Proceedings of Business and Economic Studies, 2025, Volume 8, Issue 8
http://ojs.bbwpublisher.com/index.php/PBES
Online ISSN: 2209-265X
Print ISSN: 2209-2641

Optimization of Agricultural Bank of China's "Smart Welcome" System Based on Queuing Algorithm: Taking HL Branch as a Case Study

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Abstract: This study selects the "Smart Welcome" system of Agricultural Bank of China as a research case, aiming to improve the service efficiency and quality of Agricultural Bank of China's branches through system optimization based on queuing algorithm. It first provides a systematic review of queuing theory and performance evaluation of queuing systems, to provide basic theoretical support for the improvement strategies of the "smart welcome" system in the bank queuing process system. Through a detailed analysis of the "Smart Welcome" system, covering its definition, workflow, existing channel information collection capabilities and customer service characteristics, it proposes a novel queuing algorithm application for optimizing the system's efficiency and bank processes in response to identified problems. The optimization aims to enhance the service efficiency of bank outlets, providing references and suggestions to support the improvement of bank service efficiency.

Keywords: "Smart Welcome" system; Queuing theory; Queuing algorithm; Service efficiency; Bank branch service optimization

Online publication: December 31, 2025

1. Introduction

How to optimize the "smart welcome" system to adapt to different business scenarios and improve the overall service level is of significant practical and strategic value for promoting the further enhancement of the digital services of Agricultural Bank of China. With the development of financial technology, traditional banking businesses have inevitably suffered shocks to varying degrees. Gayathri and Remica pointed out in their research that faced an increasingly competitive market, improving customer satisfaction and service quality is crucial [1]. This study selects Agricultural Bank of China as a typical case analysis object, and improves and optimizes its "smart welcome" system based on the improvement of queuing algorithms. This initiative is expected to enhance

the efficiency of bank customer business processing, improve the overall efficiency of bank branch services, and strengthen the bank's competitiveness in the digital era.

2. Literature review and theoretical foundation

2.1. Intelligent service systems

An intelligent service system is a service system integrated with artificial intelligence, which plays an important role in fields such as customer support, virtual assistants, and online shopping. Through continuous learning and optimization, intelligent service systems can adapt to changes in user needs and provide users with more intelligent and convenient services. The "smart welcome" system of Agricultural Bank of China is based on artificial intelligence and big data technologies, aiming to provide more efficient and convenient customer services, including but not limited to customer information management, business consulting, reservation services, and product recommendation functions. The "smart welcome" system can accurately identify customers through channels such as queuing machines and super counters, and obtain information such as customers' credit card opening status, mobile banking opening and activity levels, so that bank staff can quickly understand customer needs.

2.2. Current situation analysis of queuing algorithms applied in intelligent service systems

The application of queuing algorithms in intelligent service systems mainly focuses on virtual queuing, that is, customers can use mobile applications or self-service terminals to obtain queuing numbers without waiting on site. At the same time, queuing algorithms can assign appropriate time periods to customers according to their locations and needs, avoiding crowding in the hall. Moreover, in terms of customer notifications and reminders, using queuing algorithms, intelligent service systems can send notifications and reminders to customers to inform them when to arrive to receive services earlier. Therefore, researching theories related to virtual queuing has certain enlightenment for the optimization of bank intelligent service systems.

Geng and Yang pointed out that domestic bank queuing systems have been used for more than 20 years, but there are still many disputes and complaints to this day [2]. Banks usually adopt the simplest and most intuitive queuing algorithms, such as the First In First Out (FIFO) algorithm, where customers who queue first are served first. However, for diversified banking businesses, this algorithm has become insufficient. In recent years, with the research and development of artificial intelligence and queuing theory, some scholars have successively proposed new queuing models, such as the queuing model based on approximate Bayesian methods and the research on the application of Markov chains in bank queuing systems [3]. In addition, other relevant literatures have pointed out some defects of traditional queuing methods, such as unbalanced service supply and demand, system congestion, and insufficient efficiency [4,5].

2.3. Concept of queuing theory

A queuing algorithm is a mathematical model used to optimize resource allocation and task processing, derived from queuing theory, also known as "stochastic service system theory". It mainly focuses on how to effectively organize and manage the order of task processing under the condition of limited resources, and then optimally design the queuing system to improve the efficiency and performance of the system. Queuing algorithms are widely used in various fields, such as hospital nurse scheduling, port cargo dispatching, and airline flight scheduling [6–8]. Its basic principle is to enable the system to better respond to peak demand and improve resource

utilization through reasonable queuing strategies, thereby achieving more efficient operation.

3. Algorithm application and optimization of the "smart welcome" system

3.1. Current service status of the "smart welcome" system

At present, the "smart welcome" system only plays a significant role in collecting information such as customer types, customer mobile banking activation status, and customer credit card opening status. It has a single function type and only helps bank staff carry out appropriate marketing based on customer information, but does not bring convenience to customers, and the system is far from meeting the original development definition. Additionally, due to the large overall business volume in the lobby, staff have no time to take into account customer information on the system for marketing most of the time, resulting in the system being basically idle and having insufficient actual effectiveness. Through the existing information identification and collection functions of various channels of the "smart welcome" system, combined with queuing and number taking rules, it is expected to solve the existing queuing problems of the branch and the insufficient efficiency of the "smart welcome" system.

3.2. Baseline queuing algorithm models

Most bank queuing adopts the multi-service desk mode. The basic queuing algorithm models adopted in this study include the single-service desk model (M/M/1 queuing model) and the multi-service desk model (M/M/c queuing model), which is the current service model of HL Sub-branch. In addition, there are queuing network models, priority queuing models, etc. Based on the current service model of HL Sub-branch, this study focus on the discussion of queuing network models and priority queuing models.

3.2.1. Queuing network model

The queuing network model is used to describe the interaction and connection between multiple queuing systems, such as queuing systems in bank systems, computer networks, or supply chains. Queuing network models usually involve data flow and resource allocation between multiple queuing systems to maximize the efficiency of the entire system; for the existing data flow collection functions of various channels of the "smart welcome" system, resource allocation on this basis can effectively improve the service efficiency of the branch system.

3.2.2. Priority queuing model

The priority queuing model mainly considers the priority levels of different customer types or tasks, where high-priority customers receive corresponding services before low-priority customers; bank branches involve many types of businesses, and only focusing on customer type priority will lead to ordinary customers being frequently preempted by VIP customers for service, which may cause long-waiting ordinary customers to become dissatisfied and further lead to hall disputes. Researching how to handle customer priority and business priority is helpful to improve the overall service quality of banks, reduce customer complaints and customer loss.

3.3. Queuing strategies adopted based on the current service status of the "smart welcome" system

3.3.1. Optimization of queue management system service process

The queuing service process is widely used in various scenarios, including but not limited to banks, hospitals, government agencies, etc. Optimization of the queuing service process is of great significance for improving

customer satisfaction, work efficiency, and reducing costs. At the same time, reasonable adjustments of the service process also lays a good foundation for system function embedding and coding. Transform from the traditional "customers look for counters" to "counters look for customers", and adopt multi-channel customer acquisition to avoid customer loss. To facilitate the comparison of the differences between the traditional single queuing process and the optimized queuing process, this subsection will list the main step processes in detail as outlined:

(1) Traditional queuing service process

Card swiping (manual number taking) → Business type → Number assignment → Queue increment → Service desk

(2) Optimized multi-channel service process

(i) Mobile banking channel

Reservation (customer identity identification) → Time period → Selection of business type → Number assignment → Time point recording → Data interaction → "Smart Welcome" → Queue query → Queue increment → Service desk

(ii) Number taking machine (card swiping number taking) channel

Card swiping (customer identity identification) → Business type → Number assignment → Time point recording → Data interaction → "Smart Welcome" → Queue query → Queue increment → Service desk

(iii) Super counter channel

Card swiping or code scanning (customer identity identification) → Counter business → Number assignment → Time point recording → "Smart Welcome" → Queue query → Queue increment → Service desk

(iv) Counter channel

Card swiping or code scanning (customer identity identification) → Super counter business → Number assignment → Time point recording → "Smart Welcome" → Queue query → Queue increment → Service desk

3.3.2. Re-formulation of priorities

The main goal of re-designing the priority of visiting customers is to provide each customer with more calling opportunities as the waiting time increases, thereby avoiding possible service disputes caused by low-priority customers being occupied by high-priority customers for a long time. Assume that customers in the bank queuing system are divided into the following four types of queues: ordinary queue, VIP queue, caring service queue, and reservation queue, and their priority order is "reservation > VIP > caring service > ordinary". According to this rule, each visiting customer has a calling weight that changes with waiting time, and the queuing rule in the "smart welcome" system is to prioritize serving the customer with the highest weight. The calculation formula for the waiting time weight of visiting customers is:

$$W = e^{t/T_{max}}$$

W: Weight of customers changing with waiting time;

e: Natural number;

t: Cumulative waiting time of customers after taking numbers;

T_{Max}: Maximum waiting time threshold for customers

3.4. Optimization design of system functions

To fully demonstrate the system functions and help readers simplify their understanding of the system, this subsection carries out the design of the system's class diagram to better explain its operation mechanism. By describing the structural design of the system, readers can have a deeper understanding of the internal operation of the system and the correlation logic between various components. At the same time, it provides a basic model reference for system coding and testing (**Figure 1**).

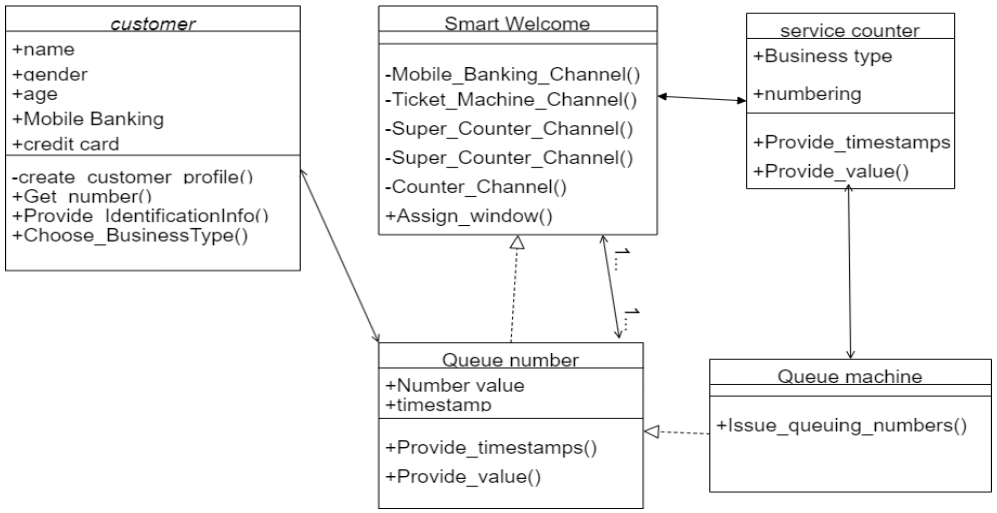

Figure 1. Key class diagram of system functions.

4. Research conclusions

The traditional "smart welcome" system only plays a significant role in collecting information such as customer types, mobile banking and credit card activation status, with a single function and is idle due to the large business volume in the lobby, resulting in insufficient efficiency; the unreasonable window setting of HL Sub-branch of Agricultural Bank of China leads to unbalanced queuing, and traditional optimization methods have poor adaptability. Research shows that expanding the queuing function of the system can improve efficiency and balance queuing. Through strategies such as optimizing the queuing algorithm, improving the queuing model, perfecting the business process, and increasing customer priority weights, simulation evaluation shows that it can solve the problem of system efficiency, balance window queues, and improve service efficiency. This study fills the research gap of dynamic queuing of intelligent systems in the context of digitalization and provides a reference for the digital transformation of the banking industry.

5. Suggestions and application prospects

Optimize demand acquisition, strengthen the inquiry of customer needs to ensure the accuracy of number assignment, add displays of common businesses to guide customers, and conduct regular satisfaction surveys. Improve processing efficiency, reduce ineffective marketing, optimize service processes, introduce AI technology to build a self-service system, and improve responsiveness. In the future, the system will be more intelligent and automated, integrating AI and other technologies to achieve personalized services; integrating multiple channels to realize appointment queuing and dynamically allocating resources through big data; promoting cross-channel

integrated services and green development.

Funding

2024 First-Class Undergraduate Course Construction Project of Guangzhou Xinhua University (Project No.: 2024YLKC085)

Disclosure statement

The authors declare no conflict of interest.

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