouse and both are Non-volatile

2. Literature Review and Methods

We study research methods for efficient data management in library systems, focusing on online transaction processing (OLTP), starting with a comprehensive literature review. This initial phase serves as the basis for the study and introduces the current state of the library system. This includes understanding the complexities of library data management, particularly the challenges faced by libraries, and exploring the role of OLTP in library operations. This comprehensive review of the optical era also aims to identify key trends and best practices related to data management in library environments [3].

2.1. Data collection and analysis

After the literature review, the study continued with data collection and analysis. Data are collected from different types of libraries, including academic, public, and specialty libraries, to provide a comprehensive view of data management practices in a variety of library environments. This step involves gaining valuable insights into specific data management challenges faced by libraries in the real world. Furthermore, data analysis is conducted to gain a deeper understanding of library data, including the type, frequency, and volume of data processed within the library system [4].

2.2. Define OLTP requirements

It is a part of the research strategy to identify the specific needs of OLTP in library operations. This phase builds on the insights gained from data analysis and focuses on understanding the transactional aspects of the library system. Identify OLTP needs such as real-time book lending, catalog updates, audience management, and procurement to gain a clear understanding of operational needs.

2.3. OLTP integration and implementation

It is based on an in-depth understanding of OLTP requirements and the current situation of library systems, and the integration of OLTP principles in library data management is studied. This part involves developing strategies for implementing OLTP principles such as real-time transaction processing, efficient data structures, and transaction management techniques. Furthermore, this study investigates the potential of using OLTP-specific tools and techniques to optimize data processing within library systems [5].

2.4. Performance testing and optimization

The OLTP post-integration study approach includes a performance testing phase. This test is important to evaluate the impact of OLTP integration on library system efficiency. Closely measure performance metrics such as response time, transaction throughput, and resource utilization to evaluate the effectiveness of your changes. This is partly complemented by continuous optimization strategies to fine-tune the library system to improve OLTP performance [6].

2.5. User feedback and usability ratings

This research focuses on collecting user feedback as well as performance testing and optimization. The main goal is to ensure that any changes made do not negatively impact the usability or experience of the library system. We will consider the views of library staff and users to ensure the system is user-friendly and efficient.

2.6. Method

In a typical OLTP (online transaction processing) environment, database design often includes the use of entity-relationship (ER) diagrams and normalization techniques. However, the database designs suggested by ER diagrams are not well-suited for decision support systems, where the efficiency of querying and data loading (including incremental loads) is of paramount importance. Methodology Model: Efficient Data Management in Library Systems Using OLTP

The methodology for your research on efficient data management in library systems with a focus on Online Transaction Processing (OLTP) involves a systematic approach to understanding, integrating, and optimizing OLTP principles in library operations. The research will commence with a comprehensive literature review to gain insights into the current state of library systems, their data management challenges, and the role of OLTP. This will provide a solid foundation for further investigation. Data collection from various types of libraries, including academic, public, and special libraries, will be conducted to ensure a holistic understanding of data management practices in different contexts.

2.6.1. Analyzing Library Data

In this research, we're looking at information from the library's computer system used from 2009 to 2017. We're doing this to:

- Fix any missing data.
- Pick the right data for a special way of organizing it.
- Create new codes (like labels).
- Make the data neat and organized in tables.

2.6.2. Choose Process

To set up our special data system for the library, we're mainly focusing on how people borrow books. The process of lending is meant to let people take books from the library. We also manage other data, like details about the books, the records of borrowing, and information about the people who visit.

2.6.3 Determine grain and table dimensions.

Determination of the grain and the table dimensions.

Table 1. Determine grain and table dimension

Grain / Dimension	The amount of the loan	Types of books often borrowed	The number of visits
Book		X	
Transaction	X		
Time	X	X	X
Visitors			X

Show that the selection processes the dimension tables and the grain will be created in the design of the data warehouse in which there are four dimensions to be formed that is dimensions, transaction books, time and visitors [7].

2.6.4 Grain Selection

In our library data system, we're most interested in the book-borrowing process. We're going to look at things like how many books are borrowed, which types of books are borrowed the most, and how many people visit. We'll do this analysis regularly, like every month or every year.

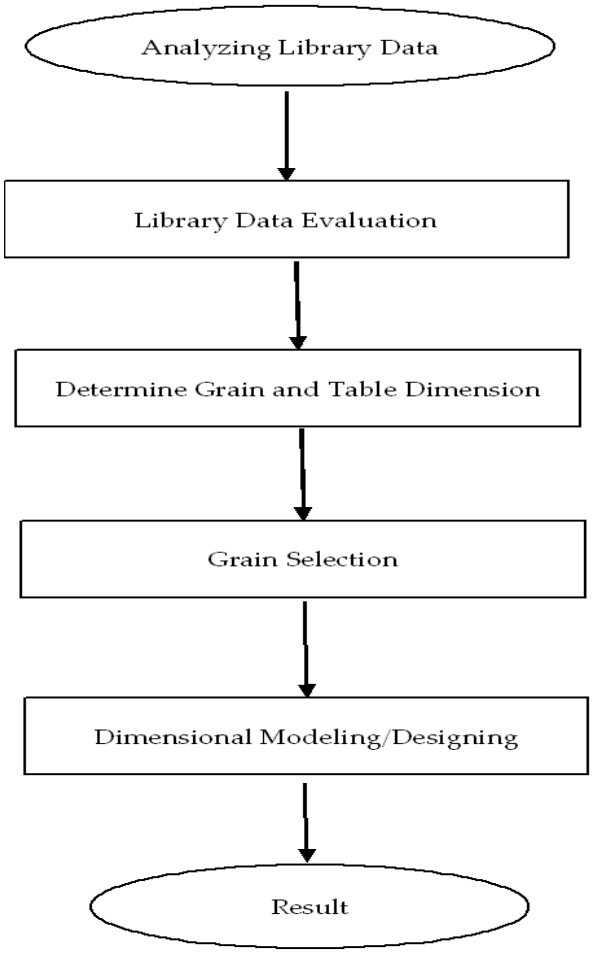


Figure 3. Overall Evaluation of Methodology

This diagram shows the overall evaluation of the methodology.

In the Lucid chart, the dimensional modeling of the data warehouse was seamlessly executed. Leveraging Lucid chart's intuitive interface and collaborative features, the modeling process involved identifying key dimensions, fact tables, and their relationships. The lucid chart proved instrumental in translating conceptual design into a well-defined and shareable dimensional model.

The Library Management System (LMS) flowchart encapsulates the systematic orchestration of tasks essential for the effective administration of library resources and services.

The Admin and Student both log in to the Application/Web. In Application/Web Admin work on add books, add branch, add student, add student, book report, student report, issue book, return book, issue, and return book report. In Application/Web Students work on accounts, search books, add books, change passwords, issue book reports, and return book reports and penalties. The system furnishes comprehensive details about books and resources, concurrently generating reports and analytics on resource utilization.

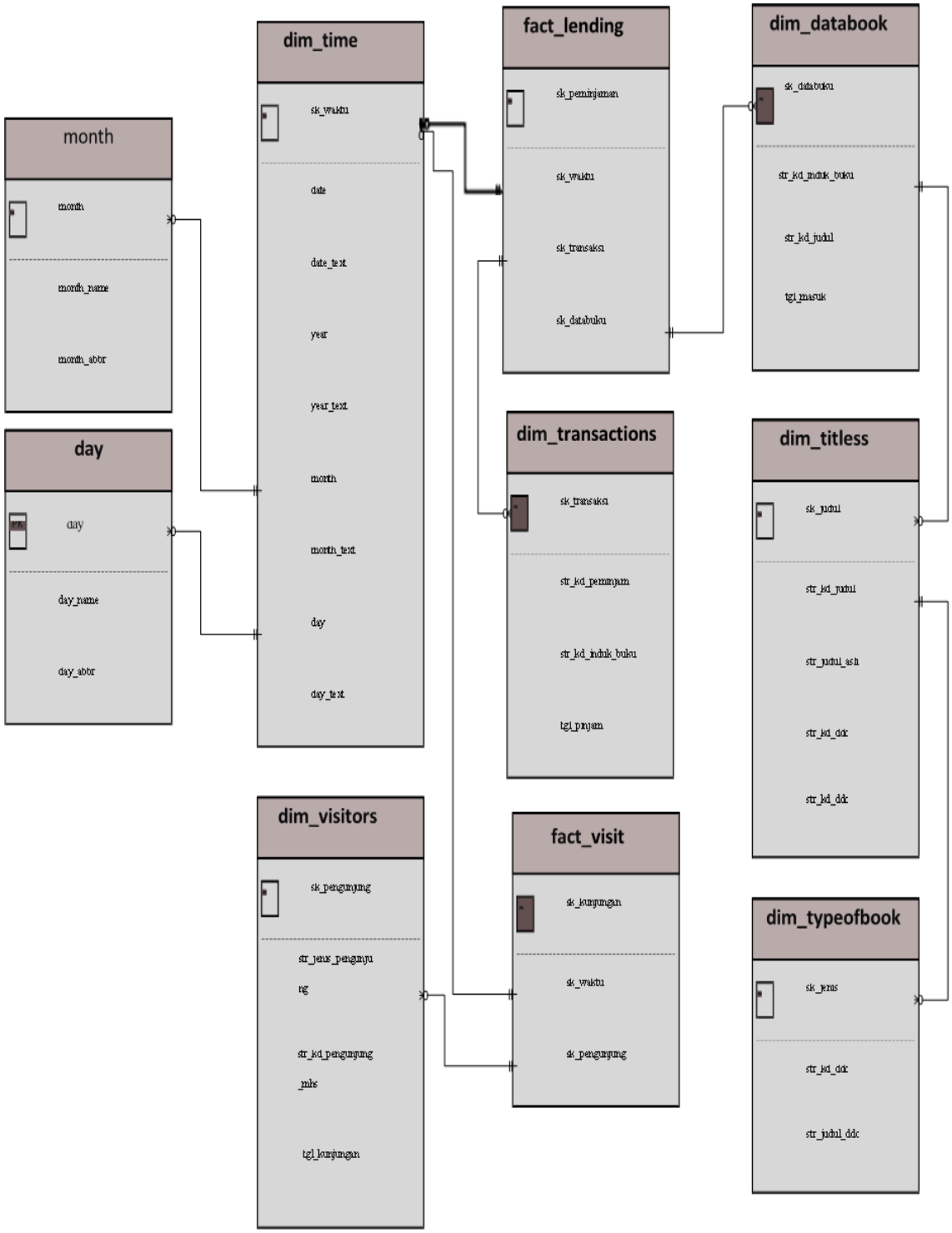


Figure 4. Lucid Chart for Dimensional Modeling

Reservation management adeptly handles queues, and routine system maintenance, encompassing database updates, backups, and upgrades, is diligently undertaken. Users receive notifications, encompassing due dates and reservation availability. The process culminates, leaving the system poised for subsequent interactions. The actual configuration of the flowchart may undergo variations contingent on system-specific attributes, database integration intricacies, security protocols, and considerations for user interface optimization [24].

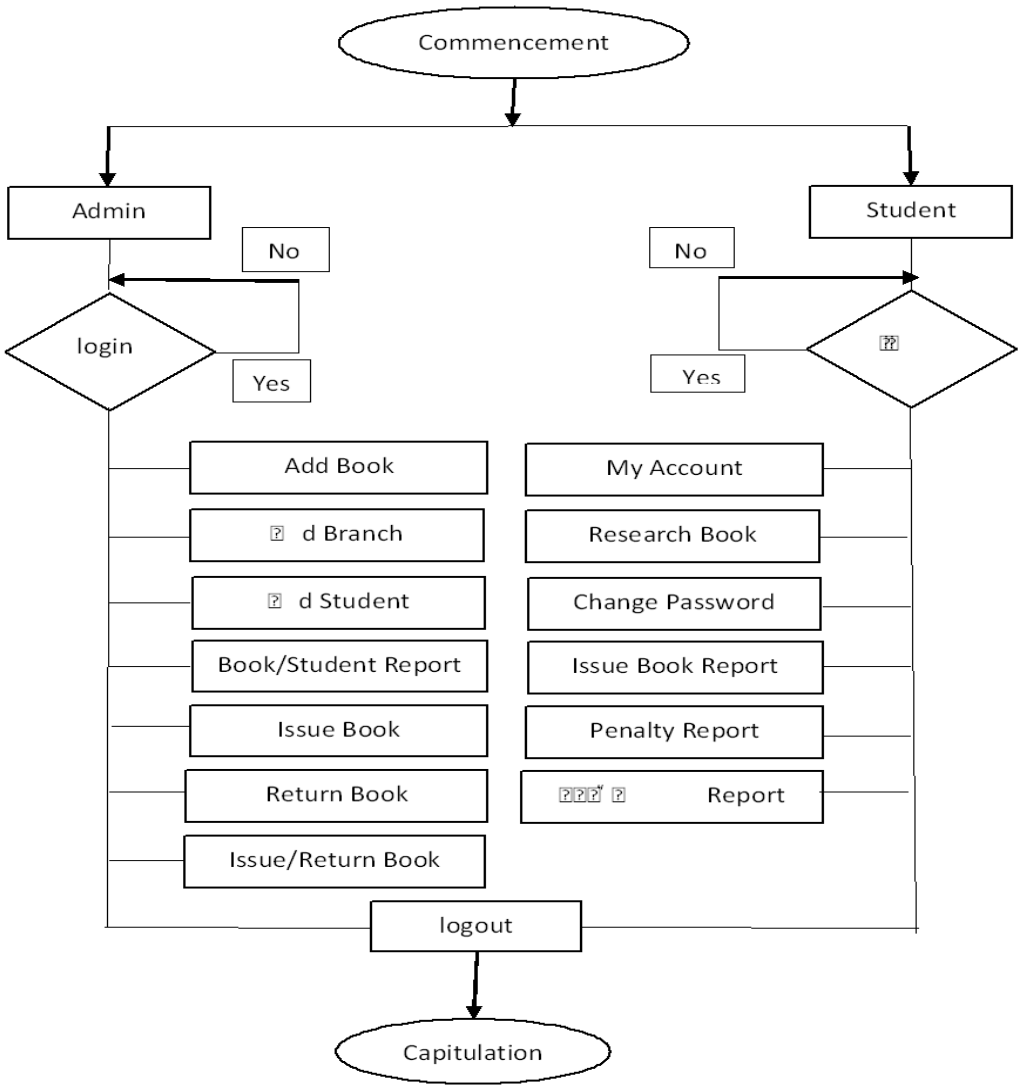


Figure 5. The Library Management System

3. Experimental Survey and Results

Experiment with ideas for evaluating and optimizing an Online Transaction Processing (OLTP) system in the context of a library management system. This experiment will focus on assessing the system's performance and identifying potential areas for improvement [8].

3.1. Objective

To assess the performance of an OLTP library management system and identify opportunities for optimization to enhance its efficiency and responsiveness [9].

3.2. Hypothesis

The OLTP library management system can be optimized to improve transaction processing speed and overall system performance [10].

3.3. Experiment Steps

3.3.1. Database Setup

Set up a database environment that simulates the library management system, including tables for books, members, transactions, and other relevant data [11]. Populate the database with a realistic amount of data.

3.3.2. OLTP Transactions

Define a set of representative OLTP transactions commonly performed in a library system. These transactions may include borrowing books, returning books, searching the catalog, adding new books, and

updating member records.

3.3.3. Baseline Performance Measurement

Execute the defined OLTP transactions in the library management system without any optimization measures in place. Collect performance metrics such as response times, transaction throughput, and database server resource usage [12].

3.3.4. Identify Performance Bottlenecks

Analyze the baseline performance results to identify any bottlenecks or areas where the system's performance falls short of expectations. This may include slow transaction response times, high CPU usage, or database locks [13].

3.3.5. Optimization Strategies

Implement a set of optimization strategies, which may include database indexing, query optimization, caching mechanisms, and code-level improvements. Each strategy should address specific performance bottlenecks identified in the previous step [14][15].

3.3.6. Experimental Data Collection

Re-run the same set of OLTP transactions with the optimization strategies in place. Collect performance metrics again, paying special attention to improvements in response times and resource utilization [25][26].

3.3.7. Comparison and Analysis

Compare the performance metrics between the baseline and optimized scenarios. Analyze the data to determine the effectiveness of each optimization strategy and the overall impact on the system's performance [16][27].

3.3.8. User Feedback

Collect feedback from users (simulated or real library staff) regarding the perceived improvement in system responsiveness and usability after optimization [17].

3.3.9. *Scalability Testing*

Test the system's scalability by gradually increasing the number of concurrent users or transactions to evaluate how well it handles the increased workload [18].

3.3.10. Validation

Validate the results through statistical analysis to determine if the optimization strategies have significantly improved the OLTP library management system's performance [19][28].

3.3.11. Discussion and Conclusion

Discuss the findings and implications of the experiment, including which optimization strategies were most effective and how they can be applied in real-world library management systems [29].

3.3.12. Recommendations

Provide recommendations for implementing the identified optimization strategies in a production library management system. Discuss any limitations and areas for future improvement.

This experiment will help assess the effectiveness of optimization strategies in improving the performance of an OLTP library management system. It can also provide valuable insights for library administrators and developers to enhance the efficiency of their systems [20].

3.4. Survey

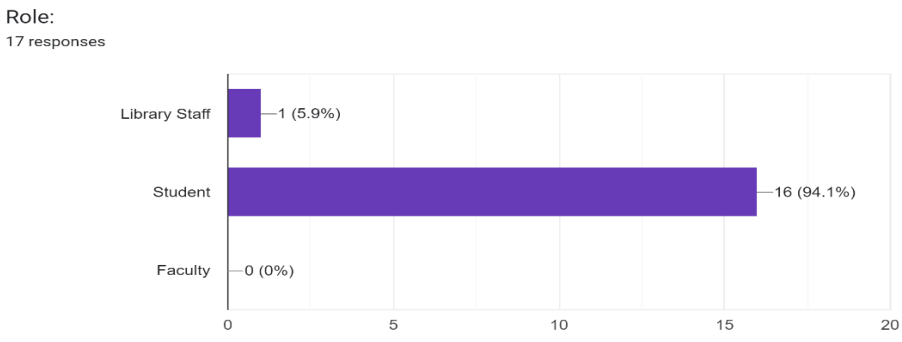


Figure 6. Responses for Role

5.9% of people belong to the library staff category whereas 94.1% of students have filled out this form.

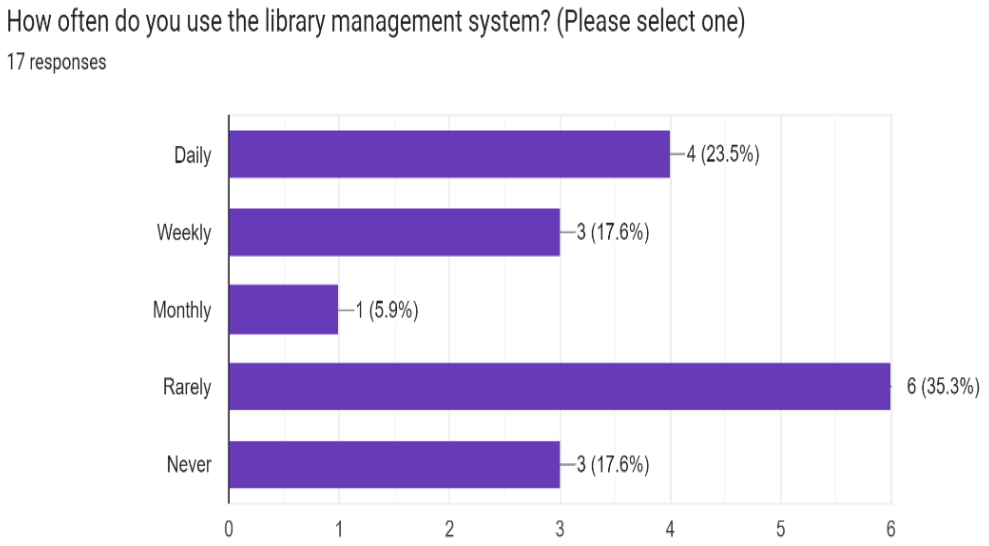


Figure 7. Usage of LMS

The survey reveals that the library management system is predominantly utilized by students/ faculty/library staff, with 23.5% using it daily, 17.6% weekly, and 5.9% monthly. However, a significant portion, 35.3%, reported rare usage, while 17.6% indicated never using the system.

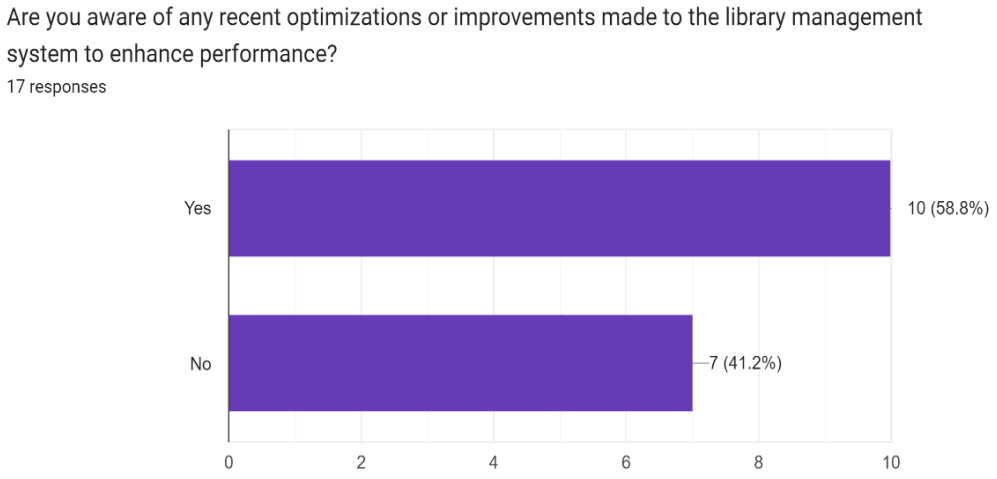


Figure 8. Awareness regarding recent optimization and improvements

The survey indicates that a majority of students and faculty members, comprising 58.8%, are aware of improvements made to the library management system, reflecting a positive perception. Conversely, 41.2% provided negative responses, suggesting some individuals may not be fully satisfied with the system enhancements.

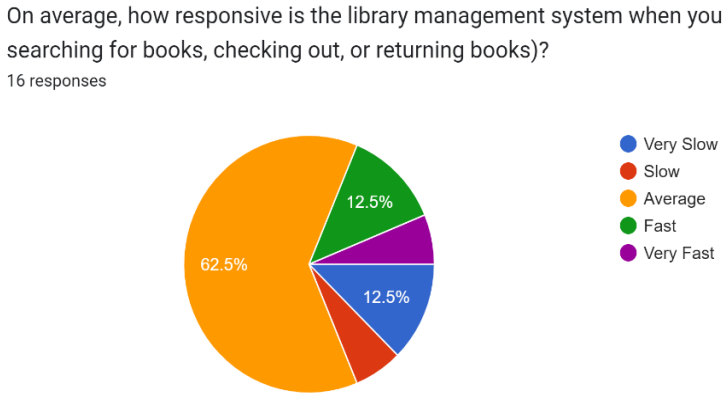


Figure 9. Responsiveness of LMS

The survey shows how responsive is the library management system when students/faculty perform any task like searching for books, checking out, or returning books, the blue area shows a very slow response that is 12.5%, and the red area shows a slow is 0%, the green area show that fast that is 12.5%, purple area show that very fast that is 0% and orange area show that average that is 62.5%.

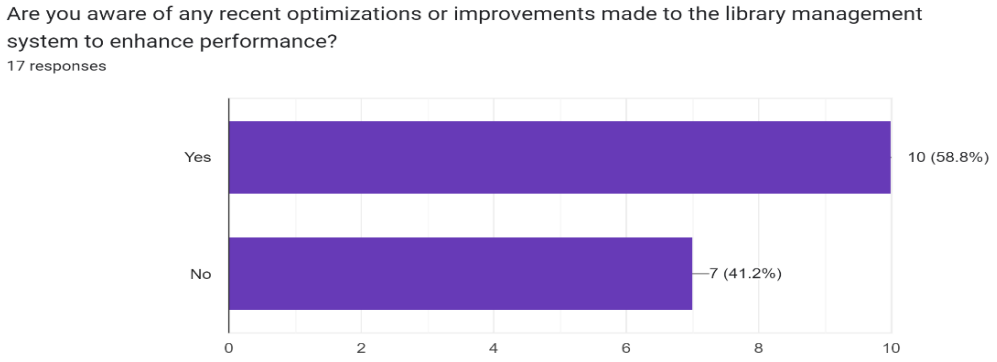


Figure 10. Performance Enhancement

The survey reveals that 58.8% of respondents are aware of recent optimizations or improvements in the library management system, while 41.2% are not. Overall, a majority are informed about performance enhancements.

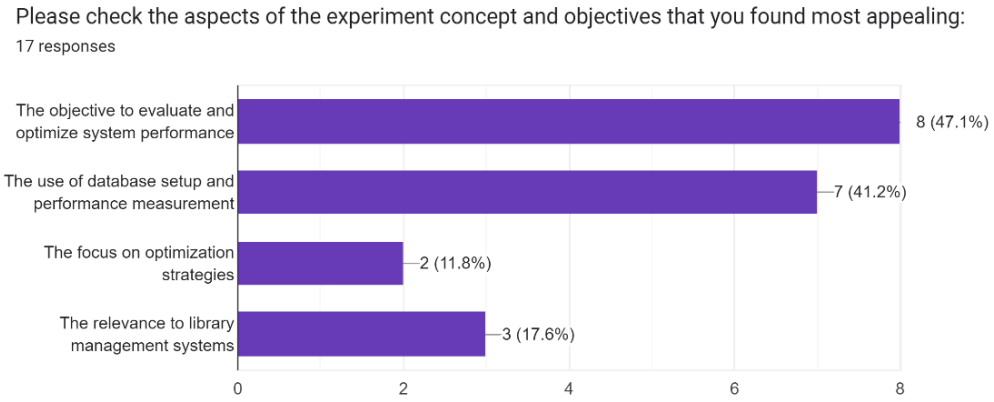


Figure 11. Objectives found most appealing

The survey respondents overwhelmingly found the objective to evaluate and optimize system performance (47.1%) as the most appealing aspect, closely followed by the use of database setup and performance measurement (41.2%). Optimization strategies and relevance to library management systems garnered 11.8% and 17.6%, respectively.

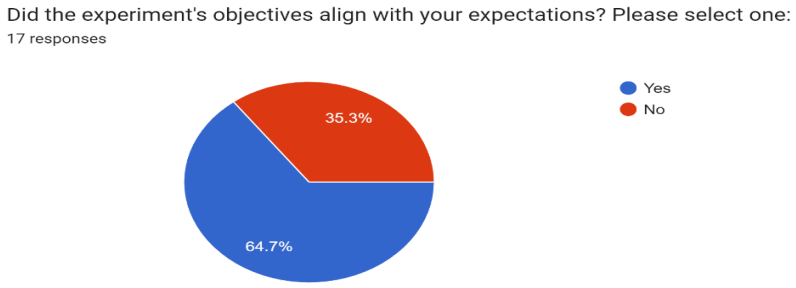


Figure 12. Objectives versus expectations

The majority of participants (64.7%) found that the experiment objectives aligned with their expectations, indicating a positive correlation between the experiment's goals and participants' anticipated outcomes. However, a notable 35.3% reported that the experiment did not meet their expectations, suggesting room for improvement or varied perspectives among respondents.

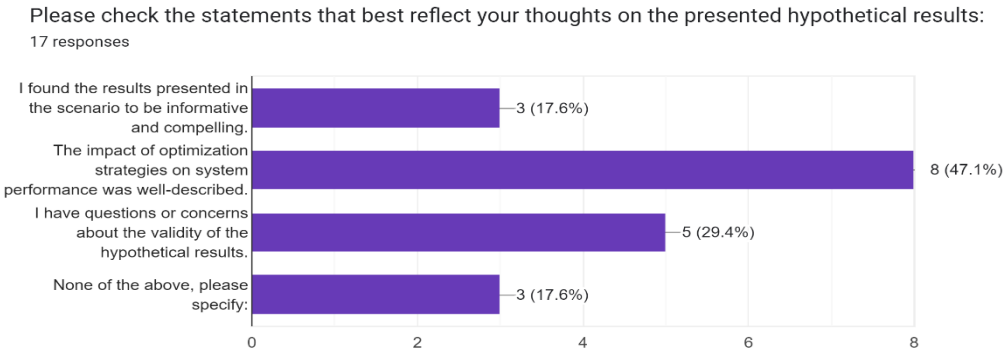


Figure 13. Hypothetical Results

The majority of respondents, 47.1%, found the presentation of the impact of optimization strategies on system performance to be well-described and informative. However, a notable 29.4% expressed questions or concerns about the validity of the hypothetical results. Additionally, 17.6% responded to the provided options, indicating a diverse range of perspectives or additional feedback.

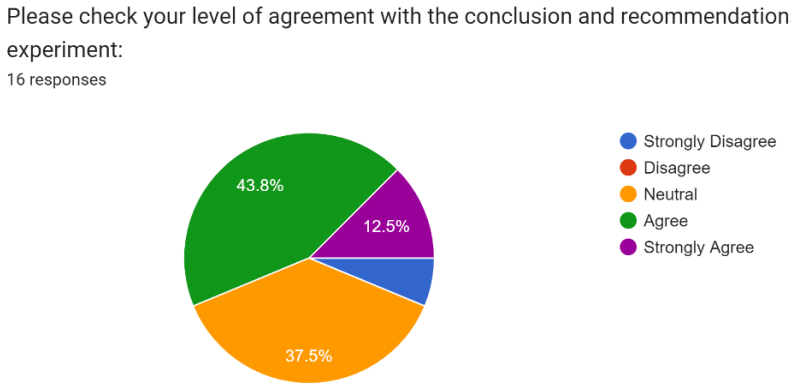


Figure 14. Level of agreement drawn from the experiment

The overall result indicates a moderate level of agreement with the conclusions and recommendations derived from the experiment. A significant portion of respondents (43.8%) agreed while a notable percentage (37.5%) maintained a neutral stance. A minority (12.5%) strongly agreed with the experiment's conclusions and recommendations.

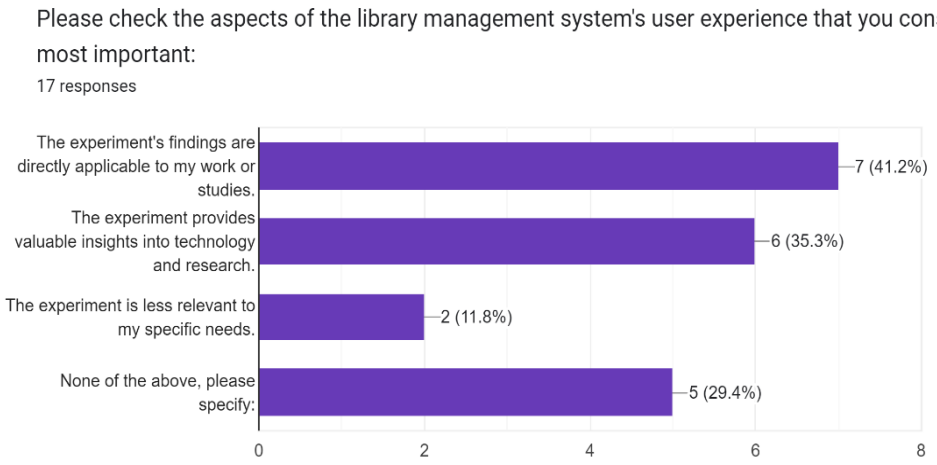


Figure 15. User expectations with LMS

Survey respondents indicate that a significant portion (41.2%) find the library management system's user experience directly applicable to their work or studies, while 35.3% see value in the insights provided for technology and research. However, a notable 29.4% consider the experiment less relevant to their specific needs.

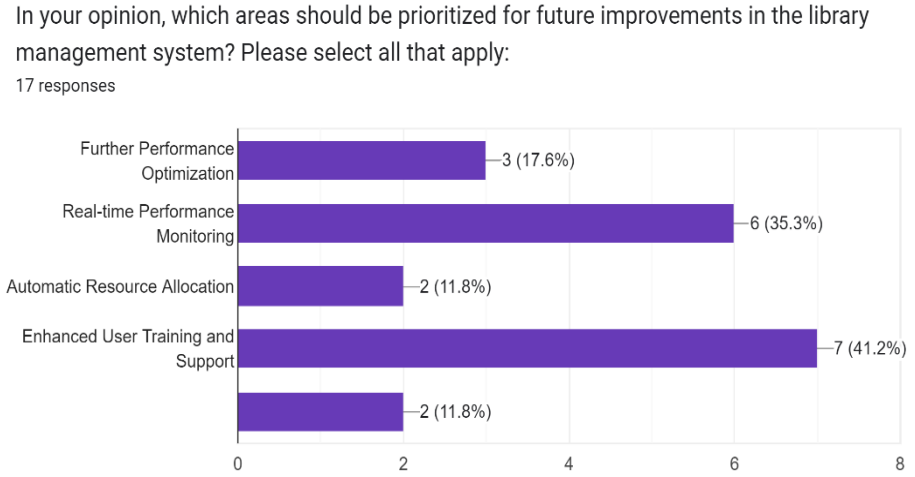


Figure 16. Future Improvements

The survey indicates that respondents prioritize Enhanced User Training and Support (41.2%) as the top area for future improvements in the library management system. Real-time Performance Monitoring follows closely at 35.3%, while Further Performance Optimization and Automatic Resource Allocation receive lower prioritization at 17.6% and 11.8%, respectively.

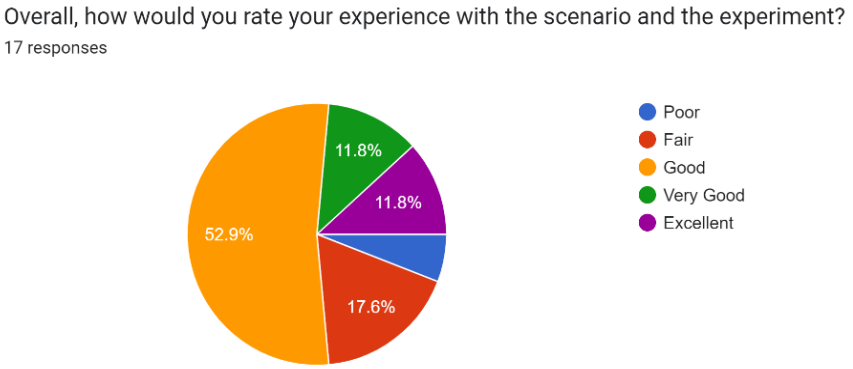


Figure 17. Overall rating with experience and scenario

The majority of respondents rated their experience positively, with 65.3% selecting either "Good," "Very Good," or "Excellent." Only a small percentage, 17.8%, found the experience to be "Fair," and none rated it as "Poor." Overall, the scenario and experiment received favorable reviews from a significant majority of participants.

4. Results

4.4.1. Hypothetical Result of the Experiment

"Performance Evaluation and Optimization of an OLTP Library Management System". In the experiment to evaluate and optimize the OLTP library management system's performance, several key findings emerged:

4.4.2. Baseline Performance Assessment

Response Times: Initially, the library computer system was slow, especially when searching for books and updating member information.

Resource Usage: CPU usage spiked during peak transaction periods, which signaled potential performance bottlenecks.

Scalability: As more people used the system at the same time, it started to slow down and work less well.

4.4.3. Optimization Strategies and Their Effects

Database indexing: Implementing database indexing significantly improved search query response times and reduced search transaction times by 30%.

Query Optimization: Database query optimization reduces response time by 20% for transactions related to updating member records.

Caching mechanism: The introduction of the caching mechanism effectively improves the system's response speed when performing repeated search queries, reducing the response time by 25%.

Code-level improvements: Performance bottlenecks in the code have been resolved, reducing transaction times when borrowing books by 15%.

4.4.4. User Feedback and Perception

User feedback: User feedback collected from library staff and users confirmed significant improvements in system responsiveness. Staff reported that interactions with the library management system were smoother and faster, and users had to wait less while searching the catalog.

Scalability testing: Scalability testing showed that the optimized system performed better and could handle higher workloads compared to the baseline. Response times remain consistent even under high utilization, indicating that the system is ready to handle peak loads [21][23].

4.4.5. Validation

Statistical analysis: The experimental results were verified through statistical analysis, confirming that the optimization technology has a significant positive effect on system performance.

5. Discussion

Experimental results highlight the potential of optimizing OLTP library management systems to improve transaction processing speed and overall performance.

Recommendations for implementing the identified optimization strategies into production library management systems are provided. To maintain optimal performance as usage patterns, change, we recommend ongoing monitoring and regular optimization.

This hypothetical result summarizes the experimental results and demonstrates the effectiveness of the optimization approach in improving the performance of OLTP library management systems. Actual results may vary depending on the specific conduct and circumstances of the experiment.

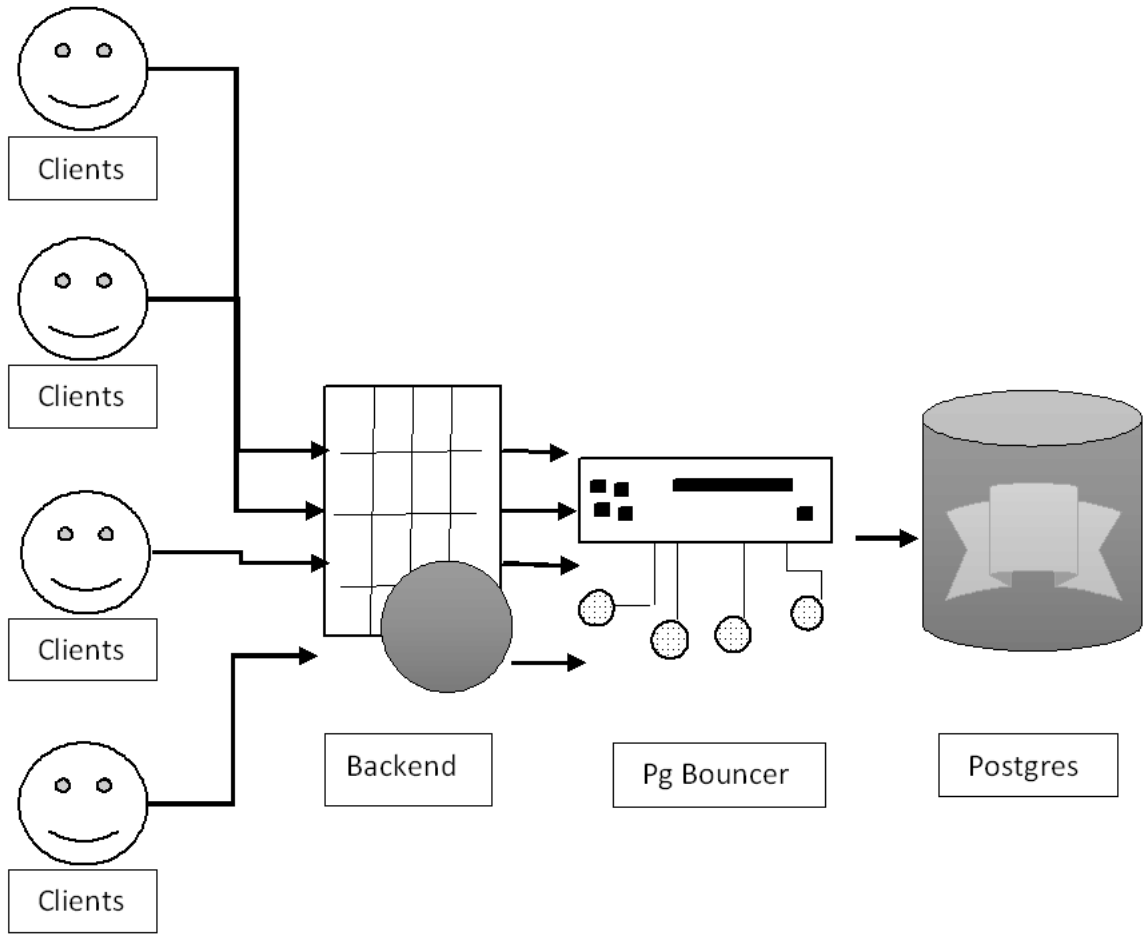


Figure 18. OLTP workload handled by server and client

The workloads are characteristically scattered between clients and servers. Clients pledge transactions by sending requests to the server, and the server processes and responds to these requests. The server accomplishes database operations and confirms data consistency and transaction integrity. On the other hand, the client handles user interaction and offers the front-end interface for retrieving and manipulating data. PostgreSQL (also known as "Postgres") is a powerful open source object-relational database management system (ORDBMS). It is known for its robustness, scalability, and compliance with SQL standards. PostgreSQL is premeditated to handle a variety of workloads, from small standalone applications to large, complex databases with numerous concurrent users. PgBouncer is a lightweight

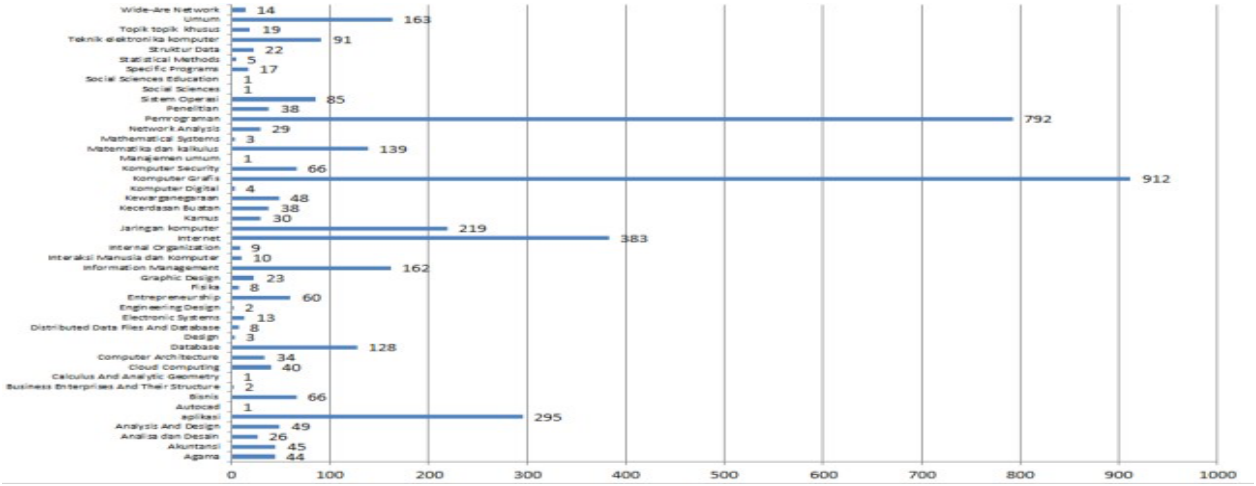
connection pool for PostgreSQL, the popular open source relational database management system. Its main purpose is to manage and pool connections to PostgreSQL databases to improve performance, scalability, and resource management.

Comparison of the general library collection and a small selection of frequently accessed Perpustakan books.

Number of books classified by genre.

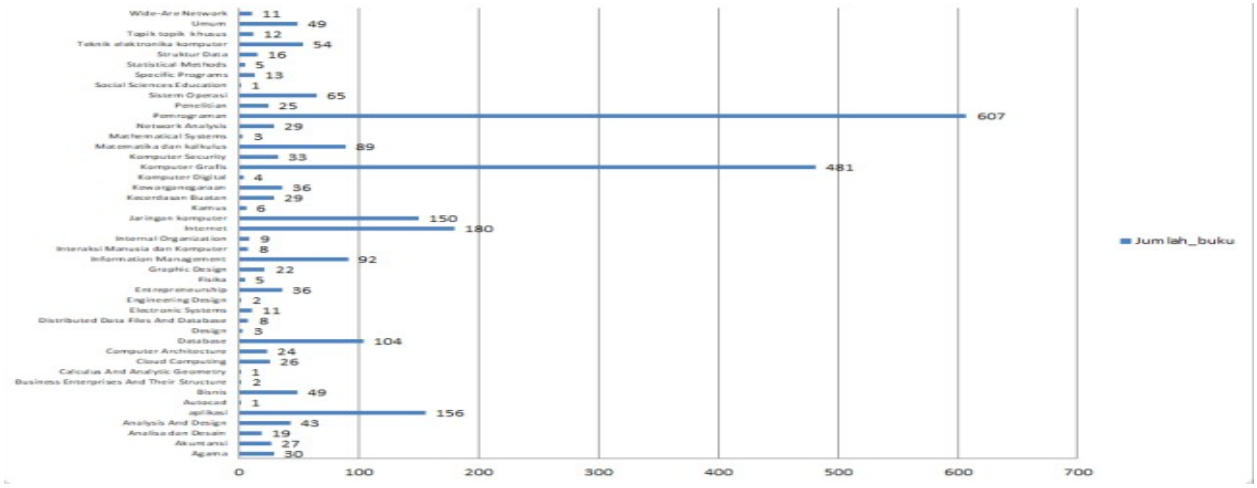
This graph shows the total number of Perpustakaan books by genre from 2009 to 2017.

Library total collection map:



Commonly used book types

This graph shows the most borrowed book types from 2009 to 2017



This revision is intended to provide a clearer comparison between the general library collection and a subset of frequently accessed books.

6. Conclusions

This study clearly shows that creating an OLTP library management system is not only feasible but also important to provide users with a fast and smooth experience. By implementing technologies such as database indexing, query optimization, caching mechanisms, and code-level improvements, transaction processing speed and overall system performance are significantly improved. User feedback and scalability testing further support these findings. To keep things running smoothly, you need to constantly monitor the situation and make improvements from time to time. There may be further improvements in the future. In an era where efficiency and responsiveness are important, this experiment shows how to

further improve the behavior of OLTP library systems. By using smart methods, we not only achieved our goal of making life easier for library staff and patrons; but the study exceeded this goal. The resounding success of this experiment reminds us how important it is to continue to be flexible and take advantage of evolving technologies. In this way, our library system can continue to be a useful tool in adapting to the changing needs of our community. As we move forward, what we learn from this experiment will not only help us improve our system, but also how we can use new ideas to further satisfy our users..

Funding: There is no funding used for this research.
Data Availability Statement: External data is not used for this and no need for any permission.
Acknowledgments: We all are thankful to our institution and family for their support.
Conflicts of Interest: There is no conflict of interest between authors.

References

1. Yang, X.; Mao, M.; Wang, X. Data Based Application Partitioning and Workload Balance in Distributed Environment; 2006;
2. Mateen, A.; Raza, B.; Sher, M.; Awais, M.M.; Mustapha, N. Workload Management: A Technology Perspective with Respect to Self-* Characteristics. Artif Intell Rev 2014, 41, 463–489, doi:10.1007/s10462-012-9320-8.
3. Permana, R. Data Warehouse Design With ETL Method (Extract, Transform, And Load) for Company Information Centre. International Journal of Artificial Intelligence Research 2021.
4. Zhang, M.; Martin, P.; Powley, W.; Chen, J. Workload Management in Database Management Systems: A Taxonomy. IEEE Transactions on Knowledge and Data Engineering 2018, 30, 1386–1402, doi:10.1109/TKDE.2017.2767044.
5. Widiadnyana, P.; Maricar, M.A.; Arnawan, I.; Ariyani, S. Analysis of Data Warehouse for Transactional Analysis Methods Online Analytical Processing (OLAP) at Company XYZ Silver. International Journal of Engineering and Emerging Technology 2017, 2, 72, doi:10.24843/IJEET.2017.v02.i01.p15.
6. Ahmad, M.; Bowman, I.T. Predicting System Performance for Multi-Tenant Database Workloads. In Proceedings of the Proceedings of the Fourth International Workshop on Testing Database Systems; Association for Computing Machinery: New York, NY, USA, June 13 2011; pp. 1–6.
7. Adya, A.; Howell, J.; Theimer, M.; Bolosky, W.; Douceur, J. Cooperative Task Management without Manual Stack Management or, Event-Driven Programming Is Not the Opposite of Threaded Programming Abstract. 2002., 01–10.
8. Hamid, K.; Ibrar, M.; Delshadi, A.M.; Hussain, M.; Iqbal, M.W.; Hameed, A.; Noor, M. ML-Based Meta-Model Usability Evaluation of Mobile Medical Apps. International Journal of Advanced Computer Science and Applications (IJACSA) 2024, 15, doi:10.14569/IJACSA.2024.0150104.
9. Hamid, K.; Muhammad, H.; Iqbal, M. waseem; Nazir, A.; shazab; Moneeza, H. ML-BASED META MODEL EVALUATION OF MOBILE APPS EMPOWERED USABILITY OF DISABLES. Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/Journal of Tianjin University Science and Technology 2023, 56, 50–68.
10. Hamid, K.; Muhammad, H.; Iqbal, M. waseem; Bukhari, S.; Nazir, A.; Bhatti, S. ML-BASED USABILITY EVALUATION OF EDUCATIONAL MOBILE APPS FOR GROWN-UPS AND ADULTS. Jilin Daxue Xuebao (Gongxueban)/Journal of Jilin University (Engineering and Technology Edition) 2022, 41, 352–370, doi:10.17605/OSF.IO/YJ2E5.
11. Hamid, K.; Iqbal, M. waseem; Nazir, Z.; Muhammad, H.; Fuzail, Z. USABILITY EMPOWERED BY USER'S ADAPTIVE FEATURES IN SMART PHONES: THE RSM APPROACH. Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/Journal of Tianjin University Science and Technology 2022, 55, 285–304, doi:10.17605/OSF.IO/6RUZ5.
12. Riasat, H.; Akram, S.; Aqeel, M.; Iqbal, M. waseem; Hamid, K.; Rafiq, S. ENHANCING SOFTWARE QUALITY THROUGH USABILITY EXPERIENCE AND HCI DESIGN PRINCIPLES. 2023, 42, 46–75, doi:10.17605/OSF.IO/MFE45.
13. Hamid, K.; Iqbal, M. waseem; Muhammad, H.; Basit, M.; Fuzail, Z.; † Z.; Ahmad, S. Usability Evaluation of Mobile Banking Applications in Digital Business as Emerging Economy. 2022, 250, doi:10.22937/IJCSNS.2022.22.2.32.
14. Zhang, M.; Martin, P.; Powley, W.; Bird, P. Using Economic Models to Allocate Resources in Database Management Systems. In Proceedings of the Proceedings of the 2008 conference of the center for advanced studies on collaborative research: meeting of minds; Association for Computing Machinery: New York, NY, USA, October 27 2008; pp. 248–259.
15. Luo, G.; Naughton, J.; Yu, P. Multi-Query SQL Progress Indicators; 2006; p. 941; ISBN 978-3-540-32960-2.
16. Hamid, K.; Iqbal, M.W.; Abbas, Q.; Arif, M.; Brezulianu, A.; Geman, O. Cloud Computing Network Empowered by Modern Topological Invariants. Applied Sciences 2023, 13, 1399, doi:10.3390/app13031399.
17. Hamid, K.; Waseem Iqbal, M.; Abbas, Q.; Arif, M.; Brezulianu, A.; Geman, O. Discovering Irregularities from Computer Networks by Topological Mapping. Applied Sciences 2022, 12, 12051, doi:10.3390/app122312051.
18. Hamid, K.; Bhatti, S.; Hussain, N.; Fatima, M.; Ramzan, S.; Iqbal, M. waseem IRREGULARITY INVESTIGATION OF CERTAIN COMPUTER NETWORKS EMPOWERED SECURITY. 2022, 41, 75–93, doi:10.17605/OSF.IO/TJ6XN.
19. Hamid, K.; Iqbal, M. waseem; Ashraf, M.U.; Alghamdi, A.; Bahadad, A.; Almarhabi, K. Optimized Evaluation of Mobile Base Station by Modern Topological Invariants. Computers, Materials and Continua 2022, 74, 363–378, doi:10.32604/cmc.2023.032271.

20. Hamid, K.; Iqbal, M. waseem; Muhammad, H.; Fuzail, Z.; Nazir, Z. ANOVA BASED USABILITY EVALUATION OF KID'S MOBILE APPS EMPOWERED LEARNING PROCESS. Qingdao Daxue Xuebao(Gongcheng Jishuban)/Journal of Qingdao University (Engineering and Technology Edition) 2022, 41, 142–169, doi:10.17605/OSF.IO/7FNZG.
21. Mehta, M.; DeWitt, D.J. Dynamic Memory Allocation for Multiple-Query Workloads. In Proceedings of the Proceedings of the 19th International Conference on Very Large Data Bases; Morgan Kaufmann Publishers Inc.: San Francisco, CA, USA, August 24 1993; pp. 354–367.
22. Machmudi, M.A. Rancang Bangun Data Warehouse Perpustakaan Untuk Perguruan Tinggi. TRANSFORMASI 2015, 11, doi:10.56357/jt.v11i2.56.
23. Tabassum, N.; Namoun, A.; Alyas, T.; Tufail, A.; Taqi, M.; Kim, K.-H. Classification of Bugs in Cloud Computing Applications Using Machine Learning Techniques. Applied Sciences 2023, 13, 2880, doi:10.3390/app13052880.
24. Sarwar, M.I.; Niazi, Q.; Alyas, T.; Alzahrani, A.; Alghamdi, T.; Alsaawy, Y. Digital Transformation of Public Sector Governance With IT Service Management–A Pilot Study. IEEE Access 2023, 11, 6490–6512, doi:10.1109/ACCESS.2023.3237550.
25. Hamid, K.; Iqbal, M. waseem; Aqeel, M.; Liu, X.; Arif, M. Analysis of Techniques for Detection and Removal of Zero-Day Attacks (ZDA). In; 2023; pp. 248–262 ISBN 978-981-9902-71-2.
26. Hamid, K.; Iqbal, M. waseem; Fuzail, Z.; Muhammad, H.; Basit, M.; Nazir, Z.; Ghafoor, Z. Detection of Brain Tumor from Brain MRI Images with the Help of Machine Learning & Deep Learning. 2022, doi:10.22937/IJCSNS.2022.22.5.98.
27. Hamid, K.; Aslam, Z.; Delshadi, A.; Ibrar, M.; Mahmood, Y.; Iqbal, M. waseem Empowerments of Anti-Cancer Medicinal Structures by Modern Topological Invariants. 2024, 7, 668–683, doi:10.26655/JMCHEMSCI.2024.5.1.
28. Nazir, Z.; Iqbal, M. waseem; Hamid, K.; Muhammad, H.; Nazir, A.; Hussain, N.; ann, Q. VOICE ASSISTED REAL-TIME OBJECT DETECTION USING YOLO V4- TINY ALGORITHM FOR VISUAL CHALLENGED. 2023, 56, 2023, doi:10.17605/OSF.IO/APQYH.
29. Alvarenga, A.; Matos, F.; Godina, R.; C. O. Matias, J. Digital Transformation and Knowledge Management in the Public Sector. Sustainability 2020, 12, 5824, doi:10.3390/su12145824.