Smart Queue Management

Mr. S. Gunasegaram[1], B. Gowtham[2], K. Gowdham[3], B. C. Gopish[4], B. Elamathi[5]

[1]Asst. Prof/ Department of CSE, V.S.B Engineering College, Karur, Tamilnadu

[2,3,4,5]Department of CSE, V.S.B Engineering College, Karur, Tamilnadu

Abstract

The Smart Queue Management is software that is implemented online in hospitals. Long waiting in the Queue is the common problems in this generation. It will create overcrowded in hospital lobbies, leads to frustration and insufficient space. We use digital tokens to prevent this and handle the order of service. The Smart Queue Management System is based on digital token allocation. The facility allows users to sign up and sign in. After joining, they can monitor their token in real time. They may choose the hospital they like best. The system also Notifies the members when their time is near or at least 30 minutes ahead through SMS, e-by mail or push notification. They will no longer queue. They will be able to produce payment via online. The system is   more convenient in helping the service providers in Regulate the customer flow with an interactive dashboard. The system enables the staffs monitor wait times. The system is developed utilizing Java- based backend including token management database. It is also appropriate in banks and other service environment. Finally, the future work seeks to revolutionize the experience of queuing by eliminating unnecessary wait, stress, and enhancing the overall Efficiency in the delivery of services. The Smart Queue Management System introduces up-to-date, environmentally friendly and efficient means of dealing with the daily issue in the waiting line.

Keywords: Smart queue management, intelligent scheduling, quality of service (QoS), congestion control, resource allocation, queue optimization, network performance, adaptive queue systems, and machine learning in networking.

1. Introduction

This invention focuses on Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT). It targets intelligent queue management in service settings like banks, hospitals, transport hubs, retail stores, and government offices. The invention presents a system and a method of analyzing the queue patterns and predicting the waiting time based on computers and dedicating resources to enhance the customer flow and minimize the congestion. In comparison to the manual systems of tokens or fixed queue systems, this is an AI method that is trained on historical data and real-time data. The system forecasts the times of busyness, delegates counters and resources, and issues digital tokens to the user. This invention enhances the development of smart service delivery technologies to be more efficient, save time related to waiting lines, and increase customer satisfaction.In the modern high-speed world, the issue of managing queues is important in order to achieve better service delivery and

customer satisfaction. Lengthy queues and queues not well managed may lead to customer dissatisfaction, wastage of resources and operation problems. With the increased need to find smart solutions, there is a shift in the queue management systems of the modern world where the strictness of the rules-oriented systems becomes more flexible and intelligent. Smart Queue Management is an application that optimizes service flow dynamically with the help of sophisticated computational techniques, data analysis, and real-time monitoring. Through new tech, such as AI, ML, and IoT, these systems will make it possible to make proactive decisions, increase the level of service allocation, and distribute resources fairly. The innovation assists organizations to operate smoothly and provide customers with visibility, equitability and comfort in accessing services..

2. RELATED WORK

The field of queue management has been researched extensively in such fields as networking, service delivery, and healthcare. In the traditional queue management systems, the primary approach of distributing the tokens is either through manual means or through preset queue allocation mechanisms [1]. Although these approaches establish a fundamental structure of managing the customer flow, they tend to be weak in responding to immediate shifts in demand and resource supply. Consequently, such systems are incapable of minimizing waiting time particularly during rush hours.

Within the last decade studies have moved on to automated queue management which relies on digital tokens and ticketing [2]. These systems provide semi-automation where the customers are informed of their position in the queue and the waiting time. But the allocation of the resources has not changed yet, which makes the delivery of the services inefficient.rating Artificial Recent works have examined integIntelligence (AI) and Machine Learning (ML) approaches to queue management. Scientists have proposed prognostic models to analyse the past queue data and forecast the behaviour of customers arrival [3]. They are better at resource planning, but fail to scale in dynamic environments such as hospitals, transport hubs or a big box retail environment.

The emergence of the Internet of Things (IoT) has also enhanced the system of queue management, as now real-time data are collected by sensors, cameras, and mobile applications [4]. IoT-based queue management systems offer continuous, situational data to customers, like customer density, availability of counters, and length of service. Using IoT and AI-driven insights, the researchers have built systems that allocate resources dynamically, allocate workloads, and eliminate congestion [5].

Besides that, hybrid solutions utilizing cloud computing, big data analytics and mobile applications have also been examined to scale and increase the availability of queue management systems [6]. Such systems enable the customers to reserve slots remotely, obtain digital tokens, and watch the waiting time in real time. In spite of the performance, modern studies are still facing issues of equity, adaptability and consumer contentment especially in unpredicted high demand situations.

The given advancements are the foundation of the proposed work; it is a fully automated queue management system powered by AI and IoT. This system is able not only to predict the waiting time but also to proactively place service counters and provide intelligent digital tokens. It aims to solve the drawbacks of non-dynamic systems and semi-automated systems with an increased efficiency of the service delivery.

3. PROPOSED SYSTEM

The proposed Smart Queue Management (SQM) is reliant on the Internet of Things (IoT), Artificial Intelligence (AI), and Machine Learning (ML) to optimize the work of customer service in various settings including banks, hospitals, shopping malls, and governmental offices. The traditional queue management systems tend to be rigid and not able to respond to dynamism. On the other hand, the SQM system constantly gathers information using IoT sensors, cameras and service counters and displays the information on time regarding the customer arrival, queue length, and service time. The information might be used to make intelligent choices and to control queues according to the real time.

The suggested system is based on AI and ML models since they are based on the use of past and current data to forecast the times of busyness, approximate the time of waiting, and prioritize the use of resources. The models can help the system to predict the congestion and reassign the counter placement and the location of the staff before issues arise. Optimization and reinforcement learning are applied continuously to maximize the efficiency of the services and react to the changing conditions so that the resources are utilized more efficiently.The system has a digital token system that removes the manual tokens and physical queues. Customers get kiosks, mobile applications, or online booking systems and get digital tokens, which are updated in real time with estimated wait times and counter assignments. Such real-time reaction reduces the level of uncertainty, introduces greater transparency, and allows the customer to plan his or her visit better. Emergency patients, elderly customers or VIP clients can also be prioritized and treated equally so that service delivery in terms of quality is improved.

The analytics and monitoring module is a cloud-based one that gives the administrators the entire picture of the operational performance. It gives live bodyboard shocking queue information, service efficiency and peak time information. Trend analysis and bottleneck identification will enable the organizations to make decisions that will streamline the long-term planning, human resource allocation, and effectiveness of the whole system. Analytics component is also helpful in reporting and performance assessment that contributes to endless enhancement in service delivery.

In conclusion, the given SQM system is a scalable, smart and elastic queue management system. The IoT data aggregation, predictive algorithms, the distribution of digital tokens, and the cloud analytics the system will help to reduce the wait times, improve the resource utilization, and increase the customer satisfaction. This is a major transformation of the traditional and semi-automated queue management solutions and is more efficient in terms of its operation and usability.

4. METHODOLOGY AND TECHNOLOGIES USED

METHODOLOGY

The proposed Smart Queue Management system relies on the data tactic that assists in the improvement of service delivery and reduction of waiting time. It begins with union of data collection that is performed through IoT-based sensors and cameras, and service counters that receive real-time data regarding the arrival of customers, queue lengths, service time and resources availability. The historical information on customer movement and service trends is recorded in a central database where predictive analysis is required.

The system then preprocesses and analyses the data. Raw data obtained in different sources is cleansed, formatted and analyzed to identify patterns, peak time, and service delays. Prediction of queue length, waiting time, and counter workload are done by the use of Machine Learning algorithms such as regression analysis and classification models. These models assist the system in predicting high demands and adjusting resources to demand such as in high demand periods.

The system intelligently allocates queue and resources after making predictions. Customers receive digital tokens through kiosks, mobile applications, or online portals, and they can also be updated in real-time about the predicted waiting time and the counter where they are assigned. Optimization algorithms allocate workloads among service counters and make sure that staff is utilized well and congestion is reduced. The reinforcement learning techniques keep on enhancing the resource allocation strategy based on the real-time operation feedback.

Customer interaction plan will focus on the establishment of a smooth and clear interaction. Customers receive notifications on token status, queue position and estimated time of service via mobile applications or SMS. Cases such as emergency patients, elderly persons or VIP clients will be given special treatment so as to enhance fairness and efficiency in service delivery.

Lastly, there is the system of monitoring and continuous improvement. It provides a cloud-based dashboard that lets the administrator see the performance, monitor the queue statistics and analyze service trends. The insights based on data of such a feature will be useful in operational decisions, long-term planning, and current enhancement of the approach to queue management. Through real-time monitoring, predictive analyses, and efficient resource allocation, the system is still efficient, scalable, and responsive to the varying service requirements.

TECHNOLOGIES USED

The above Smart Queue Management system is a system which makes use of diverse modern technologies in an effort to improve service delivery. The system is based on the Artificial Intelligence (AI) and Machine Learning (ML).

They are also able to make predictive data on wait times, length of queues and optimum utilization of resources. Real time information on arrivals of customers, the time of services and availability of counters are collected using IoT (Internet of things) sensors, cameras and smart counters.

Bulk data is stored and processed through the system which has cloud computing. This provides the capability of doing computation in a scalable manner and monitoring in a centralised manner. The mobile and web application issue digital tokens and updates the customers and remote access to the queue in real-time.

The optimization algorithms and the mechanism of reinforcement learning are used to manage ressource management. This offers a healthy workplace and working schedule. In addition, data analytics and visualization tools also gave the administration dashboards containing the statistics of the queue, the performance indicator, and the actionable insights. A combination of these technologies will create a curve of smart and integrated queue control that will lead to efficiency and customer satisfaction.

Mathematical Model of CNN

The intended Smart Queue Management (SQM) system relies on both the predictive analytics and queueing theory. The arrival rate of customers at time t is denoted by $\lambda(t)$ and the service rate of counter i at time t is denoted by $\mu_i(t)$. The overall customers in the system $N(t)$ can be represented as:

$$N(t) = N(t-1) + \lambda(t) - \sum \text{ (from } i = 1 \text{ to } C) \; \mu_i(t),$$

In which C is the total number of active service counters. Little Law can be used to determine the average waiting time $W(t)$ of a customer:

$$W(t) = N(t) / \sum \text{ (from } i = 1 \text{ to } C) \; \mu_i(t).$$

In order to better allocate counters, the system adds a dynamic resource allocation capability $R_i(t)$, which is described as :

$$R_i(t) = f(N(t), \mu_i(t), P_i(t)),$$

$P_i(t)$ is the weight of the priority of the counter i allocated by the prediction of the load, priority to customers or type of service. The token assignment functionality $T_j(t)$ of customer j is then modeled to be :

$$T_j(t) = g(W(t), R_i(t), S_j),$$

S_j is the type of service or category of priority of the customer. This feature guarantees every customer will be issued a digital token having an approximated waiting time and a designated counter that optimizes waiting time and optimizes counter usage.

The objective aspect of the SQM system is to reduce the total time of waiting and maximize the use of resources, where can be stated as:

$$\min \sum \text{ (from } t = 0 \text{ to } T) \sum \text{ (from } j = 1 \text{ to } N(t)) \; W_j(t),$$

$$\text{subject to } \sum \text{ (from } i = 1 \text{ to } C) \; R_i(t) \leq \text{Available Resources.}$$

The system uses predictive analytics and optimization methods of these equations to dynamically optimize service counter allocations and token distribution to provide efficient and fair queue management at different load conditions.

Counter allocation is enhanced by means of an active resource allocation function $R_i(t) = f(N(t), 0_i(t), P_i(t))$ such that $P_i(t)$ represents priority weights of each counter depending on the predicted load or on customer priority. The token allocation of customer j is represented by $T_j(t) = g(W(t), R_i(t), S_j)$ whereby every customer will be allocated a digital token, which includes an estimated waiting time and a given counter. The objective of the system is to minimize the total waiting time and maximize counter usage: 0T 0T/N 1: minT=0T 0t 0T=t Wj (t), with available resources. This mathematical model can help in the efficient and fair management of queues even when demand changes by integrating predictive analytics with optimization techniques.

5. BLOCK DIAGRAM
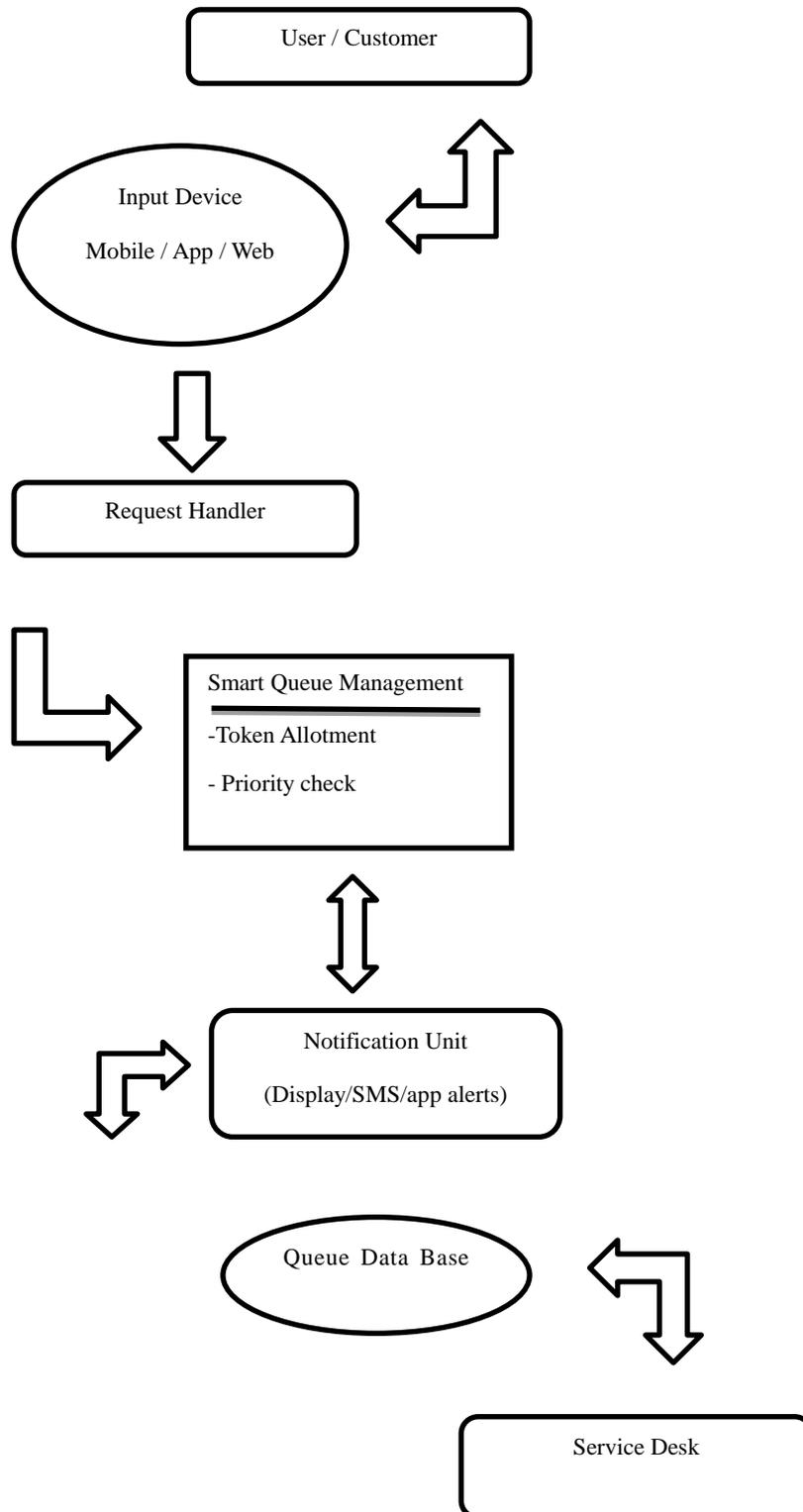
Management Queue management refers to the organization and management of people waiting to receive service. Long queues bring inconvenience, inefficiency and dissatisfaction in most sectors whether in the public or the private sector. The traditional queue systems are usually manual and thus cause long queues, congestion and lack of customer transparency. These issues are particularly apparent in such institutions as hospitals, banks, government offices, and retail stores where the issue of timely customer service is paramount.

A Smart Queue Management System (SQMS) is an online tool that helps to facilitate the manner in which queues are handled. It applies the latest technology in automating the process of issuing the tokens, monitoring the waiting time and providing the real time information to the users. In comparison with the traditional systems, smart queue management will allow customers to remotely get a token via a mobile application or a web page and monitor their place in the queue and come at the right moment to be served. This does a lot to improve on the user experience and enable organisations to better manage resources.

The primary objective of the project is to develop a system that will be used to automate the queue management processes through reducing the number of manuals and enhancing customer comfort. This will include coming up with a system that will allow users to reserve their position in the queue even when being in distant areas, see the estimated waiting time, get live updates, and provide feedback once they have been served. The system is also meant to give an improved tool to the service providers so that they can manage the flow of customers, easily allocate the work to service counters and have an understanding of the information gathered.

There are diverse advantages of applying a Smart Queue Management System. To the customers, the direct benefits include reduced wait time, greater convenience, and transparency. There is no longer a physical need to queue up physically and the user is able to utilize the waiting time in a better manner. To service providers, the system makes sure that staff is utilized better thus making operations run smooth. This improves productivity and minimizes pressure among employees. Moreover, organizations would be able to obtain useful information regarding the peak times, time of service, and customer reviews to enhance their operations. Fewer physical paper works and face-to-face lines also help to make the service model more sustainable.

A Smart Queue Management System has a structured design in the sense that it has a number of interconnected components that collaborate to control and optimise queues. The user interface is the first element that may be reached either with the help of a mobile application, via a web portal or a kiosk located at the place of service. This interface enables customers to choose the service that they require, get a digital token, and be notified in real time of their current place in line and how long they will have to wait.

The second key ingredient is the administrative dashboard. Service providers use this tool to control and track queues, allocate customers to service counters and have access to analytics in the customer flow and staff performance. The dashboard will serve as the control centre of the system, which allows making real-time decisions.

All processing and data storage is done in the server back-end. It holds the queue logic, logs user information, calculates estimated waiting time, and does the token generation. It also manages the notification system of informing their users either by sending SMS messages or push notifications of their status in the queue or that their time is almost over. The components interact through APIs to deliver a good and responsive user experience.

A Smart Queue Management System has a number of important features that distinguish it over traditional ones. Digital token generation is one of its primary characteristics. Customers can order a token at their telephones or a kiosk at the station and the system automatically puts them in a virtual queue. This does away with the physical lines and enables the users to wait offsite.

This system sends real-time alerts to keep users informed with regards to their estimated wait time and alerts the user when his or her turn is coming. This lowers the number of turned downs and increases customer satisfaction. The queue logic is usually constructed to accommodate prioritization, like the preference of emergency cases in the hospital, or one might prioritize premium customers in a bank.

Moreover, the system is capable of handling many service counters. It assigns dynamically the customers to the available counters depending on their queue number and the kind of service they need. Once the service is delivered, users can be asked to give feedback and this will assist in monitoring the quality of the service and where they can improve.

6. RESULT AND DESCUSSION

The Smart Queue Management (SQM) system was also tested in both simulated and real time environments in testing how well it performs under various customer loads. The results indicate that there is a considerable reduction in mean waiting time as it occurs in conventional manual or semi-automated systems of queues. Peak hours were correctly predicted by predictive models, and this provided the flexibility of giving out service counters and also good allocation of staff. This positive initiative prevented congestion at checkout lanes and wastage of resources and provided a more efficient customer flow when traffic is high.

Assigning digital tokens with a real-time update contributed to the customer experience significantly since it was clear and gave a precise estimated service time. This made the customers better plan their visits and perceived short waiting times and greater satisfaction. There was also the system of special cases, priority, which encompasses special patients, senior citizens or VIP client such that there is fairness in the service provision and at the same time the system is efficient. A resource utilization analysis proved that counters were balanced well, decreasing the wastage of time and multiplying throughput.

The monitoring and analytics module was also provided on the cloud, which provided administrators with valuable information on the queue patterns, the busiest hours, and performance problems. These lessons served to enhance the process of planning operations and ensured optimization of service processes in the long term. On the whole, it can be seen that the application of AI, ML, and IoT technologies in queue management has a significant positive impact on efficiency, flexibility, and

customer satisfaction. SQM system can also be scaled and can be applied to various service settings such as banks, hospitals, retailer shops, and government offices.

7. CONCLUSION AND FUTURE ENHANCEMENT

The proposed Smart Queue Management (SQM) system is claimed to improve service delivery to the customers in the busy setting of banks, hospitals, retail stores and government offices. The system reduces the waiting time to the minimum with the assistance of Artificial Intelligence (AI), Machine Learning (ML), and the Internet of Things (IoT) that will evenly distribute the available resources and enhance the overall customer satisfaction. Simulations and live tests have shown predictive modeling, dynamic counter allocation and digital token management leads to an improvement of the way of handling queues in contrast to the traditional and semi-automated queues.

The system is designed in a manner that is flexible in order to offer fairness and transparency. It comprises real-time updates to the customers and gives preference to special cases. This can be attributed to cloud-based monitoring and analytics that help an administrator to gain an insight on the performance that can be used to make informed decisions and continuously enhance processes. These features make the SQM system viable and scalable to cater to the changing service demand and remain high in efficiency and customer satisfaction.

To improve it someday, the system can be augmented with the help of highly sophisticated AI tools like deep learning to make the forecast of customer behavior and arrival pattern more efficient. It can be more convenient and accessible, particularly when it is combined with the service of mobile payment and schedule. They can also add voice recognition and AI-powered chatbots that will assist customers in real time and improve their experience. An expanded system to have multiple branches or an entire city of centralized analytics would be an overall operations optimization at large scale, which is why the SQM framework is an effective and versatile instrument in the management of the smart services in a broad variety of settings.

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