The Approaches Utilized in Queuing Modeling: A Systematic Literature Review

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***Abstract*— Queue scheduling is an important process that is used when processes can be divided into different classes based on the scheduling needs. In general, queue lengths and waiting times can be predicted with the use of a queuing model; especially, the importance of the services provided by any sector or organization for delivering effective services to their consumers highly depends on managing the queues in an effective manner. So, in general, analyzing and evaluating queues is more significant in fulfilling customer needs in a limited time. The applications and tactics developed earlier would not provide satisfactory solutions to solve this problem. But the studies done in the recent past have utilized newer technologies. Especially by incorporating Machine Learning techniques and various queuing models. During this study, a thorough analysis was carried out to discover the different strategies used in optimizing the queues by presenting a Systematic Literature Review (SLR) by examining available research perspective to queue management systems from 2016 to 2022. Initially 200 studies selected using seven electronic repositories and finally selected 14 for this analysis. The study's findings reveals that most of the studies have used machine learning approaches, utilizing tools like ARENA,SIMIO and adapting various queuing algorithms to solve this problem.**

Keywords*— *Systematic Literature Review, Machine learning, Queue scheduling, Queuing models

I. INTRODUCTION

A queue, also known as a waiting line, is a social phenomenon that is particularly common in today's environmental communities, where there are insufficient facilities or none at all to meet the needs of the end consumers of a given commodity or service. Customers are referred to as arriving units in a queue, who are individuals who are in need of a specific service at a service delivery center and must patiently wait in a line or wait if the services are not delivered promptly. So, waiting in a line can be uncomfortable and exhausting for customers, and it can lead to lower customer satisfaction. Queuing theory has been widely used to evaluate consumer waiting times, optimize staff schedules, and improve the robustness of a queuing system in the face of changing demand [1] [2] [3].

When a large number of individuals require access to a resource and the service can't keep up with the demand, queuing issues arise. On the other hand, lineups may become too long, for this reason, resulting in protracted periods of inactivity for clients. Customers or users are in a hurry to get the service. So, long wait times have also been linked to customer unhappiness, thus businesses should aspire to more effective resource allocation that would reduce wait times [5].

There are queues for paying for groceries, getting food at a restaurant, and placing an appointment foe a doctor, among other commonplace tasks. The majority of queuing scenarios would benefit from queue management to lower the cost of the used resources, in terms of staff costs and consumer waiting periods, even if research has shown that longer waiting times may occasionally result in increased consumption in some cases. Several businesses employ queue optimization methods to enhance customer service. Queue scheduling approaches can be applied to manage long queues, and in many sectors.

In the banking sector, queue scheduling can be adopted in service counters and as well as ATM machines. Here, the bank management can focus on resource factors such as making separate counters for particular purposes, and locating more ATM machines and deposit machines. These factors help to divide a long queue into a few short queues. Then it is easy to manage rather than long queues. Simply increasing the number of bank servers and branch locations is not beneficial for the banks. Unwise location selection and too routine bank operations will undoubtedly do the bank great harm [1][7][17]. And considering the healthcare sector, such as allocating a few doctor counters, a few pharmacy counters and keeping separating the consulting doctors may help to reduce the long queues and helps to manage the queues. Queuing models are used in the healthcare industry to increase hospital resource utilization and manage trade-offs that will increase the effectiveness and caliber of the services delivered by healthcare systems. Queuing models can evaluate service and wait times in pharmacies with heavy workloads or several points of service [3].

Queuing management planning is important for security checks and the check-in process in airports. Here, wait time estimation, considering the effect of change in personnel is more focused as factors. Image processing, ANN and Machine learning are used as the technologies when developing these queue scheduling [13][18].

Automated queue management technologies are widely employed in various industries, including banking. They manage customer arrivals and direct them to the appropriate locations for service. However, the majority of existing solutions in real-world systems do not account for consumer wait times [6]. We can forecast the length and duration of a line by building a queuing model. The waiting time of someone in a queue can be minimized using queuing theory [7]. The technique of improving a business by managing the

waiting experience of customers is known as queue management.

In addition, in every industry where waits are required, the lineups are analyzed and the queuing theory is implemented in order to maximize revenues while improving customer satisfaction. Different queuing approaches, such as shortest job first, longest job first, most lucrative work first or different priority classes, have been using today [8]. Incorporating mobile applications is a means of having a better queuing system can be facilitated by taking advantage of the frequently used cell phones.

The purpose of this study is to provide a full description of the artificial neural network approach for queue management and scheduling to reduce the waiting time. Additionally it is conducted a systematic literature review utilizing various research papers done by various researchers.

A. Motivation of the Study

A large number of people reach banks to fulfill their needs in their day-to-day lives. When considering the banking sector, especially in Sri Lanka, waiting more time in a queue is becoming as common because of increasing the customer amount.

Basically, two sorts of queuing can be seen as structured queues and unstructured queues. A structured queue is one whose members are positioned in a known location. This is evident at grocery store checkout desks and other retail locations like banks and post offices. To manage ticket ranking for a service that requires identification, this type of queue system is frequently used, allowing for stress-free waiting.

In fact, successfully implementing a method of arranging these queues is difficult. The reason for this is that human behavior is difficult to predict. Prior research on queue management principles, including Shortest Processed First (SPF), First Come First Serve (FCFS), Single Queue (SQ), Multiple Queue (MQ), Diffuse Queue (DQ), and Head of Queue, has taken many different forms (HQ). A scheduling policy known as SPF gives the processing jobs that require the least amount of time the highest priority. A scheduling policy known as SPF gives the processing jobs that require the least amount of time the highest priority. The oldest entries are processed first as part of the FCFS protocol. According to FCF's conduct, people leave the line in the order that they entered. When every consumer believes they are on a level playing field, there is the most equitable service supply. The snake format is known as SQ or single queue. Each client is attended to thanks to the layout, which eliminates crowding. Customers feel more confident that they will be treated fairly because they can see that the line is moving. In addition, when working with large groups of people, it is imperative to use the multiple queues, or MQ, as it is an improvement over the single queue. This is the line that forms at the grocery store every time.

A queue management system can benefit both the customer service provider and the customer. The advantages to the system can be immediate or indirect.

II. METHODOLOGY

Here systematic mapping is applied to queue scheduling in the banking sector and this study is focusing on Artificial Neural Networks, queuing theory and time scheduling-based approaches. The systematic mapping process which is used for this study is as follows [9].

- Identify Research questions – Review scope
- Conduct search – All papers
- Screening of papers – Relevant papers
- Abstract search – Most relevant papers
- Mapping process – Systematic map

A. Research Questions

TABLE I. RESEARCH QUESTIONS

No	Research Question
RQ1	What kind of queuing systems are available in banks?
RQ2	Why do we need a proper queue management system?
RQ3	How do banks manage long queues?
RQ4	How do we determine priorities in the scheduling algorithm?

B. Conduct Search for primary studies

For this study, the primary search is done using search strings on scientific databases and browsing manually with keywords. Structure them in terms of population, intervention, comparison, and outcome to build a good search string. The research topics should, of course, guide the structure. Each part of the structure can provide keywords for the search string.

TABLE II. SEARCH STRINGS

Area	Search terms
Queue Scheduling	“queue scheduling”, “queuing scheduling”
Queue Scheduling Method	“queue scheduling tactics”, “queue scheduling approach”,
Artificial Neural Network	“artificial neural network”
Search String	(“queue scheduling” OR “queuing scheduling”) AND (“queue scheduling tactics” OR “queue scheduling approach”) AND “artificial neural network”

The choice of databases was different. The search strings and the search keywords and query combinations will be used to locate pertinent resources. In that situation, by looking at earlier study publications, all of the works related to queue management with artificial neural networks were found and categorized.

C. Sources

This Systematic Literature Review was performed using the following electronic databases and considered the most relevant studies.

- IEEE Explore http://ieeexplore.ieee.org
- Springer Link http://www.springerlink.com
- Science Direct http://www.sciencedirect.com
- Academia https://www.academia.edu
- Research Gate https://www.researchgate.net
- Revista https://www.revistaespacios.com
- IOP publishing https://ioppublishing.org

1) Screening papers for inclusion and exclusion

Following inclusion and exclusion criteria are used to exclude studies that are not relevant to answering the research questions.

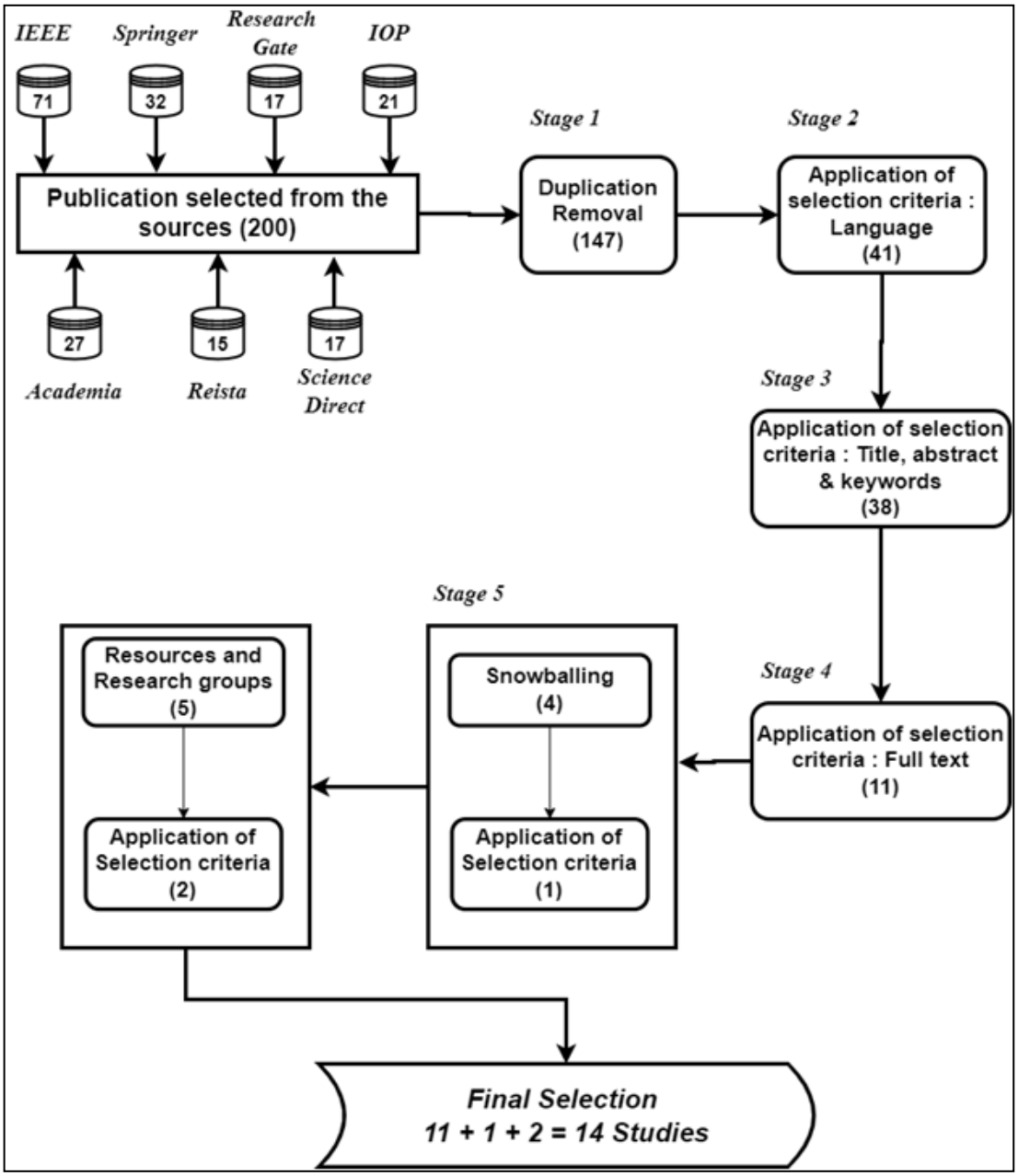

Fig. 1. Search and Selection Process

2) Inclusion Criteria

Books, papers, journals and technical reports regarding queuing theory and queue management have been selected. Only the most recent paper was considered when multiple papers reported the same study.

TABLE III. INCLUSION CRITERIA FOR THE SELECTION PROCESS

No Inclusion Criteria
IC1 The papers have a standard structure and reference format.
IC2 The papers have clearly defined the discussion and conclusion of the research.
IC3 The studies that have contained Artificial Neural Networks and queue scheduling.

3) Exclusion Criteria.

TABLE IV. EXCLUSION CRITERIA FOR THE SELECTION PROCESS

No Exclusion Criteria
EC1 The studies which are not written in English
EC2 The studies do not have an abstract
EC3 The studies that have published only the abstract
EC4 The studies outside the artificial neural network and queue scheduling domain.

4) Keywording of abstracts

Keywording is a technique for shortening the time it takes to construct a classification system while also guaranteeing that the scheme takes prior studies into consideration. There are two steps to keywording. The reviewers begin by reading abstracts and looking for keywords and themes that indicate the paper's contribution. While doing so, the reviewer also determines the research's context. When this is completed, the set of keywords from many papers is integrated to produce a high-level understanding of the research's nature and contribution. This assists the reviewers in developing a collection of categories that is reflective of the whole population. When the quality of the abstract prevents reviewers from selecting useful keywords, they can opt to look at the paper's introduction or conclusion. After deciding on a final set of keywords, they can be clustered and utilized to create the map's categories.

D. Sentiment Analysis Process

Within the sentiment analysis process, can be viewed as a series of various data mining steps.

1) Data Collection

When considering this study collecting data for the banking sector is more complicated and should do combining with a bank. It should be clearly mentioned the reasons for each person to arrive at the bank and wait. And also it should be mentioned about if the above reason fulfilled or not.

2) Data Pre-processing

Pre-processing entails cleaning and filtering data, which, if done incorrectly, can result in inaccurate data classification. There may be some noisy information like misspelt or unclear data records. They can degrade the accuracy of a sentiment classifier approach. Data filtering entails maintaining only the useable portion of the data and removing the undesired or junk component so that classifiers can accurately classify the given data.

*3) Feature Selection and Extraction**

Although feature selection and feature extraction are both phases in the sentiment analysis process, they are semantically distinct. The feature selection and extraction process is divided into two stages: first, feature sets are chosen, and then feature values are extracted from the text.

III. Results and Discussion

Many researchers and academicians around the globe have contributed to calculating and reducing the queue waiting time through various data. This section provides a short overview of the work done by them.

In the research automated queue management system, Uddin et al (2016) has introduced an automated queue scheduling system, especially for the banking sector. It has designed to manage certain customers with a single department and multiple counters. Pre-arrival, arrival, queuing or waiting, serving, and post-serving are all parts of the Customer Flow Management process. The pre-arrival process allows customers to book appointments before arrival. In here system design a customer will select required services either service A, B or C and get an acknowledgement receipt which consists of information such as token number, service selected, date and time. For this development, Intel Galileo Gen 2 board is a microcontroller board, Adriano hardware and software compatibility, a push-button for simple switch mechanism for controlling, a liquid crystal display; a buzzer beeper and Ds307 real-time clock module have been used as components. The result analysis part has been done by using several simulations. A randomized generated number has been used to create a sequence of the customer's arrival time and the services from which they can choose [10].

The Queue Management research done for elimination, expectation and enhancement (Weiss, 2018) says that there are three approaches to queue management. They are (1) Eliminate or reduce the wait through process enhancement. (2) Manage expectations through timely and relevant communication with one’s customers and (3) Enhance the waiting experience. Within this paper, they have suggested approaches to selected three approaches. To expectation management, with live highway signage, a more high-tech solution to the same queue-management concept is used. Commuters have the ability to circumvent the obstacle by being informed of delays before they pass the last exit before the delay, which not only reduces their personal travel time but also improves system performance. Using technology to reduce operations that compel customers to wait is one type of innovative queue management. From the standpoint of operations, this could be considered merely another sort of waste reduction, but it could be far more significant. Waiting in a line is a source of frustration for consumers, and tackling the source of the line can be a worthwhile target for waste-reduction efforts. If a backlog is unavoidable, make it part of the service process rather than just a preamble to it for a better outcome for both the customer and the company [11].

The research by Kyritsis et al (2019) a machine learning approach to waiting time prediction in queuing scenarios has introduced an approach to queue management using a machine learning approach. They have suggested QueueForMe, a system that allows anyone to create a queue by setting an initial set of parameters specific to that queue, as well as response options for those parameters. Each client who joins the queue responds to all of the required criteria, and machine learning is used to estimate the client's expected waiting time. The machine learning model considers the time the client joined the queue, his or her position in the queue, the number of servers available for the queue, and the client's responses to the aforementioned additional parameters. They have computed the number of individuals waiting in line at the time the client entered the line. To do so, they added the waiting time to the arrival time to compute the queue departure time for each client, and then we tallied the number of persons who had yet to leave the queue when a new client joined it. They utilized Python 3.7.3 and Tensorflow 2.0.0-beta1 for the machine learning experiment presented in this paper [12].

The research by Sundari et al (2020) artificial neural network simulation for Markovian queuing models in a busy airport has suggested an ANN model for the queuing system and waiting time management. In this study, airport runways are modelled as a single server with finite capacity queuing. Kendall's and Little's formulas are used to solve runway queuing [14] [15]. Three data are used for modelling the input layer: (i) Flight Arrival rate, (ii) Takeoff or landing rate, and (iii) Number of runways. And eight mathematical equations have been used for arrived queuing data. This technique simulates runway scheduling using three neurons

in the input layer and sixteen neurons in the output layer. In this model, the number of hidden layers is considered starting with one and gradually increasing to improve the accuracy of the solution. The ANN is modelled in MATLAB, and the network is trained, evaluated, and tested using nntool. The ANN model architecture is trained using the Feed Forward Back Propagation Algorithm [13].

The research by Abusair et al (2021) is an approach for queue management systems if non-critical services are done for the healthcare vaccination system. They have proposed an approach that uses a queue management system with priority to address the problem in their study. The strategy attempts to cut wait times and crowds while also encouraging parents to keep their appointments. They have proposed an approach that uses a queue management system with priority to address the problem in their study. The strategy attempts to cut wait times and crowds while also encouraging parents to keep their appointments. Here a priority queue algorithm has been suggested for managing the queue. And the customers in the queue have been divided into three priority classes [16].

TABLE V. RESULTS OF THE SELECTED STUDIES

Paper ID	Title	Tools used	Considered features	Sector	Results	Limitations
1	Automated Queue Management System	-Intel Galileo Gen 2 -Liquid Crystal display -Ds307 Real-Time Clock Module –FCFS and SPF algorithms	-Arrival -Waiting -Serving -Managing	Banking Sector	Considerable difference between new and ordinary algorithms. New one is effective.	Adding sensors to cameras can detect a customer at a certain time.
2	Short-term prediction of vehicle waiting queue at ferry terminal based on machine learning method	-Support Vector Machine (SVM) -ANN -Machine Learning	-Ensemble Hybrid Model -MAE -MAPE -RMSE	Ferry Terminal	-MAE increased up to 22.46% -MAPE increased up to 13.72% -RMSE increased up to 30.92	Trigonometric polynomial can be used to better capture the cyclical pattern in the vehicle queue data, and increase the prediction accuracy for both the ANN and SVM models
3	A Machine Learning Approach to Waiting Time Prediction in Queuing Scenarios	-QueueForMe web application -Adam Optimization algorithm -Fully connected neural network with 2 hidden layers, with 12 and 8 neurons. -Rectified linear unit	-Number of waiting people -Waiting time -Queue departure time -Arrival time	Banking Sector	-naïve mean model, 28.9% improvement -naïve median model, 27% improvement	Use a simulator: can verify the predictive capabilities.
4	Overview Impact of Applications of Queuing Theory Model on Productivity Performance in a banking sector	-Artificial Neural Network -Business Process Reengineering -Erlang B&C formulas -Queuing theory	-Arrival Rate -Purpose	Banking Sector	System actively busy for 96% and highly utilized	Can apply for another sectors such as traffic in transportation systems and telecommunication
5	Petrol Pump Queue Management system for Sultanate of Oman Using Artificial Intelligence Techniques	-Machine Learning -Image AI -Tensorflow -Computer vision	-Service providing speed -Refueling liter amount -Refueling time duration	Petrol pump		Use sensors for calculate the correct volume of the fuel tank and the empty volume.
6	Intelligent Queue Management System at Airports using Image Processing and Machine Learning	-Image processing -Machine learning -Haar cascade -Multiple liner regression algorithm -Open CV -AdaBoost	-Estimated time captured by a passenger -Shortest possible root -Waiting time	Airport	-Identify the passenger count in a queue -Using data calculate the estimation time	-can be improved to identify overlapping faces of multiple people. -features for the airport security like unattended baggage tracking.
7	Artificial Neural Network simulation for Markovian Queuing Models in a Busy airport	-ANN -Infinite capacity -MATHLAB -nntool -Feed Forward Back Propagation algorithm	-Waiting time -Arrival rate	Airport	R value obtained to 0.9999	It can be scheduled for minimum waiting time and lower fuel cost.
8	Design of advanced queue system using artificial neural network for waiting time prediction	-ANN -Standard Back propagation algorithm -ARENA Rockwell -QTR	-Queue length -Waiting time -number of counters	Banking sector	90% of predicted waiting time is correct	ANN is more appropriate and can be adapted for advanced systems
9	An Approach for Queue Management Systems of Non Critical Services	-Little's law queuing theory -Priority queue algorithm	-Waiting time -Priority class -Average service time	Health care Vaccination	Priority class average waiting time is lower than average waiting time.	Only for priority customers
10	Automated Taxi Queue Management at High-Demand Venues	-Linear Regression -Marcov Decision Process	-Passenger Demand -Cumulative	Taxi Queue	-Poison Demand Assumption by 43%	Use this model in other airports to get more demand

			prediction		-Reduce the gap by 23%	
11	Application of queuing theory to reduce waiting period at ATM using a simulated approach	-Little's theorem -The Single Server Poisson Queue Model	-Arrival rate -Service rate	Banking Sector ATM	Service rate is higher than appearance rate. M/M/1 model is sufficient	Increasing the sever count is not needed and it will affect for the customer demand and the profit.
12	Queue behavioural patterns for passengers at airport terminals: A machine learning approach	-Random Forest Algorithm -Simulation	-Passenger volume -Waiting time	Airport	Achieved 70% accuracy	Adapt this model to improve passenger sevice level by predicting patterns
13	Enhance System Utilization and Business Revenue with AI-based Queue Reservation System	-ANN -Queue Reservation System -Insert Algorithm -MATHLAB	-Waiting time -Customer Satisfaction	Business	-95% accuracy for predicted waiting time -Customer service improved from 13% up to 54%	Reserved customer lateness is random. A smart phone should be implemented for communication purpose.
14	Queue Monitoring System for Bank	-FIFO algorithm -RSS algorithm -Priority Service algorithm	-Waiting time -Service time -Arrival time -Customer count	Banking Sector	-Sensor technology accuracy 80%. -From real time data 90% accuracy	-Develop a machine learning model for a queuing system for effective customer service. - integrating a motion sensor camera into the system

There are many of algorithms and tools which is used for queue scheduling. Out of the researches most of the time queue scheduling systems are developed and tested using ARENA software powered by Rockwell Automation. Especially, considering the banking sector they have used ANN, ARENA Rockwell, Stand Back propagation algorithm, Business Process Reengineering, Erlang B&C formulas and Adam Optimization algorithm [3][6][8][10][19]. Within these algorithms and tools they have been get successes more than 90% accuracy. And considering the airport sector they have used image processing, machine learning, Haar cascade, multiple linear regression, Open CV, ANN and Feed Forward Back Propagation algorithm. As well as in airport sector also they have achieved more than 90% accuracy in queue scheduling systems [13][18]. Such as these mentioned sectors, petrol pump sector and the ferry terminal sector also have used ANN, machine learning, computer vision and Image processing for their developments. And also a considerable achievement and accuracy have been achieved.

IV. CONCLUSION

This paper has explored how machine learning can be used for queue scheduling and what are the various technologies that have been used for queue scheduling. From the results obtained and analysis done utilizing several repositories and finally filtered around 14 papers utilizing inclusion and exclusion criteria and snowballing. And most of the selected studies have achieved their target or considerable accuracy. It can be planned to do utilizing this systematic literature review to expand my research to mainly focus on developing a queue scheduling process or a model mainly focused on Artificial Neural Network to develop a final queuing model for the banking sector. This will be a promising start for the future researches to enhance their idea or enhance their model development on queuing scheduling to increase the accuracy to focus on this hybrid approaches.

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