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An Analysis of Digital Queuing Systems in Indonesian Banking Services: A Systematic Literature Review

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Abstract: Queue systems play pivotal roles in banking services, affecting both operational effectiveness and client satisfaction. The issue of long waiting times and unequal distribution of services across all regions of Indonesia remains a significant issue. Using the PRISMA methodology to perform a systematic literature review (SLR), this research investigates the last 5 years of 25 digital queue management academic works. The selection process to narrow this down began with the Sinta and Garuda databases, although more from Scopus were used to validate the research. The research indicates that identified technologies, such as online queue systems, self-service kiosks, and reservation systems, can improve customer satisfaction and experience by greatly decreasing waiting times. However, the majority of the observations are based on theoretical models or narrow case studies, leading to doubts regarding the generalizability of their findings. The effectiveness of the solutions proposed is highly dependent on the region's infrastructure as well as the users' capacity to utilize the available technology. The integration of queue theory and process simulation provides a foundational approach to the design of systems with improved efficiency. However, there are still significant obstacles to overcome: deficient digital infrastructure, low levels of technological literacy, and poorly integrated systems. Sufficient, systematic responses are required to these issues, as well as more localized systematic studies, to improve queue management systems in the context of the Indonesian banking sector.

Keywords: Queuing Systems; Banking Services; Literature Review; Operational Efficiency; Digital Transformation.

1. Introduction

Queue management stands as a cornerstone of banking operations, directly impacting service efficiency and customer experience. Across Indonesian financial institutions, queue handling functions as a key service quality indicator, with waiting periods frequently extending to 20-60 minutes during peak hours—significantly exceeding the 15-minute standard tolerance threshold Sihombing (2017) established in early studies [1][2]. Such extended delays necessitate queue systems characterized by speed, accuracy, and adaptability to varying customer volumes Agustina and Wijaya (2022) argued in their assessment of public service innovations [3].

Modern banking customers increasingly demand faster service delivery with greater process transparency and real-time monitoring capabilities . This shift in expectations coincides with rapid technological advancement, creating both opportunities and challenges for financial institutions. Despite technological progress, substantial obstacles persist in implementing digital queue solutions, particularly in regions beyond major urban centers. Wulandari and Rahman (2023) documented how technological literacy gaps and inconsistent digital infrastructure access create adoption barriers that vary significantly across Indonesia's diverse geographical landscape [4].

The banking sector has responded with various technological implementations to address these challenges. Innovations include kiosk-based queue management, mobile applications for virtual queuing, and online monitoring systems that provide real-time updates. Lestari and Saputra (2023) examined how Internet of Things (IoT) applications, artificial intelligence algorithms, and e-banking platforms enable features such as remote service reservations and automated notification systems [6]. These technologies show promise in laboratory settings and controlled implementations, yet their effectiveness diminishes when confronted with practical limitations in user technological familiarity, infrastructure reliability, and cross-platform integration capabilities.

Financial institutions face particular challenges when implementing queue technologies in regions with inconsistent internet connectivity, limited smartphone penetration, or populations with varying degrees of digital literacy. Dewi and Wibowo (2021) observed that queue management solutions often fail to account for these regional variations, resulting in systems that function effectively in Jakarta or Surabaya but prove impractical in smaller cities or rural areas [5]. This disparity creates a technological divide in service quality that requires targeted solutions rather than universal approaches.

Previous research demonstrates digital technology's potential to reduce waiting times and enhance operational efficiency. Aditya and Nugroho (2020) documented waiting time reductions of up to 40% following implementation of cloud-based queue management in selected urban branches [8]. Similarly, Suryani and Pratama (2021) found customer satisfaction improvements of 27% after introducing mobile queue applications in mid-sized banking operations [9]. However, these studies primarily examined technology implementation under optimal conditions, leaving significant knowledge gaps regarding real-world challenges across Indonesia's diverse banking environments.

Sari and Hidayat (2021) conducted field observations revealing that customer perception of waiting time often exceeds actual measured time by 30-45%, highlighting the psychological dimension of queue management beyond mere operational metrics [2]. Additionally, Putri and Nugraha (2021) found that Islamic banking institutions face unique challenges when implementing digital queue systems due to different customer demographics and service requirements [7]. These findings underscore the need for queue solutions tailored to specific banking contexts rather than generic technological implementations.

This study conducts a systematic literature review of digital queue systems in Indonesia's banking sector, focusing specifically on technological effectiveness, implementation barriers, and contextual solutions. The research examines how queue technologies perform across varying infrastructure conditions, customer demographics, and operational environments. By analyzing implementation patterns across diverse settings, this study aims to identify adaptable approaches that accommodate Indonesia's technological landscape. The findings provide practical guidance for banking institutions and technology developers seeking to create more efficient, accessible queue management solutions while encouraging further research aligned with actual market conditions and customer needs.

2. Related Work

Banking queue management research encompasses theoretical frameworks, digital implementations, and context-specific solutions. Krisna and Sumiati (2021) applied queuing theory to optimize teller services, achieving 18-25% reductions in waiting times through strategic staff allocation [14]. Oktafiani and Rahmiati (2022) extended this work by establishing correlations between queue efficiency and service quality perceptions, noting that customer patience diminishes exponentially after 12 minutes regardless of transaction complexity [17]. International perspectives from Kılıf and Ozkan (2020) introduced fuzzy logic systems for

evaluating banking queue performance [13], while Yifter *et al*. (2023) employed simulation modeling at Commercial Bank of Ethiopia to predict operational bottlenecks before they affected customer experience [28].

The technological evolution of queue systems has progressed from basic number tickets to sophisticated digital platforms. Santoso *et al*. (2019) documented smart card-based queue systems that improved data collection capabilities [22]. Putra and Lestari (2020) examined real-time notification systems that reduced perceived waiting time by allowing customers to engage in other activities while waiting [19]. Mobile applications represent a significant advancement, with Saputra and Anwa (2021) finding that mobile-based queue models reduced physical banking hall congestion by approximately 35% through remote registration and status tracking [23]. Amelia and Suryadi (2023) studied application-based queues with customer data integration, demonstrating how personalized service preparation reduced transaction times through advance profile access [10].

Authentication technologies have enhanced queue system security and efficiency. Susanti and Firmansyah (2022) evaluated QR code implementation in microbanking queue systems, documenting improved verification speed alongside reduced paper consumption and operational costs [25]. Sampe *et al*. (2024) developed an integrated system incorporating fingerprint recognition and digital scoring boards, resulting in improved security and more accurate service time tracking [21]. The integration of advanced analytics represents another significant evolution, with Hidayat and Firmansyah (2021) demonstrating how historical transaction data informed staffing decisions during predicted peak periods [12]. Susanti *et al*. (2023) achieved 87% accuracy in queue pattern prediction using machine learning algorithms, enabling proactive resource allocation before congestion occurred [26].

Blockchain technology offers innovative solutions for queue transparency challenges. Lestari and Saputra (2023) examined blockchain implementation in queue systems, documenting how distributed ledger technology created immutable records of queue progression, enhancing accountability and reducing disputes about waiting order [15]. This technology showed particular promise for high-value banking services where queue fairness significantly affected customer trust. Queue management solutions increasingly recognize the need for context-specific adaptations, with Rahman *et al*. (2022) developing hybrid queuing systems for areas with limited connectivity [20]. Setiawan and Arief (2021) found that solutions incorporating both digital and analog components achieved 76% higher adoption rates than purely digital systems in regions with connectivity challenges [24].

Customer satisfaction remains a critical outcome measure for queue system effectiveness. Firmansyah and Saputra (2021) established that perceived fairness in queue management correlated more strongly with overall satisfaction (r=0.78) than actual waiting time (r=0.62), emphasizing the value of transparent, equitable queue systems regardless of technological sophistication [11]. While not directly focused on banking, healthcare queue management research offers transferable insights. Melyant *et al*. (2019) designed online queue systems for outpatient clinic visits with features adaptable to appointment-based specialized banking services [16]. Perdana *et al*. (2019) developed QR code verification for hospital arrivals, a methodology applicable to banking environments seeking reduced check-in friction [18]. Communication platform integration shows promise across sectors, with Wardana *et al*. (2020) creating health clinic queue services using web and WhatsApp platforms, demonstrating how common communication channels supported queue management without requiring specialized applications [27].

3. Research Method

We built our study on the Systematic Literature Review (SLR) methodology, following PRISMA guidelines to maintain rigor, clarity, and reproducibility throughout our analysis process. This structured approach strengthens the scientific foundation of our findings. Our investigation centers on banking queue systems literature, particularly examining how IoT, AI, and Blockchain technologies enhance service delivery. We gathered scholarly materials from three key databases: Scopus, SINTA, and Garuda. When searching these repositories, we used varied terminology in both Indonesian and English, including: "sistem antrian perbankan" (banking queue system), "antrian digital perbankan" (digital banking queue), "efisiensi sistem antrian" (queue system efficiency), "IoT dalam antrian bank" (IoT in bank queue), and "AI-based queuing system in banking." Our initial search yielded 132 potential articles. After removing duplicates, 118 remained. Title and abstract screening narrowed the collection to 64 papers warranting full examination. We structured our selection through four sequential phases: (1) initial identification, (2) duplicate removal, (3) title/abstract screening, and (4) full-text assessment. Figure 1 shows the PRISMA diagram detailing our selection workflow.

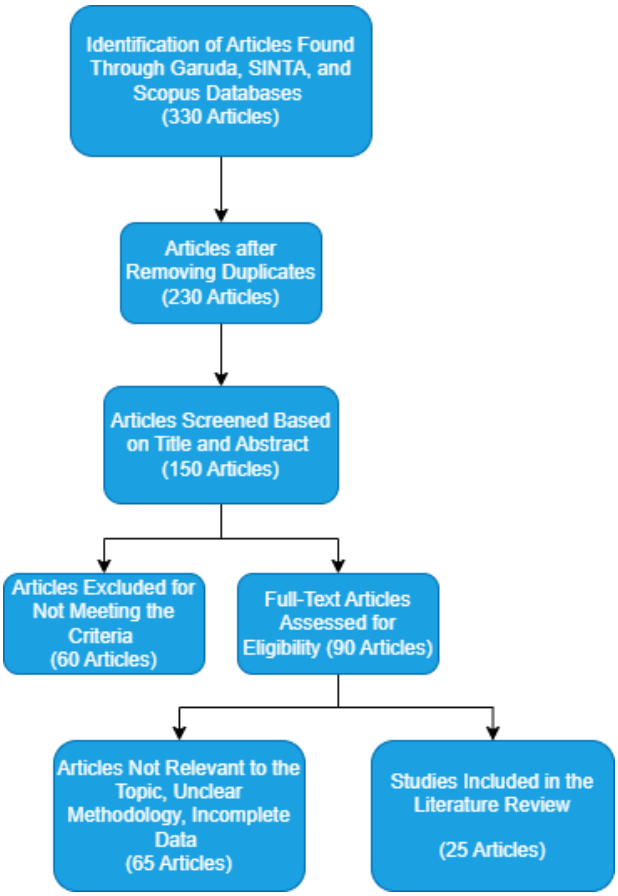

Figure 1. Article Selection Flow Diagram

To maintain scholarly standards, we established clear criteria for inclusion and exclusion. We selected articles that specifically addressed banking queue systems utilizing IoT, AI, or Blockchain, contained sound methodologies, and presented empirical evidence. We excluded papers that lacked technological focus, offered overly general discussions, or presented insufficient data. Through careful evaluation, we identified 25 high-quality articles that formed the basis for our analysis and recommendations. Our selection progressed methodically through several stages: initial identification, duplicate removal, title and abstract screening, and full-text evaluation. From the 64 thoroughly reviewed articles, we eliminated 39 that failed to meet our criteria. The remaining 25 papers underwent thematic analysis to determine technology effectiveness, implementation challenges, and practical solutions applicable to Indonesian banking environments.

4. Result and Discussion

4.1 Results

This study uses PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) as a guideline to select relevant articles on the topic of queue systems in banking services in Indonesia. The selection process was conducted systematically and resulted in 25 articles that met the inclusion criteria. The PRISMA diagram illustrates the stages of article selection, starting from article identification, duplicate removal, abstract screening, to full-text evaluation. The selected articles provide various important information related to the application of theories and methods in queue systems. Data extracted from each article include the author's name, year of study, article title, theories used, methods employed, and tools utilized in the research. This information is processed to provide an overview of the development of queue systems within the context of banking services in Indonesia.

Table 1. Data Extracted from Articles

No	Authors	Year	Article Title	Theory	Method	Tools
1	Rika Melyant *et al.*	2019	Design of an Online Queue System for Outpatient Visits	Waterfall Model	Quantitative	PHP, MySQL

2	Richo Wardana *et al.*	2020	Web and WhatsApp-Based Health Clinic Queue Service System	TAM	Qualitative	PHP, MySQL, WhatsApp API
3	Oktafiani & Rahmiati	2022	Analysis of Queuing System to Improve Service Quality in the Banking Sector	Queueing Theory	Quantitative	Excel
4	Kılıf & Ozkan	2020	Evaluating the Bank Queuing Systems by Fuzzy Logic	Queueing Theory	Quantitative	MATLAB
5	Rahman *et al.*	2022	Hybrid Queueing System for Remote Areas	Hybrid System	Qualitative	Python, Raspberry Pi, Java, SQLite
6	Gunawan & Saraswati	2022	Effectiveness of IoT-Based Systems in Queueing	TAM	Quantitative	Arduino, MQTT
7	Putri & Nugrah	2021	Analysis of Digital Queueing System in Islamic Banking	TAM	Qualitative	PHP, MySQL
8	Arief *et al.*	2019	Cloud Computing-Based Queue Implementation	Cloud Computing Scalability Theory	Quantitative	Google Cloud, Firebase
9	Samarina *et al.*	2021	Electronic Queue Management System in Commercial Banks in Conditions of Economic Digitalization	Queueing Theory	Quantitative	Python, Tableau
10	Susanti *et al.*	2023	Utilization of Machine Learning for Queue Prediction	Machine Learning Algorithms	Quantitative	Python
11	Wulandari *et al.*	2022	Effectiveness of QR Code-Based Queue System	QR Code Technology Framework	Quantitative	Java, QR Code Library
12	Saputra & Anwa	2021	Mobile Application-Based Queue Model	TAM	Quantitative	React Native, Firebase
13	Putra & Lestar	2020	Real-Time Notification-Based Queueing System	Real Time System Theory	Quantitative	Python, MATLAB
14	Krisna & Sumiati	2021	Optimization of Teller Services Using Queuing Theory at XYZ Bank	Queueing Theory	Quantitative	Python
15	Hidayat & Firmansya	2021	Data Analytics-Based System in Banking Services	Data Analytics Framework	Quantitative	RFID, Python
16	Santoso *et al.*	2019	Application of Smart Card-Based Queueing System	Smart Card Technology	Quantitative	PHP, MySQL
17	Amelia & Suryad	2023	Application-Based Queueing with Customer Data Integration	TAM	Quantitative	Python, Apache Kafka
18	Firmansyah *et al.*	2022	Real-Time Analytics-Based Queueing System	Real Time Analytics Framework	Quantitative	Ethereum, Solidity
19	Lestari *et al.*	2022	Development of Blockchain-Based Queueing System	Blockchain Technology	Quantitative	PHP, MySQL
20	Aditya & Nugroh	2022	Queueing System with Arrival Prediction Algorithm	Predictive Analytics Algorithms	Quantitative	Firebase, Node.js
21	Perdana *et al.*	2019	Hospital Queue Control System using QR Code	Quick Response Code (QR Code)	Qualitative	sensor GM65, Arduino Uno
22	Firmansyah & Saputra	2021	Effect of The Implementation of Queue	TAM	Quantitative	SPSS

			System on Customer Satisfaction			
23	Yifter *et al.*	2023	Simulation of Queuing System to Improve Service Quality at Bank	TAM	Quantitative	SPSS, Microsoft Excel
24	Abdul Gimba *et al.*	2020	Queue Monitoring System for Bank	TAM	Quantitative	Python, TensorFlow
25	Sampe *et al.*	2024	An Integrated Queue System With Fingerprint Recognition And Scoring Board In Bank	Queueing Theory	Quantitative	Python, TensorFlow, algorithms

Table 1 presents data extracted from 25 selected articles analyzed in the literature review on queueing systems, particularly in the banking sector and other public services. The information displayed includes the authors' names, publication year, article titles, theories or approaches used, research methods, as well as tools or software employed in system development. The theoretical foundations in these studies vary, ranging from the Technology Acceptance Model (TAM) and Queueing Theory to advanced technologies such as Blockchain, Machine Learning, and Cloud Computing. Most articles utilize quantitative approaches, while only a few adopt qualitative methods. The tools used reflect a diversity of technologies, including PHP, Python, MATLAB, Arduino, as well as cloud platforms and modern databases like Firebase and Apache Kafka. Overall, this table shows trends in the use of digital technologies to enhance queueing system efficiency, along with the analytical and technical approaches applied in the development and evaluation of these systems.

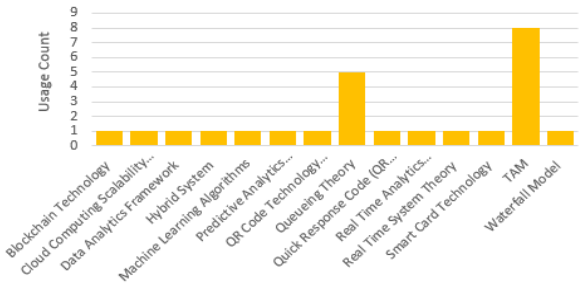

Figure 2. Theories Used in the Articles

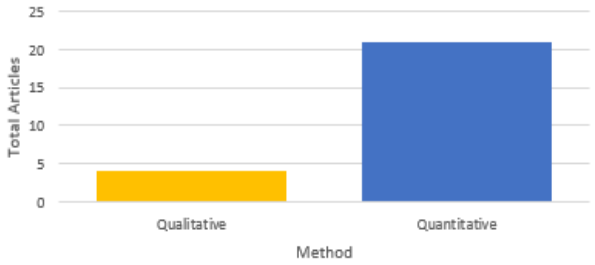

Figure 3. Most Frequently Used Methods

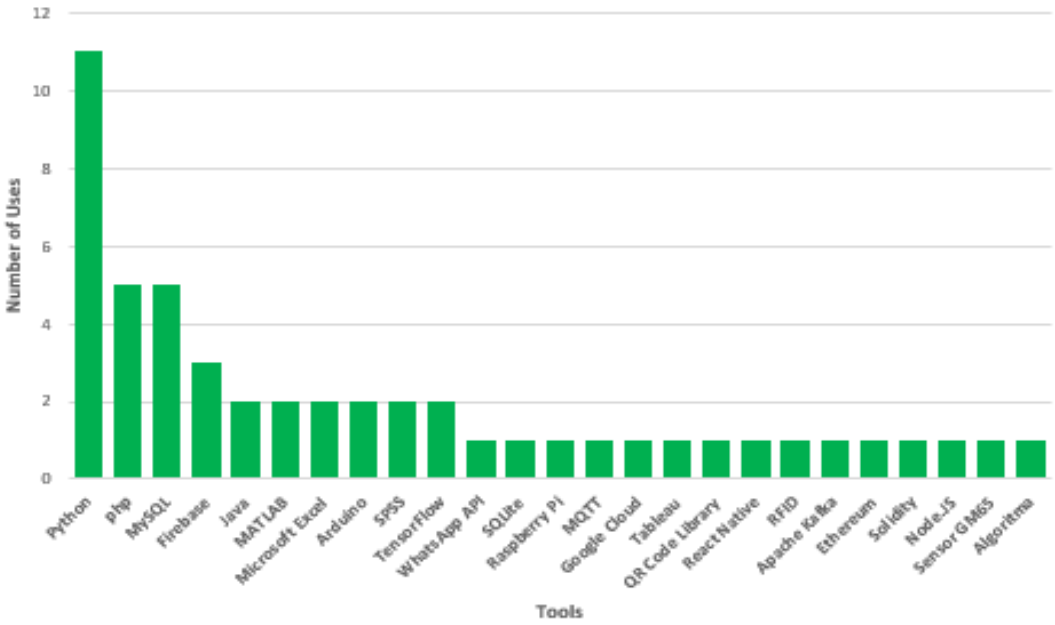

Figure 4. Most Frequently Used Tools

4.2 Discussion

To facilitate analysis, the references in this table are grouped according to key themes, such as the types of technologies employed (*e.g.*, IoT, Blockchain, Machine Learning) and the implementation challenges faced, including infrastructure limitations, user literacy, and system integration. The approaches taken in these studies are also evaluated in depth, showing that although advanced technologies are widely applied, successful implementation largely depends on the readiness of human resources and support from the

operational environment. Figure 2 illustrates the most frequently used theories in the analyzed articles. The Technology Acceptance Model (TAM) holds a dominant position, as many studies emphasize the importance of user acceptance of technology—an ongoing challenge in Indonesia. The varying levels of digital literacy and unequal access to technology across regions make user acceptance a critical factor for the effective adoption of technological solutions. In addition, Queueing Theory is widely applied to analyze waiting time efficiency from a technical and quantitative perspective, which is indeed a pressing issue in both public and commercial services in Indonesia. However, the limited adoption of advanced theories such as Blockchain, Machine Learning, and Real-Time Analytics indicates that much of the research still focuses on solving fundamental problems rather than exploring more complex technologies. This may reflect existing challenges related to infrastructure and human resources that hinder the implementation of cutting-edge technologies across sectors.

Figure 3 shows that quantitative methods are the primary choice in queue system research due to their ability to objectively measure efficiency through statistical data. However, the dominance of quantitative approaches also reveals a limitation in capturing social dimensions and user behavior—factors that are highly relevant in the Indonesian context. Aspects such as queuing culture, trust in technology, and varying levels of user understanding of digital systems significantly influence the success of queue technology implementation. Although less commonly used, qualitative approaches are crucial for exploring social and psychological barriers that arise when new technologies are introduced, particularly in regions with low digital literacy. Therefore, combining quantitative and qualitative methods may offer a more thorough strategy to address the challenges of technology implementation in Indonesia.

Figure 4 shows that PHP, MySQL, and Python are the most popular tools for data processing and queue system development based on the literature analyzed. The popularity of PHP and MySQL aligns well with the need for cost-effective and accessible web application development in Indonesia, considering that many organizations still rely on basic IT infrastructure and operate under budget constraints. Python, with its extensive analytics and machine learning libraries, has increasingly been adopted in response to growing demands for complex data analysis. However, despite the flexibility and accessibility of these tools, their implementation faces significant challenges. One of the main issues is the limited availability of skilled human resources and the lack of ongoing training in many institutions. In addition, infrastructure constraints—such as uneven internet connectivity across various regions in Indonesia—pose substantial barriers to optimizing the use of cloud-based and real-time data processing technologies. Therefore, while these tools effectively support queue system development, strengthening human resource capacity and improving digital infrastructure are key to overcoming technology implementation challenges in Indonesia.

5. Conclusion and Recommendations

Our research on queue systems in Indonesia's banking and public service sectors revealed several key findings. The Technology Acceptance Model (TAM) and quantitative approaches dominate current research methodologies. Social aspects and user perceptions need more attention, especially considering the varying levels of digital literacy and queueing behaviors across different regions of Indonesia. PHP, MySQL, and Python remain popular tools for developing queue systems due to their accessibility and versatility. However, implementing these technologies presents numerous challenges—particularly inadequate digital infrastructure, low tech literacy among users, and integration problems in non-urban areas. The effectiveness of digital queueing systems largely depends on social understanding, user education, and robust infrastructure. We suggest future studies should blend quantitative and qualitative methods while focusing on creating adaptable solutions that address local needs and constraints.

Banking sector queue system research should focus more on practical implementation, especially in rural branches where infrastructure limitations, platform accessibility, and economic conditions vary greatly. Long-term studies would help track evolving customer behaviors and queue patterns over extended periods. Current research lacks sufficient real-world testing of queue models, as well as studies on AI integration for prediction and automated management. More comparative analysis of different queueing algorithms would help optimize existing solutions. Research has overlooked critical factors like usability, customer experience, and personalized service options—all essential for widespread adoption. Additionally, researchers must pay greater attention to ethical considerations regarding data privacy and information security to ensure responsible innovation in queue management technology.

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