

Healthcare Queue Management: IoT-Based Automated Patient Calling System for Primary Care Facilities

Manajemen Queue Layanan Kesehatan: Pemanggilan Pasien Otomatis Berbasis IoT–Fasilitas Perawatan Primer

Abi Ari Sandy¹, Septriandi², Zanu Saputra³, Yus Dwi Santi⁴

^{1,2,3,4} Electrical/Electronics Engineering and Industrial Agriculture Department, Faculty of Engineering, Departmentteknik Manufaktur Negeri Bangka Belitung; email: ¹abisandy914@gmail.com

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Corresponding Author: Abi Ari Sandy

ABSTRACT — Community Health Centres (Puskesmas) as primary health care facilities face problems in queue management that affect service satisfaction and efficiency. Manual queuing systems, which are still commonly used, cause patient backlogs, irregular queuing, and psychological stress, especially for vulnerable groups such as the elderly and children. This study aims to design and implement an Internet of Things (IoT)-based automatic queue calling system to improve service effectiveness at Puskesmas. The methods used include case studies, field observations, and comprehensive system testing. This system integrates an ESP32 microcontroller as the control centre with various supporting components, including a thermal printer for printing queue tickets, a DFPlayer Mini module with a speaker for audio notifications, a P10 LED panel for visual display, and a 20x4 LCD with RTC for real-time monitoring. The system is also connected to a web platform via Firebase for recording and monitoring queue data. Test results show that the system operates optimally in all aspects, with clear audio output up to a distance of 15 metres, a printer that can print tickets consistently, and a clear visual display on the P10 panel. This system has proven effective in reducing patient waiting times, improving service comfort, and assisting staff in managing queues efficiently. The implementation of IoT technology in the queue calling system has made a significant contribution to improving the quality of public health services in the digital era.

KEYWORDS — Automatic Queue System, Community Health Centre, ESP32, Health Service Management, Internet of Things

INTISARI — Pusat Kesehatan Masyarakat (Puskesmas) sebagai fasilitas layanan kesehatan tingkat pertama menghadapi permasalahan dalam manajemen antrian yang berdampak pada kepuasan dan efisiensi pelayanan. Sistem antrian manual yang masih umum digunakan menyebabkan penumpukan pasien, ketidakteraturan giliran, serta tekanan psikologis terutama bagi kelompok rentan seperti lansia dan anak-anak. Penelitian ini bertujuan merancang dan mengimplementasikan sistem pemanggilan antrian otomatis berbasis *Internet of Things* (IoT) untuk meningkatkan efektivitas pelayanan di Puskesmas. Metode yang digunakan meliputi studi kasus, observasi lapangan, serta pengujian sistem secara komprehensif. Sistem ini mengintegrasikan mikrokontroler ESP32 sebagai pusat kendali dengan berbagai komponen pendukung meliputi printer thermal untuk mencetak tiket antrian, modul DFPlayer Mini dengan speaker untuk notifikasi audio, panel LED P10 untuk tampilan visual, dan LCD 20x4 dengan RTC untuk monitoring real-time. Sistem juga terhubung dengan platform web melalui Firebase untuk pencatatan dan pemantauan data antrian. Hasil pengujian menunjukkan bahwa sistem success beroperasi secara optimal pada seluruh aspek, dengan output audio yang jernih hingga jarak 15 meter, printer yang dapat mencetak tiket dengan konsisten, dan tampilan visual yang jelas pada panel P10. Sistem ini terbukti efektif dalam mengurangi waktu tunggu pasien, meningkatkan kenyamanan layanan, serta membantu petugas dalam mengelola antrian secara efisien. Implementasi teknologi IoT dalam sistem pemanggilan antrian memberikan kontribusi signifikan terhadap peningkatan mutu pelayanan kesehatan publik di era digital.

KATA KUNCI — ESP32, Internet of Things, Manajemen Pelayanan Kesehatan, Puskesmas, Sistem Antrian Otomatis

I. INTRODUCTION

Community Health Centres (Puskesmas) as primary health care facilities play a strategic role in ensuring public access to basic health services. As technical implementation units of the District/City Health Office, Puskesmas are responsible for providing equitable and affordable promotional, preventive, curative, and rehabilitative services. However, in practice, the effectiveness of Puskesmas services still faces operational constraints, particularly in relation to queue management systems that are not yet optimal [1], [2].

The manual queue system that is still predominantly used causes various problems such as patient backlogs, irregular service turns, and delays in treatment. This situation has a negative impact on patient satisfaction and staff work efficiency. Long and uncontrolled queues also cause psychological stress, especially for vulnerable groups such as the elderly and children. Patients often lose their turn due to a lack of transparency in queue information or are forced to leave the facility due to uncertain waiting times

[3], [4], [5], [6]. This indicates the urgency of modernising the queue system, which will not only improve operational efficiency but also strengthen the transparency and accountability of services [7], [8], [9], [10], [11], [12], [13], [14].

Internet of Things (IoT) technology offers innovative solutions to optimise queue management in healthcare facilities. IoT enables the integration of various devices such as sensors, actuators, and embedded systems in a digital ecosystem connected through a network, thereby supporting real-time monitoring and process automation [15], [16], [17]. In the context of queue systems, IoT can integrate call buttons, voice modules, and digital displays into a single responsive and integrated system.

The ESP32 microcontroller with built-in Wi-Fi and Bluetooth features is the right platform for developing an automated queue system because it supports wireless communication with efficient power consumption. The integration of ESP32 with a thermal printer, DFPlayer Mini module, and P10 LED display enables the system to print tickets, play audio notifications, and display queue numbers in real-time. This multimodal system is designed to reduce patient waiting times, improve staff efficiency, and present clearer and more structured service information.

This study aims to design and implement an IoT-based automatic patient queue calling system for community health centres with multimodal output characteristics (visual, audio, printed ticket), multi-department queue management, and real-time monitoring via a web dashboard. It is hoped that this system can make a practical contribution to improving the effectiveness, efficiency, and quality of public health services in the digital era.

II. LITERATURE REVIEW

Prior research developed an IoT-based emergency call system designed for ICU patients in hospitals, as a modern solution to replace conventional call systems that still use long cables and have limited features. The background is the need for a more practical, faster system that is integrated with the hospital database so that emergency responses can be carried out more efficiently. The objective of this research is to create a device capable of automatically detecting a patient's need for assistance and sending data wirelessly to a server connected to the patient database. The main hardware components include NodeMCU ESP8266 as the client device and Raspberry Pi 3 as the server, while the software uses Arduino and Python for control and data display. The way it works is that patients press a button according to their needs; the data is sent via Wi-Fi to the server, which displays complete patient information and history in real-time, allowing medical staff to respond quickly and appropriately. The results show that this system works well, improving the efficiency of emergency calls and supporting 24-hour medical services in hospitals [18].

Previous study proposed an IoT-based nurse call system that uses a local WiFi network to improve the responsiveness and efficiency of emergency services in hospitals. The background to this is that traditional call systems are rigid and expensive because they are cable-based, and are unable to support nurse mobility. The main objective of this study is to create a solution that is inexpensive, flexible, and easy to install, with features for monitoring response times and healthcare worker efficiency. The hardware components include an ESP8266 WiFi module, a nurse wristband complete with OLED, a call button, RFID for authentication, and a Django-based local server that stores call data. The software consists of a web-based system and an application that manages calls and notifications in real-time via HTTP/HTTPS protocols. The system works by having patients press a call button that sends data to the server via a WiFi network. The server then forwards the notification to the relevant nurse's wristband while storing the call data for analysis. The results of the study show that this system is capable of providing a fast, measurable response that can be scaled according to hospital needs, as well as improving service efficiency and monitoring the performance of healthcare personnel [19].

Another study aimed to develop a wireless emergency call system in hospitals that can improve communication efficiency between patients and medical personnel, especially in emergency situations. The background is based on the need for a fast, simple, and efficient communication system to speed up the response of medical personnel and improve the quality of health services. The hardware components used include a Bluetooth module, ATmega8 microcontroller, LCD screen, LED, and buzzer, while the software includes microcontroller programming and a user interface. The way it works is that the patient simply presses the call button, which triggers the microcontroller to send a signal via Bluetooth to the receiving device on the medical staff's side, which then displays the information and provides a quick response. The results of the research show that this device is able to simplify installation, look neat, and speed up the communication and emergency response process in hospitals [20].

III. METHOD

This study utilised a Research and Development (R&D) approach with a case study method at a Community Health Centre (Puskesmas) to design, implement, and test an Internet of Things (IoT)-based automatic queue calling system. The research stages included field observation, system design, device implementation, and performance testing. Data collection was conducted through direct observation at the Puskesmas location to identify service flows, existing queue systems, and operational constraints in patient queue management. The observation data was used as the basis for designing a system that suited the actual needs and conditions in the field, including the characteristics of the waiting room, the number of departments, and service flow patterns.

The system architecture was designed by integrating three main components: input, process, and output. The input component consists of a push button for each department and a web dashboard as a control interface for officers. The process component uses an ESP32 microcontroller connected to a Wi-Fi network to synchronise data with a cloud database via the HTTP protocol. The output component includes a thermal printer for ticket printing, a speaker with a DFPlayer Mini module for audio notifications, and a P10 LED panel for visual display of queue numbers. Each department (paediatric, dental, and ophthalmology) has a unique identification code that allows the system to separate queues independently to avoid overlap between departments.

The software was developed using Arduino IDE with C/C++ programming language, while the web dashboard was designed using HTML, CSS, and JavaScript. The system connects to a Firebase database for real-time queue data storage and synchronisation, and supports historical recording of daily queue data for evaluation and reporting purposes. System testing was conducted in stages using blackbox testing methods to validate system functionality. Testing parameters included the successful printing of queue tickets,

the quality and range of audio output at distances of 5, 10, and 15 metres, the accuracy of the visual display on the P10 LED Panel, the responsiveness of the system to push button inputs, the stability of the internet connection and database synchronisation, and the consistency of data display on the web dashboard. Each component was tested repeatedly to ensure the reliability and consistency of system performance under operational conditions.

IV. RESULT AND DISCUSSION

The IoT-based automatic queue calling system developed in this study aims to improve service efficiency and patient comfort at community health centres. This system implements Internet of Things technology to facilitate real-time queue monitoring via an internet connection. The main components of the system include an ESP32 microcontroller as the central processing unit, a thermal printer for printing queue tickets, a DFPlayer Mini module for audio output, a P10 LED Panel display for visualising queue numbers, and a 20×4 LCD with an RTC module for time monitoring. The hardware schematics shown in Figure 1 illustrates the integration between input components (push button, thermal printer, LCD I2C, TCA, RTC) connected to the ESP32, and output components (Panel P10, speaker with DFPlayer Mini) that receive signals from the microcontroller to display queue information in a multimodal manner.

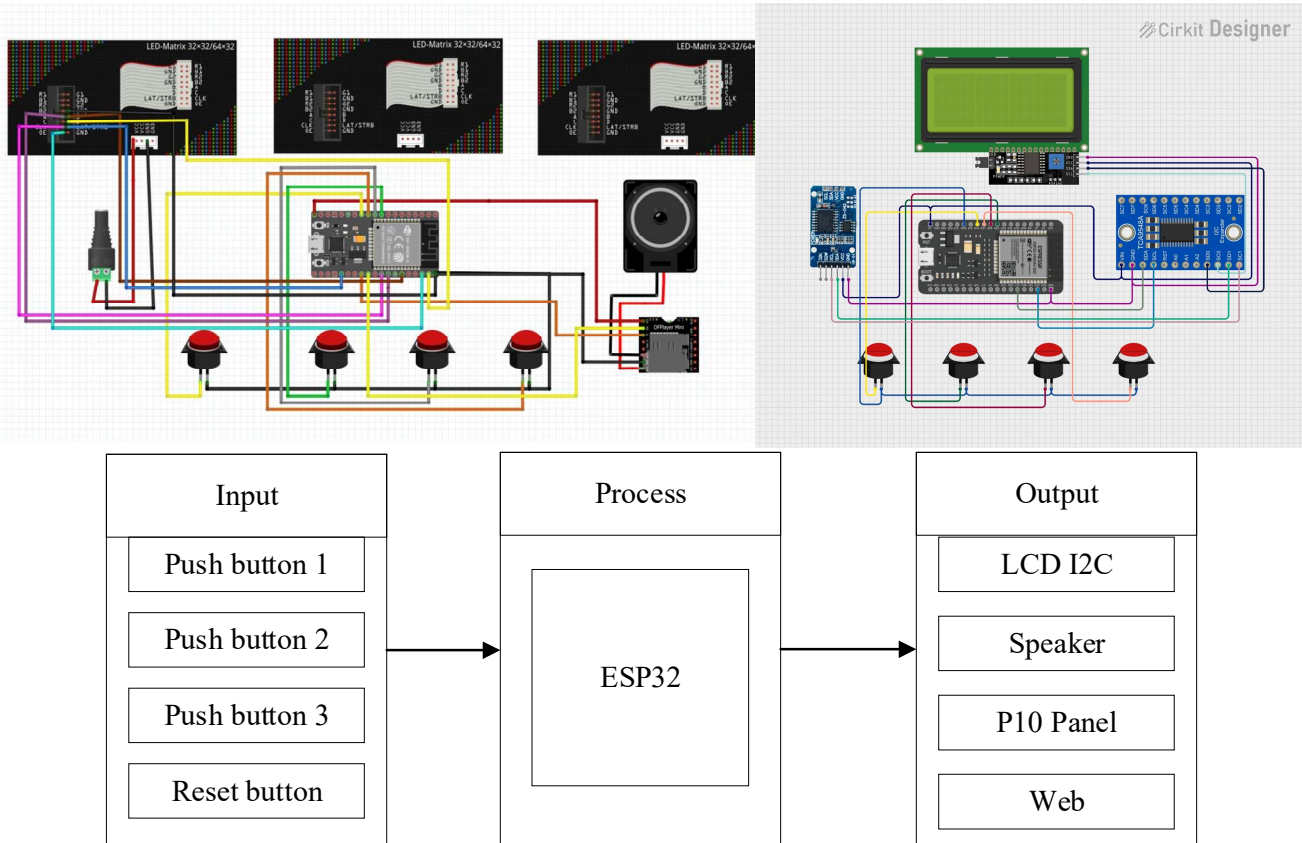


Figure 1. Hardware Schematics and Block Diagram

The system begins operating when a patient presses a button at one of the clinics (ophthalmology, dental, or paediatric) which then triggers the thermal printer to print a queue ticket. The queue number is simultaneously visualised on the P10 Panel and LCD, while the DFPlayer Mini module plays an audio notification through the speaker. The ESP32 microcontroller functions as the main controller that receives input from the push button, processes data, and distributes information to all output components in a coordinated manner. Queue data is also synchronised with the Firebase database via a Wi-Fi connection for historical recording and monitoring via a web dashboard.



Figure 2. Design of Casing in 3D View

The hardware implementation consists of mechanical and electrical design. The mechanical aspect includes the design of a casing with dimensions of 18.5 cm × 14 cm × 6.5 cm, which is produced using 3D printing technology with ABS plastic material. The casing is designed with an adequate ventilation system to prevent heat accumulation and is equipped with access slots for USB ports, control buttons, and openings for LCD installation, as shown in Figure 2. The locking system uses magnets at each corner to facilitate opening during maintenance. The results of the mechanical hardware assembly can be seen in Figure 3, which show the top, bottom, and side views of the casing. The electrical aspect involves the arrangement of circuit schematics using Circuit Designer software, for the input and output circuits. All electronic components are connected to the ESP32 microcontroller using jumper cables with a predetermined pin configuration, as shown in Figure 4, ensuring stable and reliable data communication.

TABLE I
 SYSTEM TEST RESULT

No	Department	Queue	Status
1	paediatrics	1	saved
2	paediatrics	2	saved
3	paediatrics	3	saved
4	dentistry	1	saved
5	dentistry	2	saved
6	dentistry	3	saved
7	ophthalmology	1	saved
8	ophthalmology	2	saved
9	ophthalmology	3	saved

Functionality testing of the web interface was conducted to validate the system's ability to store queue data to the Firebase database. Figure 5 shows the web interface design with simple yet functional features. The test results listed in Table I show that the system successfully stored queue data for nine trials covering three different department (paediatric, dental, and ophthalmology) with three queue numbers each. All trials showed a 'saved' status without any failures, indicating the stability of the internet connection between the ESP32 microcontroller and the Firebase server and consistency in the data synchronisation process. The web interface was developed using VS Code as a text editor, with Firebase serving as the backend for storing daily historical data that can be accessed by officers for evaluation and reporting purposes.



Figure 3. Finished Product

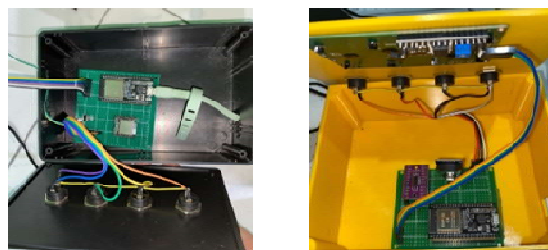


Figure 4. Electronics inside the Product

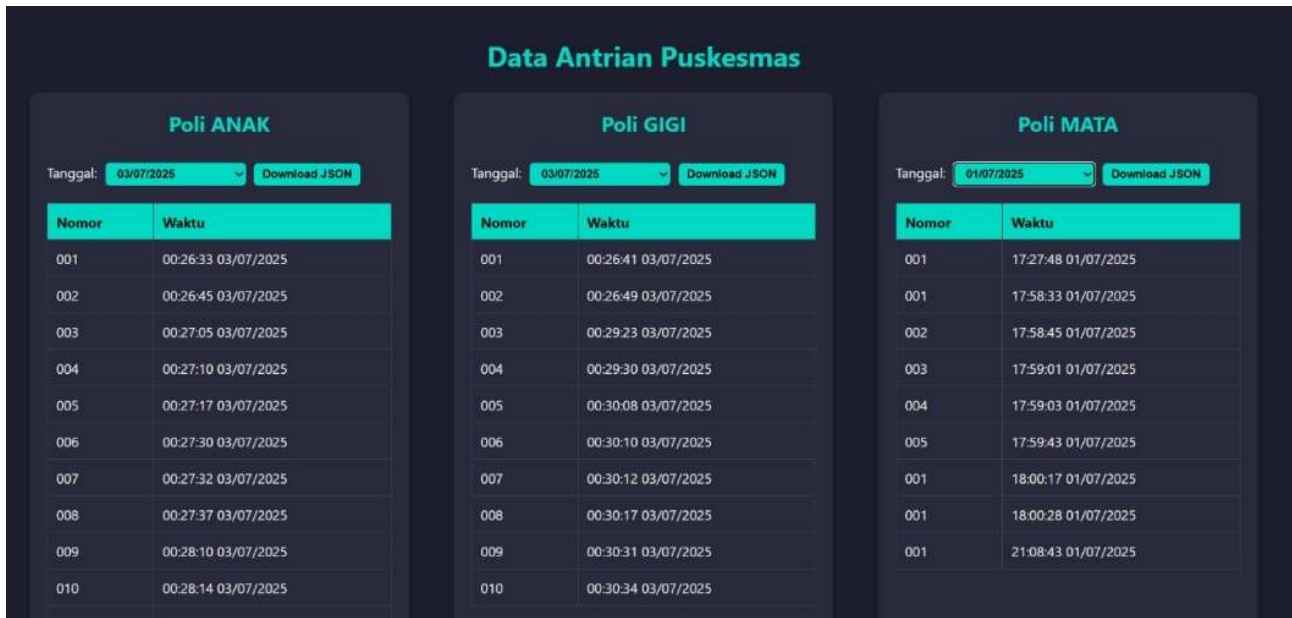


Figure 5. User Interface of the Website

Thermal printer testing aims to evaluate the consistency and reliability of queue ticket printing. The printer is connected to a microcontroller with a push button as a trigger to print tickets according to the selected department. Figure 6 shows an example of a queue ticket successfully printed by a thermal printer. Table II presents the results of thermal printer testing in 15 trials covering various combinations of departments and queue numbers. From this data, it can be seen that the thermal printer successfully printed all tickets with a 'successful' status in each trial, from ophthalmology clinic number 1 to dental clinic number 5. There were no operational problems such as paper times, stuck paper, or printing errors during the testing. This 100% success rate indicates that the thermal printer has high reliability and is capable of operating consistently under intensive use, which is an important characteristic for applications in health centres with high patient visit volumes.

TABLE II
THERMAL PRINTER OUTPUT

No	Department	Queue	Print output
1	ophthalmology	1	success
2	ophthalmology	2	success
3	dentistry	1	success
4	dentistry	2	success
5	paediatrics	1	success
6	paediatrics	2	success
7	ophthalmology	3	success
8	ophthalmology	4	success
9	dentistry	3	success
10	dentistry	4	success
11	paediatrics	3	success
12	paediatrics	4	success
13	ophthalmology	5	success
14	ophthalmology	6	success
15	dentistry	5	success

Testing of the DFPlayer Mini module was conducted to evaluate the quality and range of audio output at various distances. It should be noted that the DFPlayer Mini reads audio files based on the order in which they are stored on the microSD card, not based on file names, so the files need to be arranged in sequence to ensure accurate playback. Testing was conducted at three distance parameters: 5 metres, 10 metres, and 15 metres to measure the effectiveness of the system in the spacious waiting room of the community health centre.



Figure 6. Thermal Printer Result

Table III shows the results of audio output testing at a distance of 5 metres for six experiments covering three different departments. All experiments showed a ‘successful’ status with audio output as expected, namely ‘ophthalmology clinic, queue 1’, ‘ophthalmology clinic, queue 2’, and so on for the dental clinic and paediatric clinic. At this distance, the system was able to produce clear and distinct sound without distortion. A delay of ±2 seconds from the time the push button was pressed to the audio being played was identified as the normal processing time from the microcontroller to the audio module, which was still within the tolerance limit for queueing system applications.

TABLE III
AUDIO OUTPUT TEST RESULT: 5 METRES

No	Department	Queue	Voice output	Status
1	ophthalmology	1	"ophthalmology department, queue 1"	success
2	ophthalmology	2	"ophthalmology department, queue 2"	success
3	dentistry	1	"dentistry department, queue 1"	success
4	dentistry	2	"dentistry department, queue 2"	success
5	paediatrics	1	"paediatrics department, queue 1"	success
6	paediatrics	2	"paediatrics department, queue 2"	success

Table IV presents the test results at a distance of 10 metres with different queue numbers (queues 3 and 4 for each clinic). The results show the same consistency as the 5-metre distance test, where all experiments successfully produced the appropriate audio output without any reduction in sound quality. There were no errors or file playback errors at this distance. Table V displays the test results at a maximum distance of 15 metres with queue numbers 5 and 6. The system performance remained consistent with a 100% success rate, proving that the DFPlayer Mini module and speakers used were able to work reliably up to a distance of 15 metres without signal disruption or interference. All audio files were played in sequence and were clearly audible in the test area, indicating that in the scenario of a large health centre waiting room, the system continues to deliver optimal performance and ensures that patients can clearly hear queue calls.

TABLE IV
AUDIO OUTPUT TEST RESULT: 10 METRES

No	Department	Queue	Voice output	Status
1	ophthalmology	3	"ophthalmology department, queue 3"	success
2	ophthalmology	4	"ophthalmology department, queue 4"	success
3	dentistry	3	"dentistry department, queue 3"	success
4	dentistry	4	"dentistry department, queue 4"	success
5	paediatrics	3	"paediatrics department, queue 3"	success
6	paediatrics	4	"children department, queue 4"	success

TABLE V
AUDIO OUTPUT TEST RESULT: 15 METRES

No	Department	Queue	Voice output	Status
1	ophthalmology	5	"ophthalmology department, queue 5"	success
2	ophthalmology	6	"ophthalmology department, queue 6"	success
3	dentistry	5	"dentistry department, queue 5"	success

4	dentistry	6	"dentistry department, queue 6"	success
5	children	5	"children department, queue 5"	success
6	children	6	"paediatrics department, queue 6"	success

LCD testing aims to evaluate the ability to monitor queue numbers in real time with an accurate time display. The 20×4 LCD uses I2C communication via the SDA and SCL pins connected to the ESP32 microcontroller. Integration with the RTC (Real-Time Clock) module allows the system to display the time in real time and synchronise with the data printed on the thermal printer ticket. Figure 7 shows the LCD display, which is capable of displaying numbers and letters clearly.



Figure 7. LCD Displaying the Queues

Table VI presents the results of LCD testing in nine trials covering the three departments with sequential queue numbers. The data shows that the LCD successfully counted the queue for each department with a ‘successful’ status in all tests. The time column shows the timestamp recorded for each queue transaction, starting from 21:09:56 for ophthalmology clinic number 1 to 21:12:05 for dental clinic number 3. The time interval between transactions ranged from 15-19 seconds, indicating good system responsiveness. The LCD receives data signals from the ESP32 every time the department push button is pressed and automatically updates the queue number display. The reset function also operates well, allowing staff to reset the queue counter at the start of the operational day by pressing the reset push button.

TABLE VI
 LCD TEST RESULT

No	Department	Queue	Counting	Time
1	ophthalmology	1	success	21.09.56
2	ophthalmology	2	success	21.10.15
3	ophthalmology	3	success	21.10.32
4	paediatrics	1	success	21.10.45
5	paediatrics	2	success	21.10.59
6	paediatrics	3	success	22.11.12
7	dentistry	1	success	21.11.31
8	dentistry	2	success	21.11.50
9	dentistry	3	success	21.12.05

Panel P10 testing is a comprehensive evaluation of the system's main visual output components. Panel P10 is connected to ESP32, which is also connected to the DFPlayer Mini module and a push button as a trigger. The test is conducted using three parameters: microcontroller connection stability to the panel, audio-visual synchronisation, and display brightness. Figure 8 displays the visualisation of the P10 Panel output for ophthalmology departments with queue numbers 1, 2, and 3.



Figure 8. Ophthalmology Department

TABLE VII
 OPHTHALMOLOGY DEPARTMENT QUEUE 1 TEST

Data	Testing scenario	Status	Detail
ophthalmology department no queue 1	Arduino-panel connection	success	stable connection
ophthalmology department no queue 1	voice-visual match	success	match
ophthalmology department no queue 1	panel brightness	success	clear visual

TABLE VIII
 OPHTHALMOLOGY DEPARTMENT QUEUE 2 TEST

Data	Testing scenario	Status	Detail
ophthalmology department queue 2	Arduino-panel connection	success	stable connection
ophthalmology department queue 2	voice-visual match	success	match
ophthalmology department queue 2	panel brightness	success	clear visual

TABLE IX
 OPHTHALMOLOGY DEPARTMENT QUEUE 3 TEST

Data	Testing scenario	Status	Detail
ophthalmology department queue 3	Arduino-panel connection	success	stable connection
ophthalmology department queue 3	voice-visual match	success	match
ophthalmology department queue 3	panel brightness	success	clear visual

Tables VII, VIII, IX present the test results for ophthalmology department on three different queue numbers. All test parameters showed a ‘successful’ status with stable connection, proper audio-visual synchronisation, and clear display. These results indicate that the P10 Panel is capable of displaying ophthalmology department information consistently and responsively to input from the microcontroller. Figure 9 display the output of the P10 Panel for the dental department, with the test results listed in Tables X, XI, XII. Similar to the ophthalmology department, all tests for the dentistry department demonstrated success in all three parameters with stable connections, synchronised audio-visual alignment, and optimal panel brightness.



Figure 9. Dental Department

TABLE X
 DENTISTRY DEPARTMENT QUEUE 1 TEST

Data	Testing scenario	Status	Detail
dentistry department queue 1	Arduino-panel connection	success	stable connection
dentistry department queue 1	voice-visual match	success	match
dentistry department queue 1	panel brightness	success	clear visual

TABLE XI
 DENTISTRY DEPARTMENT QUEUE 2 TEST

Data	Testing scenario	Status	Detail
dentistry department queue 2	Arduino-panel connection	success	stable connection

dentistry department queue 2	voice-visual match	success	match
dentistry department queue 2	panel brightness	success	clear visual

TABLE XII
DENTISTRY DEPARTMENT QUEUE 3 TEST

Data	Testing scenario	Status	Detail
dentistry department queue 3	Arduino-panel connection	success	stable connection
dentistry department queue 3	voice-visual match	success	match
dentistry department queue 3	panel brightness	success	clear visual

Figure 10 shows the visualisation of Panel P10 for paediatrics department, with test data in Tables XIII, XIV, XV. The consistency of the results is maintained with a ‘successful’ status on all test parameters. From a total of nine test combinations (three department × three queue numbers), the system showed a 100% success rate with no failures in connectivity, synchronisation, or display quality. The P10 panel with a pixel pitch of 10mm demonstrated excellent connectivity performance through its modular design, which facilitates installation and maintenance. The panel’s optimal brightness ensures the visibility of queue information even in varying room lighting conditions, while the panel control system allows real-time connection monitoring so that communication issues can be detected and resolved immediately.



Figure 10. Paediatrics Department

TABLE XIII
PAEDIATRICS DEPARTMENT QUEUE 1 TEST

Data	Testing scenario	Status	Detail
paediatrics department queue 1	Arduino-panel connection	success	stable connection
paediatrics department queue 1	voice-visual match	success	match
paediatrics department queue 1	panel brightness	success	clear visual

TABLE XIII
PAEDIATRICS DEPARTMENT QUEUE 2 TEST

Data	Testing scenario	Status	Detail
paediatrics department queue 2	Arduino-panel connection	success	stable connection
paediatrics department queue 2	voice-visual match	success	match
paediatrics department queue 2	panel brightness	success	clear visual

TABLE XIII
PAEDIATRICS DEPARTMENT QUEUE 3 TEST

Data	Testing scenario	Status	Detail
paediatrics department queue 3	Arduino-panel connection	success	stable connection
paediatrics department queue 3	voice-visual match	success	match
paediatrics department queue 3	panel brightness	success	clear visual

Based on comprehensive testing of all system components, it can be concluded that the IoT-based automatic queue calling system has been successfully implemented with a high level of reliability. The 100% success rate in web interface testing demonstrates the stability of the internet connection and the consistency of data synchronisation with Firebase. The thermal printer achieved a reliability rate of 100% in 15 trials, proving the system’s ability to provide consistent physical proof of queues. The DFPlayer Mini audio module showed reliable performance across all distance parameters, with an effective range of up to 15 metres

without sound quality degradation. The 20×4 LCD successfully displayed queue information and timestamps accurately, while the P10 Panel showed optimal consistency across all multi-department test combinations.

The integration of multimodal output (visual via the P10 Panel and LCD, audio via speakers, and printed tickets) proved effective in presenting queue information that was accessible to various user segments. The system was able to operate consistently without errors, supporting independent multi-department queue management and providing historical data recording for service evaluation. The implementation of IoT technology with the ESP32 microcontroller as the control centre proved its effectiveness in automating the queue calling process, reducing the workload of officers, and increasing information transparency for patients in primary health care facilities.

V. CONCLUSION

This research has successfully designed and implemented an Internet of Things (IoT)-based automatic queue calling system for community health centres that integrates an ESP32 microcontroller with a thermal printer, DFPlayer Mini module, P10 LED panel display, and 20×4 LCD with RTC. The system is designed with a casing measuring 18.5 cm × 14 cm × 6.5 cm using ABS material 3D printing technology, with a multimodal output working principle that includes ticket printing, queue number visualisation, and audio notifications. Test results show a 100% success rate across all components, including data storage to Firebase, thermal ticket printing in 15 trials, consistent audio output up to a distance of 15 metres with a delay of ±2 seconds, LCD display with accurate timestamps, and P10 Panel with stable connection and precise audio-visual synchronisation in nine multi-department test combinations. This system has proven capable of reliably automating the queue calling process, reducing the workload of officers, and improving the transparency and efficiency of healthcare services in primary care facilities with an approach that is accessible to various user segments. Future research may include providing online booking system and more access through the creation of Android and iOS applications in order to facilitate inclusive access for mobile users.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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