



**PROTOTYPING OF INTELLIGENT MEDICATION PLATFORM**

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**MASTER OF SCIENCE  
IN  
DIGITAL TRANSFORMATION TECHNOLOGY**

**SCHOOL OF APPLIED DIGITAL TECHNOLOGY  
MAE FAH LUANG UNIVERSITY**

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**THIS INDEPENDENT STUDY IS A PARTIAL FULFILLMENT OF  
THE REQUIREMENTS FOR THE DEGREE OF  
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## ABSTRACT

Currently, medication non-adherence remains a significant problem, particularly among elderly patients and individuals with chronic diseases. Forgetfulness and limited access to healthcare services often lead to missed doses, resulting in reduced treatment effectiveness and increased health risks. To address these challenges, this research presents the design, development, and technical evaluation of the Intelligent Medication Platform.

The Intelligent Medication Platform is an IoT-based medication management system constructed with an acrylic structure and powered by a Raspberry Pi 4 as the central controller. The system integrates medication reminders, an electric door-lock dispensing mechanism, real-time video conferencing, and activity logging through a web-based interface. Key hardware components include a relay-controlled magnetic lock, speaker, monitor, camera module, and database system.

The system evaluation was designed to emphasize technical performance validation rather than user satisfaction assessment. To ensure comprehensive performance verification, three principal experimental procedures were conducted. First, command execution accuracy was evaluated through 100 consecutive operational cycles for each core system function. Second, power consumption analysis was performed under various operating conditions to determine energy efficiency and operational requirements. Third, 72-hours continuous operation (stress) test was carried out to assess system stability, reliability, and long-term operational endurance.

The results demonstrate high functional reliability, with 98% accuracy in door unlocking, 100% reliability in alarm notification, 96% success rate in video call connectivity, and over 97% accuracy in database logging. The system maintained stable operation with acceptable energy consumption and 100% uptime during the continuous testing period. These findings confirm that the Intelligent Medication Platform is technically reliable, energy-efficient, and suitable for home healthcare deployment to support medication adherence and telemedicine services.

**Keywords:** Medication Adherence, Internet of Things (IoT), Telemedicine, Raspberry Pi 4, Smart Medication System



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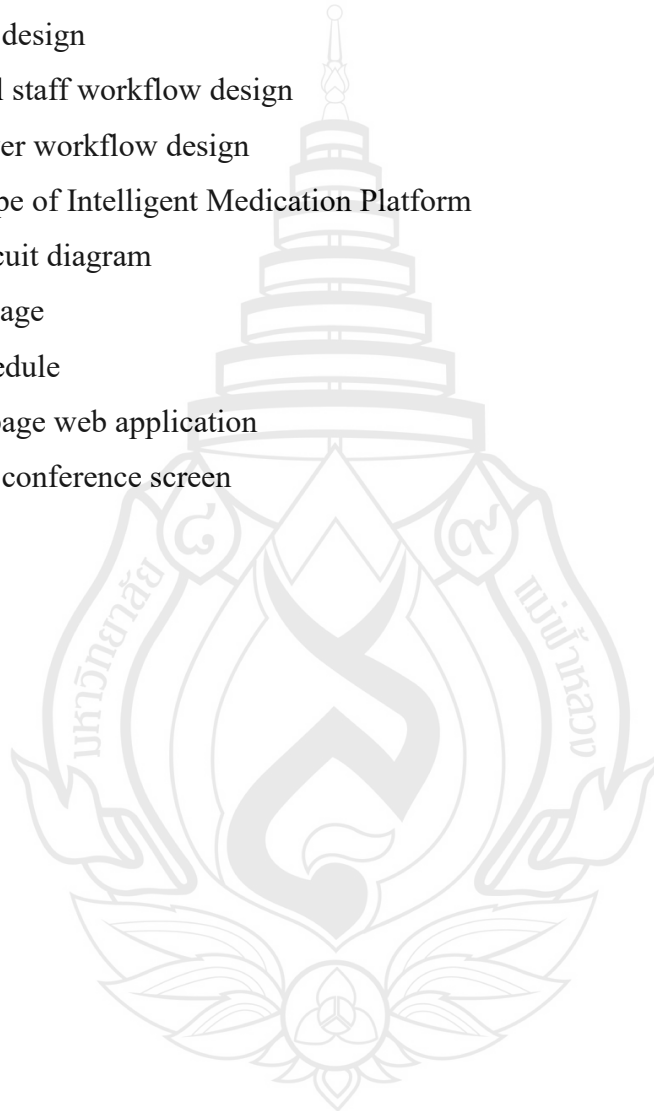
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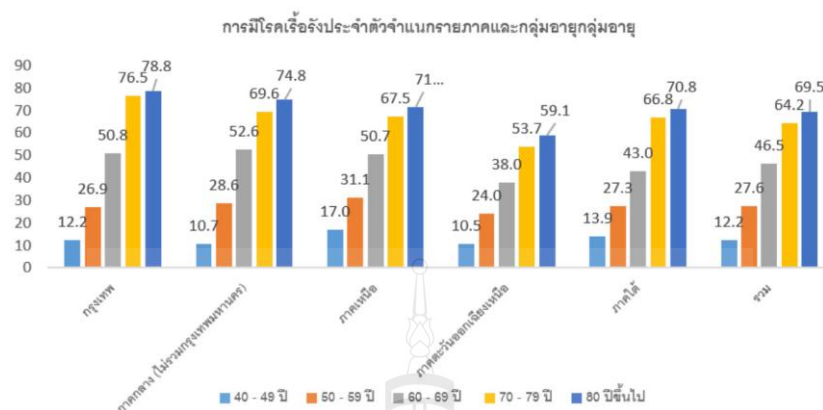


## CHAPTER 1

### INTRODUCTION

#### 1.1 Background and Importance of the Research Problem

The issues that led to this research include elderly patients forgetting to take their medication, confusion about medication schedules, medication safety, and the ability of doctors to monitor patients' conditions. These challenges prompted the development of this research to address and resolve these problems. Currently, there are many patients who are unable to take care of themselves, especially elderly individuals with chronic diseases. Among these elderly patients, the average age is  $69.66 \pm 6.78$  years, with approximately 63.8% being female. The adherence to medication instructions is categorized as high adherence (39.2%), medium adherence (23.8%), and low adherence (36.9%). Among those with moderate to low adherence, forgetfulness was the most common reason, accounting for 55.4% of the cases (1). This forgetfulness can be attributed to various factors, such as caregivers being unable to always monitor patients, leading to missed doses. Adherence to prescribed medication schedules is crucial for maximizing the effectiveness of treatment. Failure to follow these instructions can result in severe health complications, increased medical costs, and even death. According to the National Community Pharmacists Association (NCPA), only 24% of patients strictly follow their prescriptions, with non-adherence leading to approximately 125,000 deaths annually in the United States (2). Figure 1.1 shows the percentage of chronic disease patients in Thailand.



Source (3)

**Figure 1.1** Percentage of chronic disease patients in Thailand

The percentage of individuals who do not take medication or take it inconsistently varies depending on the type of disease, the characteristics of the medication, and the demographic group. However, several studies provide the following preliminary information:

1. Medication Non-Adherence: Failing to take medication as prescribed by doctors is a significant and common issue. Studies have shown that among patients with chronic diseases, such as diabetes, hypertension, and heart disease, the rate of non-adherence is approximately 30-50%, depending on the complexity and nature of the treatment regimen.

2. Medication Non-Persistence: Taking medication inconsistently or discontinuing medication before the prescribed duration is another common problem. Research indicates that around 20-30% of patients stop taking their medication before the period specified by their doctors (4).

To address these challenges, the Intelligent Medication Platform has been developed to assist both healthcare providers and caregivers in managing treatment more efficiently. The system supports telemedicine consultations through video conferencing, enabling doctors to monitor patient conditions from home. It also features reminders to ensure that patients take their medication on time.

The Intelligent Medication Platform is constructed from acrylic materials and powered by a Raspberry Pi 4. It controls video conferencing, voice reminders, and electric door locks for medication compartments.

This research presents the process and testing of the Intelligent Medication Platform, demonstrating its effectiveness in real-world scenarios. The key features tested include medication reminders, unlocking the electric lock for medication access, and video conferencing capabilities. The goal of this research is to improve adherence to medication instructions, ensuring better health outcomes for patients.

## **1.2 Research Objectives**

Developed the functions of the Intelligent Medication Platform, such as medication reminders, medication door opening data collection, and video calls, to improve their efficiency.

## **1.3 Scopes of Research**

This research focuses on the design, implementation, and technical performance evaluation of the Intelligent Medication Platform. The scope of the study includes the following aspects:

### **1.3.1 System Development Scope**

1.3.1.1 Design and construction of a hardware prototype using Raspberry Pi 4 as the main controller.

1.3.1.2 Integration of the following modules:

1. Medication reminder system (audio and visual notification)
2. Relay-controlled magnetic door lock mechanism
3. Web-based medication schedule management system
4. Real-time video conferencing using WebRTC (PeerJS)
5. Database logging system for medication access records

### **1.3.2 Technical Performance Evaluation Scope**

The evaluation focuses on technical validation rather than user satisfaction assessment. The system performance was measured through:

#### **1.3.2.1 Command Execution Accuracy Test**

1. 100 test cycles per function

2. Functions tested: door unlock, alarm notification, video call initiation, database logging

3. Measurement of success and failure rates

#### 1.3.2.2 Power Consumption Analysis

1. Measurement of voltage and current under different operating modes

2. Evaluation of energy efficiency for home healthcare usage

#### 1.3.2.3 Continuous Operation

1. 72-hours uninterrupted operation

2. Monitoring CPU temperature, system stability, and uptime

3. Verification of alert triggering accuracy and log consistency

#### 1.3.3 Target Environment

The system is designed for home healthcare environments, particularly for:

1. Elderly patients with chronic diseases

2. Patients requiring regular medication schedules

3. Individuals with limited access to healthcare facilities

The research does not include clinical outcome measurement or large-scale field deployment but focuses on prototype-level technical validation under controlled testing conditions.

## 1.4 Expected Result

The results of the performance testing on the use of the Intelligent Medication Platform indicate a good average level.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Theoretical Background

This chapter outlines the theoretical foundations and technological components relevant to the development of the Intelligent Medication Platform. It draws upon established behavioral models to understand factors influencing medication adherence and discusses the enabling technologies that support the system's implementation.

##### 2.1.1 Health Behavior Theories

Understanding why patients do or do not adhere to medication regimens is central to improving healthcare outcomes. Several health behavior theories offer insights into the cognitive and social factors that influence health-related decision-making.

##### 2.1.1.1 Health Belief Model (HBM)

The Health Belief Model (HBM) is a psychological framework developed to explain and predict health behaviors by focusing on individual attitudes and beliefs. According to HBM, a person's likelihood of engaging in a health behavior such as taking medication is influenced by the following six constructs:

1. **Perceived Susceptibility:** The belief in the personal risk of contracting a condition.
2. **Perceived Severity:** The belief in the seriousness and potential consequences of the condition.
3. **Perceived Benefits:** The belief in the efficacy of the recommended action to reduce the risk or severity.
4. **Perceived Barriers:** The belief in the potential costs or obstacles (physical, emotional, or financial) of the recommended action.
5. **Cues to Action:** Internal or external triggers that prompt the individual to act (e.g., symptoms, reminders, or health advice).

6. Self-Efficacy: The confidence in one's ability to successfully perform the behavior (5).

In the context of medication adherence, HBM suggests that individuals are more likely to take their prescribed medications when they recognize their vulnerability to health complications, understand the severity of those complications, believe the medication will be effective, encounter minimal barriers, receive adequate reminders, and feel confident in their ability to manage the regimen.

#### 2.1.1.2 Theory of Planned Behavior (TPB)

The Theory of Planned Behavior (TPB) posits that behavior is primarily determined by behavioral intentions, which are influenced by:

1. Attitude Toward the Behavior: The individual's positive or negative evaluation of performing the behavior.

2. Subjective Norms: The perceived social pressure to perform or avoid the behavior, shaped by the expectations of important others.

3. Perceived Behavioral Control: The perceived ease or difficulty of performing the behavior, based on experience and anticipated challenges.

Applied to medication adherence, TPB implies that patients are more likely to follow their medication schedules if they hold favorable attitudes toward adherence, perceive support or expectations from significant others, and believe they are capable of successfully managing the regimen (6).

#### 2.1.1.3 Social Cognitive Theory (SCT)

Social Cognitive Theory (SCT) emphasizes the dynamic interaction between personal, behavioral, and environmental influences on behavior. A central concept in SCT is self-efficacy, defined as the belief in one's ability to organize and execute the necessary actions to achieve a specific goal.

According to SCT, individuals with high self-efficacy are more likely to adopt and maintain health-promoting behaviors, invest effort in overcoming barriers, and persist in the face of difficulties. In the context of the Intelligent Medication Platform, enhancing users' self-efficacy through intuitive design, positive reinforcement, and clear feedback can significantly improve medication adherence (7).

## 2.2 Relevant Technologies

Technological integration plays a crucial role in enabling and supporting the functionalities of the Intelligent Medication Platform. The following components have been selected for their relevance and adaptability to the healthcare context.

### 2.2.1 Raspberry Pi 4

The Raspberry Pi 4 Model B is a compact, credit-card-sized single-board computer developed by the Raspberry Pi Foundation, offering significant processing power and I/O capabilities at a low cost (8).

1. It features a quad-core 64-bit ARM Cortex-A72 CPU at 1.5 GHz, with options for 2GB, 4GB, or 8GB LPDDR4 RAM, making it suitable for multitasking and data-intensive tasks like local image processing (8).

2. The board includes dual-band Wi-Fi, Bluetooth 5.0, Gigabit Ethernet, two USB 3.0 ports, two USB 2.0 ports, and dual micro-HDMI outputs supporting up to 4K resolution (8).

3. Its 40-pin GPIO header supports integration with external hardware such as sensors and actuators, essential for controlling devices like pill dispensers (9).

4. Raspberry Pi 4 can operate as an edge computing device, running machine learning models (e.g., TensorFlow Lite) for on-device data analysis, thereby reducing reliance on cloud services and improving latency (10).

5. Security can be managed through Linux-based firewalls and SSH encryption, making the system suitable for use in healthcare applications requiring compliance with data protection standards such as HIPAA or GDPR (11).

In the Intelligent Medication Platform system, the Pi 4 manages user interactions, reminder scheduling, and hardware control, acting as the core processor and local server (8).

Raspberry Pi 4 is used as the central processing unit of the Intelligent Medication Platform.

Its computing power and connectivity options make it ideal for managing real-time operations, including video conferencing and device control (12).

### 2.2.2 Internet of Things (IoT)

The Internet of Things (IoT) refers to an interconnected ecosystem of devices capable of exchanging data over networks. In healthcare applications, IoT enhances automation, remote monitoring, and data-driven decision-making.

For the Intelligent Medication Platform, IoT integration enables:

1. Synchronization of medication schedules with cloud-based platforms.
2. Remote monitoring by caregivers and healthcare professionals.
3. Automated dispensing mechanisms controlled via network-based triggers (13).

### 2.2.3 Reminder and Monitoring Systems

Reminder and monitoring systems are critical in promoting consistent medication adherence. They typically incorporate a range of features, such as:

1. Auditory reminders: Alarms, chimes, or voice notifications.
2. Visual reminders: Blinking lights, display messages.
3. Electronic reminders: Mobile alerts via SMS, email, or apps.

Monitoring capabilities may include:

1. Time-stamped logging of medication access.
2. Detection of compartment activity.
3. Generation of adherence reports for healthcare review (14,15).

### 2.2.4 Integrated Care Platforms

Integrated care platforms are holistic systems designed to coordinate multiple aspects of patient care. They bridge communication between patients and providers, promote data sharing, and improve the efficiency of healthcare delivery (16).

Typical components include:

1. Electronic Health Records (EHRs)
2. Telehealth services
3. Medication management tools
4. Patient portals

## 2.3 Related Work and Comparative Studies

Table 2.1 compares this research with two related projects in terms of hardware, features, and interaction methods:

**Table 2.1** Comparison between existing research and this study

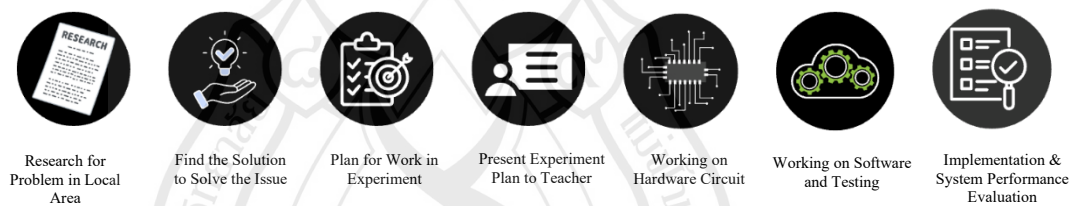
Feature	Intelligent Medication Platform	Smart Medicine Box (COVID, NodeMCU) (17)	STM32-Based Medicine Box (18)	Unique Features
Controller	Raspberry Pi 4	NodeMCU (IoT + Lua)	STM32	High-performance computing, GPIO control
Alerts	Audio, video, web	App notification + OTP	Audio + real-time dispensing	Multi-modal reminders
Interface	Web app + monitor	Mobile app	Serial screen	Integrated with telemedicine
Unlock Mechanism	Relay magnetic lock	+ OTP-based control	app Servo motor	Automatic hardware control

## CHAPTER 3

### METHODOLOGY

#### 3.1 Research Overview

This research utilizes a design science methodology to develop and evaluate a technological solution aimed at improving medication adherence among patients, especially the elderly and those with chronic illnesses. The Intelligent Medication Platform combines Internet of Things (IoT) technologies with telemedicine capabilities to deliver timely medication reminders, remote doctor consultations, and secure medicine dispensing.



**Figure 3.1** Process of Methodology

The development process of the Intelligent Medication Platform followed a systematic seven-step methodology, as shown in Figure 3.1. Each step was carefully designed to guide the project from problem identification to system implementation and evaluation

##### 1. Research for Problem in Local Area:

The first step involved exploring and identifying healthcare-related issues, especially those affecting elderly or vulnerable populations in the local context. This step ensured that the system addressed real and relevant needs.

## 2. Find the Solution to Solve the Issue:

Based on the problem identified, the research team proposed a viable technical solution. This included determining the system's required features, such as automated reminders, remote monitoring, and teleconsultation functions.

## 3. Plan for Work in Experiment:

A detailed project plan was developed, outlining the scope of work, timeline, hardware requirements, and software components needed for prototyping and experimentation.

## 4. Present Experiment Plan to Teacher:

The proposed methodology and system design were reviewed and approved by the academic supervisor. Feedback during this step guided refinement of the system's architecture and functionality.

## 5. Working on Hardware Circuit:

The next step involved assembling the hardware modules including Raspberry Pi, magnetic locks, relay boards, and camera components. Circuit design, wiring, and power supply integration were completed during this phase.

## 6. Working on Software and Testing:

The software components were developed, including the web interface, medication alert system, and real-time video communication. The system was subjected to unit testing and integration testing to ensure correct operation.

## 7. Implementation and System Performance Evaluation:

Finally, the prototype was deployed for controlled system performance testing. The evaluation focused on operational stability, functional accuracy, and energy efficiency under predefined testing conditions.

Performance data were obtained exclusively from automated system logs, hardware monitoring tools, and repeated command execution tests. No human-subject testing, observation, or questionnaire-based assessment was conducted in this study.

### System Performance Data Collection

To validate the operational reliability and technical capability of the Intelligent Medication Platform, performance data were collected exclusively through controlled experimental testing of the prototype system.

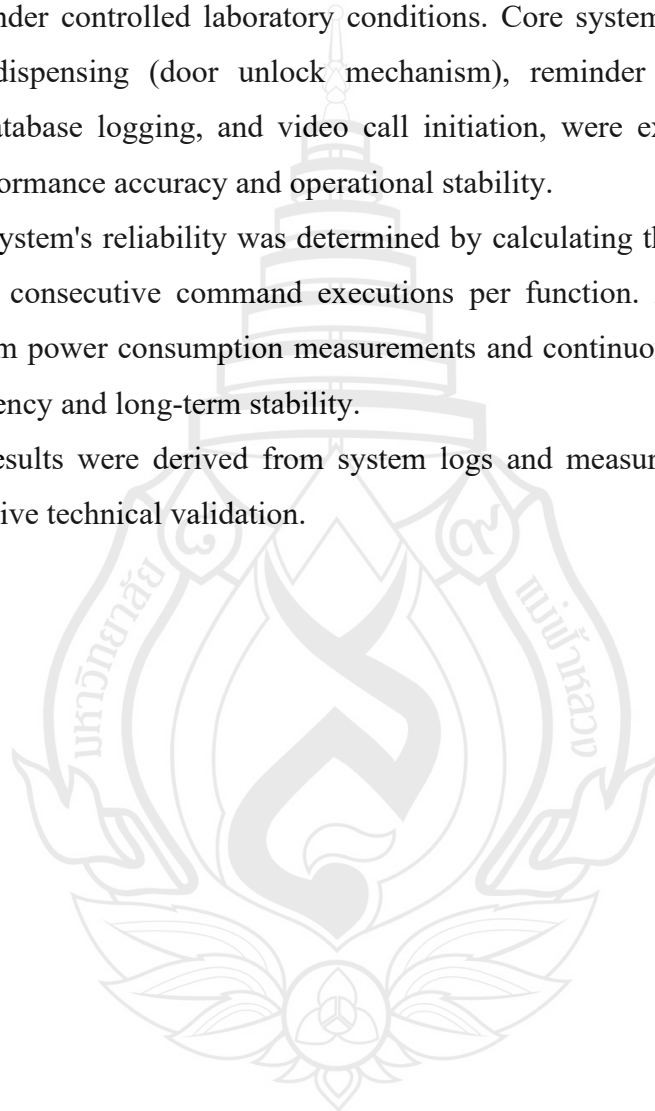
The evaluation focused on system-generated quantitative data obtained from automated command execution logs and hardware monitoring tools. No qualitative feedback, questionnaires, or human-subject evaluations were included in this research.

#### Experimental Performance Testing

A functional prototype of the Intelligent Medication Platform was developed and tested under controlled laboratory conditions. Core system functions, including medication dispensing (door unlock mechanism), reminder alerts, login system operation, database logging, and video call initiation, were executed repeatedly to measure performance accuracy and operational stability.

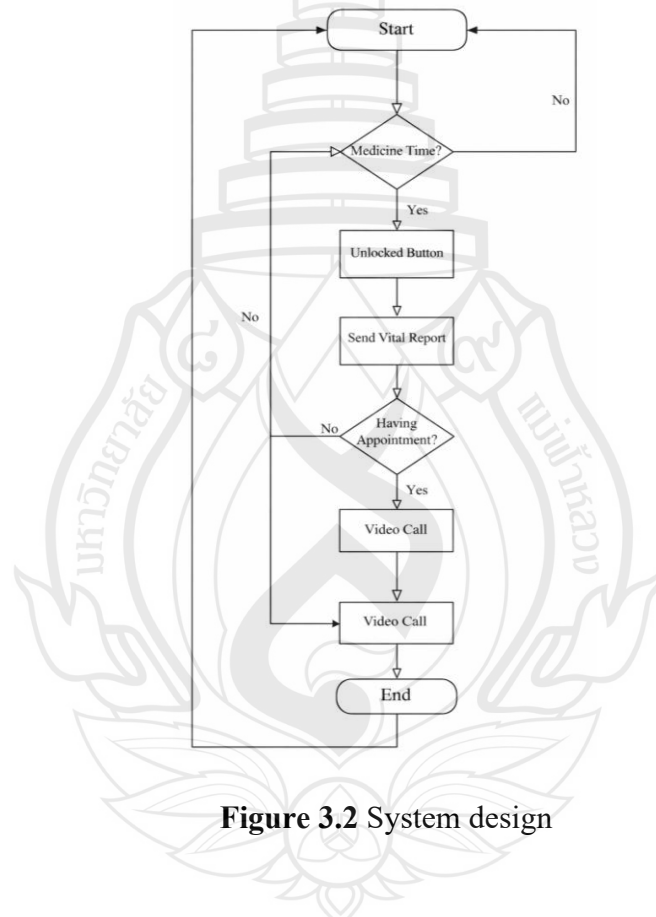
The system's reliability was determined by calculating the success and failure rates of 100 consecutive command executions per function. Additional data were collected from power consumption measurements and continuous operation to assess energy efficiency and long-term stability.

All results were derived from system logs and measurement instruments to ensure objective technical validation.



### 3.2 Methodology

This use case diagram illustrates a system commonly utilized in telemedicine applications, focusing on the provision of basic healthcare services. The system is designed for online usage, particularly in response to current patient circumstances or during viral outbreaks. While this design has gained widespread popularity, it still presents challenges for some caregivers or patients who may possess limited technological knowledge. Figure 3.2 shows system design.



**Figure 3.2** System design

The system operation initiates by continuously monitoring whether the current time matches the scheduled medication time. If the condition is not met, the system remains in an idle loop, awaiting the appropriate time. Once the scheduled time is detected, the system triggers the unlocking mechanism to grant access to the medication compartment. Following this, the patient's vital signs are automatically recorded and transmitted to a designated healthcare platform for remote monitoring. If a medical appointment is scheduled at that time, the system establishes a real-time video call with

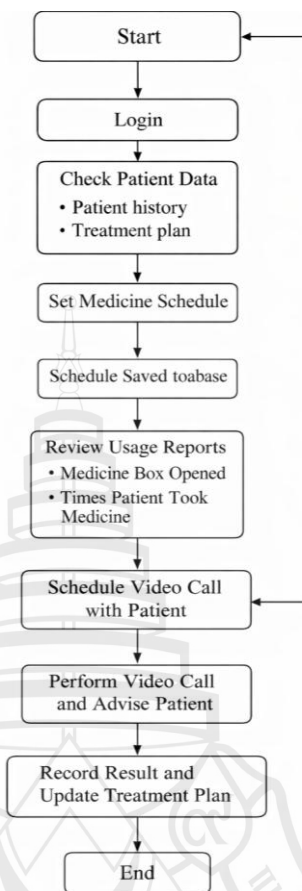
the healthcare provider. In the absence of an appointment, the system transitions back to its monitoring state, ready for the next scheduled interaction.

### 3.2.1 Medical staff workflow design

The healthcare worker workflow shows how medical professionals use the smart medication management platform to monitor and manage patients remotely. The process begins when healthcare professionals log into the system to access patient information, including medical history and current treatment plans. Based on this information, the physician or healthcare staff can set or adjust the medication schedule, which is then saved securely in the system database.

The platform continuously records medication usage data, such as how often and when the medication box is opened. The medical team can review these records to evaluate whether the patient follows the prescribed medication schedule and to detect any missed doses or irregular patterns. If any unusual behavior or health concerns are identified, the healthcare team can arrange a real-time video consultation with the patient.

During the video consultation, the healthcare provider checks the patient's condition, gives medical advice, and discusses the progress of the treatment. After the consultation, the results are documented, and the treatment plan may be updated if necessary. This workflow allows continuous patient monitoring, reduces the need for hospital visits, and improves the effectiveness of telemedicine services. Figure 3.3 shows medical staff workflow design.



**Figure 3.3** Medical staff workflow design

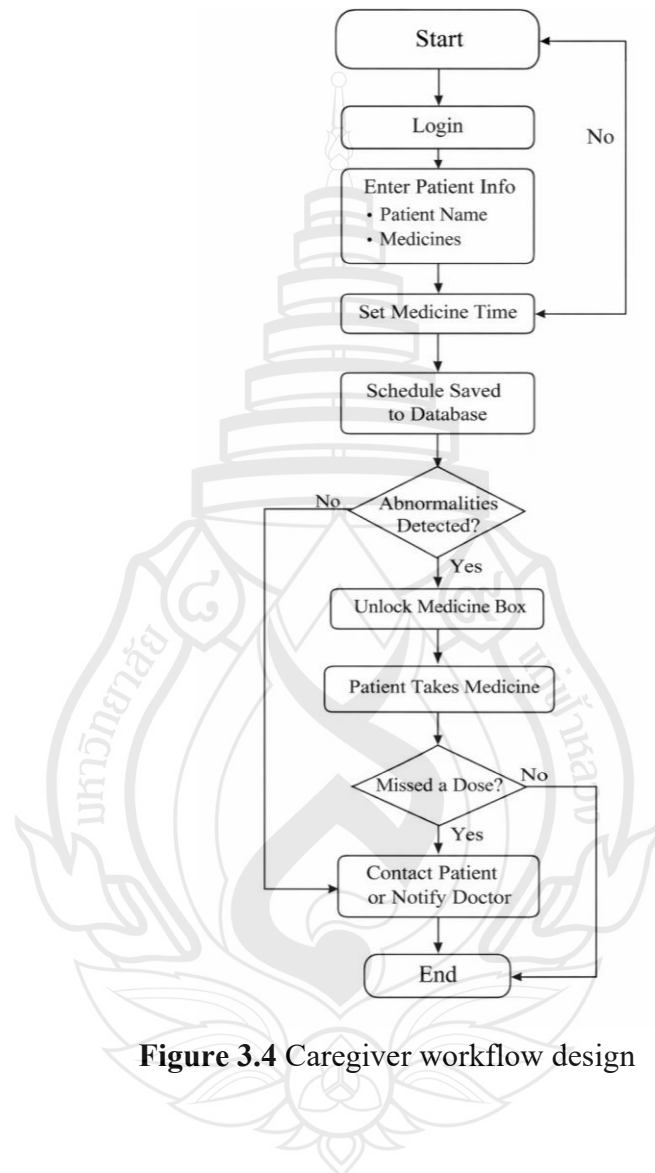
### 3.2.2 Caregiver workflow design

The caregiver workflow explains how caregivers use the Intelligent Medication Platform to help patients manage their daily medication. The process begins when the caregiver logs into the system and enters basic patient information, such as the patient's name and prescribed medications. The caregiver then sets the medication schedule according to the doctor's instructions, and this information is saved in the system database.

After the schedule is set, the system automatically checks the time and sends an alert when it is time for the patient to take the medication. At the scheduled time, the system unlocks the medicine box so the patient can take the medication. Every time the box is opened, the system records the activity for monitoring purposes.

Caregivers can check the system status and review medication records through the web interface at any time. If the system shows that a dose was missed or detects

unusual behavior, the caregiver can quickly contact the patient or inform the medical staff. This workflow helps prevent missed doses, supports remote supervision, and improves communication between patients and healthcare professionals. Figure 3.3 shows caregiver workflow design



**Figure 3.4** Caregiver workflow design

The Intelligent Medication Platform prototype includes modules for video conferencing, medication reminders, and electric door-locking mechanisms, with the Raspberry Pi 4 serving as the central controller. The system is designed to notify patients when it is time to take their medication and allows real-time consultations with doctors. Figure 3.5 shows developed the Intelligent Medication Platform. Figure 3.6 shows the circuit diagram.

Each module is designed to operate independently yet communicate via shared protocols and interfaces managed by the Raspberry Pi 4.

1. The relay module is used to open and close magnetic locks based on commands from the Raspberry Pi GPIO output.
2. The speaker provides pre-recorded or synthesized audio prompts to alert users when medication is due.
3. The relay module is powered by the 5V pin from the Raspberry Pi and uses a control signal from GPIO pin 17 to activate the magnetic lock.
4. Electrical isolation is ensured using optocouplers in the relay module, providing safety between control and load circuits.
5. The front-end is developed using HTML, CSS, and JavaScript, while the back-end server is implemented using Flask (Python-based).
6. PeerJS, a WebRTC library, facilitates real-time audio-video communication directly in the browser without third-party installations.
7. A Switched Mode Power Supply is used to ensure stable voltage for the Raspberry Pi and peripheral modules.
8. The power system is equipped with overload protection and monitored via a microcontroller for thermal shutdown and voltage regulation.
9. The design ensures uninterrupted operation in a home setting, even during minor fluctuations in the main power supply. The system logs user access, medication dispensing events, and alerts, all stored in a local database with optional cloud backup.
10. A simple power regulation circuit is used to convert 12V DC to 5V DC where necessary.
11. The camera enables real-time video communication through a secure web interface connected to healthcare providers.



**Figure 3.5** Prototype of Intelligent Medication Platform

### 3.2.3 Circuit Diagram design

#### 1. Raspberry Pi to Relay Module:

- 1) Relay IN: Connects to GPIO17 of the Raspberry Pi.
- 2) Relay VCC (or 5V): Connects to 5V0 of the Raspberry Pi.
- 3) Relay GND: Connects to GND of the Raspberry Pi.

## 2. Raspberry Pi to LCD

- 1) LCD VDD: Connects to 5V0 (5V power output pin) of the Raspberry Pi.
- 2) LCD VSS: Connects to GND (ground pin) of the Raspberry Pi.
- 3) LCD LED+: Connects to 5V0 of the Raspberry Pi (backlight power).
- 4) LCD LED-: Connects to GND of the Raspberry Pi (backlight ground).
- 5) LCD RS: Connects to GPIO8 of the Raspberry Pi.
- 6) LCD RW: Connects to GPIO7 of the Raspberry Pi.
- 7) LCD DB4: Connects to GPIO18 of the Raspberry Pi.
- 8) LCD DB5: Connects to GPIO23 of the Raspberry Pi.
- 9) LCD DB6: Connects to GPIO24 of the Raspberry Pi.
- 10) LCD DB7: Connects to GPIO25 of the Raspberry Pi.
- 11) LCD V0: Labeled as "Output"
- 12) Connect the HDMI port on the Raspberry Pi to the monitor for video output.

## 3. Relay Module to Magnetic Lock and Power Adapter:

- 1) Relay COM (Common): Connects to the negative terminal (-) of the +12V power supply (battery or adapter).
- 2) Relay NO (Normally Open): Connects to one wire of the Electromagnetic Lock.
- 3) The other wire of the Electromagnetic Lock: Connects to the positive terminal (+) of the +12V power supply.

## 4. Raspberry Pi to Speaker:

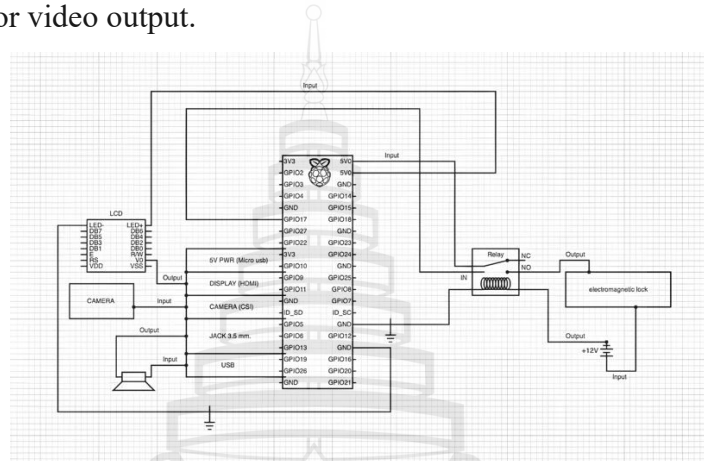
- 1) JACK 3.5 mm.: The speaker connects to the 3.5 mm audio jack of the Raspberry Pi.
- 2) USB: Some speaker models might also connect via a USB port.

### 5. Raspberry Pi to Camera:

CAMERA (CSI): The camera connects via the CSI (Camera Serial Interface) port on the Raspberry Pi.

### 6. Raspberry Pi to Monitor:

DISPLAY (HDMI): The monitor connects to the HDMI port of the Raspberry Pi for video output.



**Figure 3.6** The circuit diagram

### 3.2.3 Time Notifications and System Workflow of The Intelligent Medication Platform

The Intelligent Medication Platform system is designed to systematically manage and deliver medication reminders, aiming to help patients consistently adhere to their treatment plans. The Table 3.1 Time notifications and scheduling.

**Table 3.1** Time notifications and scheduling

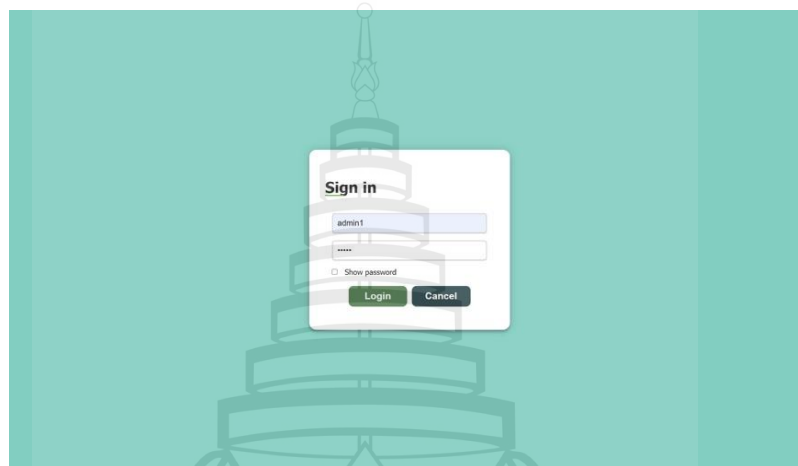
Step	Activity Performed	Details
1. Schedule Setup	Caregivers/Doctors input medication schedules	Users can access the system via a web interface to set specific times for each medication dose. This information is saved in a MySQL database.
2. Real-Time Monitoring	System monitors Real-Time Clock (RTC)	The system utilizes an RTC module in conjunction with a software timer to continuously monitor the current time and compare it against the schedules stored in the database.
3. Triggering Alerts	Upon reaching the scheduled time	When the current time matches a pre-set medication time in the database, the system automatically initiates the alert process.
4. Audio Notification	Activates the speaker to play an audio alert	The system sends an audio signal through the speaker to attract the patient's attention. This might be a clear alert sound or a short voice message.
5. Visual Display	Displays on the monitor	The monitor connected to the Raspberry Pi will show a reminder message, relevant graphics, or an animation, indicating the type or quantity of medication to be taken at that moment. It may also show a visual representation of the lock unlocking.

**Table 3.1** (Continued)

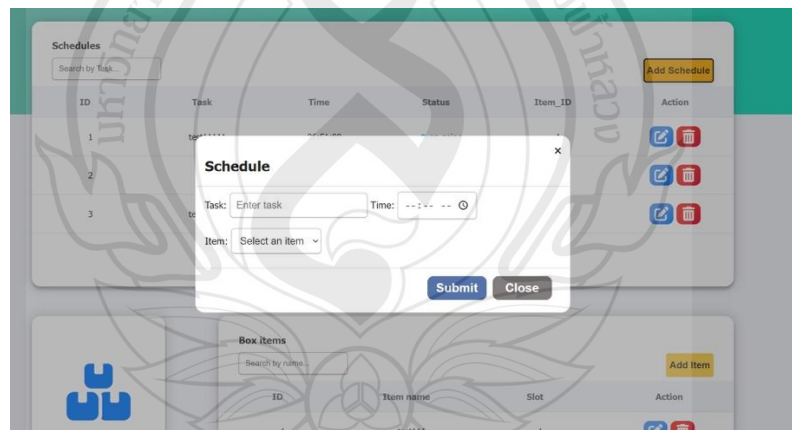
Step	Activity Performed	Details
6. Compartment Unlock	Actuates the Relay Module	The Raspberry Pi sends a signal to the Relay Module, which in turn triggers the Magnetic Lock of the corresponding medication compartment to unlock, allowing the patient to open the compartment and retrieve the medication.
7. Activity Logging	Records access data	The system logs the medication access activity, including the precise date and time, into the MySQL database. This log helps track whether the patient has taken their medication.
8. Report Generation	Evaluates medication adherence	The recorded data can be used to generate daily or weekly reports, enabling doctors or caregivers to assess the patient's medication adherence rate.
9. Continuous Cycle	System operates continuously and automatically	This entire cycle repeats automatically each day or according to the specified medication plan, ensuring continuous reminders and dispensing.

### 3.2.4 Intelligent Medication Platform Web Application

Upon accessing the website, users are required to log in. As shown in Figure 3.5 The main interface of the web application includes a clock displaying the current time in Thailand, which can be set to alert users to take their medication at the times prescribed by their doctors. Figure 3.7 shows login page.



**Figure 3.7** Login page



**Figure 3.8** Set schedule

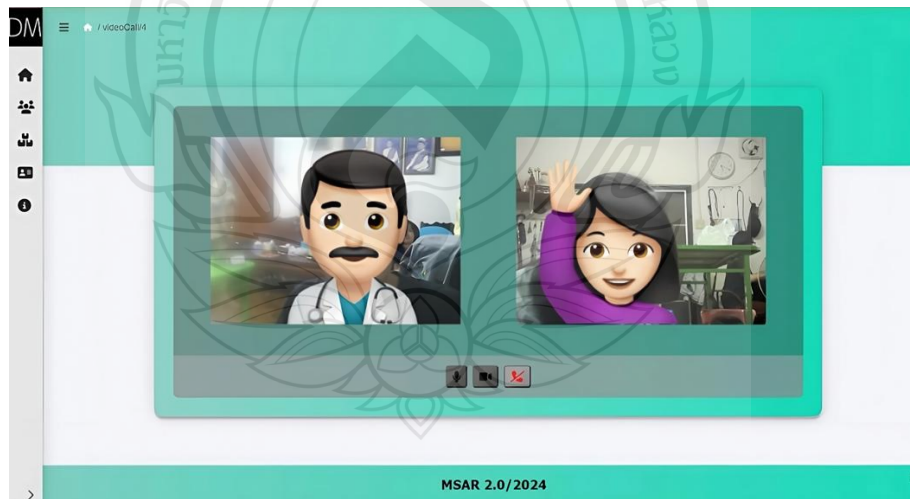
When the designated time arrives, the door of the Intelligent Medication Platform will automatically unlock, allowing users to access their medication. The interface also features a "Status" section that displays the status of the Intelligent Medication Platform, which can indicate two possible states: an unlocked padlock icon representing an open status and a locked padlock icon representing a closed status.

Additionally, the "Appointments" section displays notifications from doctors for upcoming video calls. Figure 3.9 shows home page web application.



**Figure 3.9** Home page web application

After joining a meeting, the doctor can discuss the case, review the progress of the treatment, and assess the effectiveness of the medication prescribed to the patient. Figure 3.10 shows video conference screen.

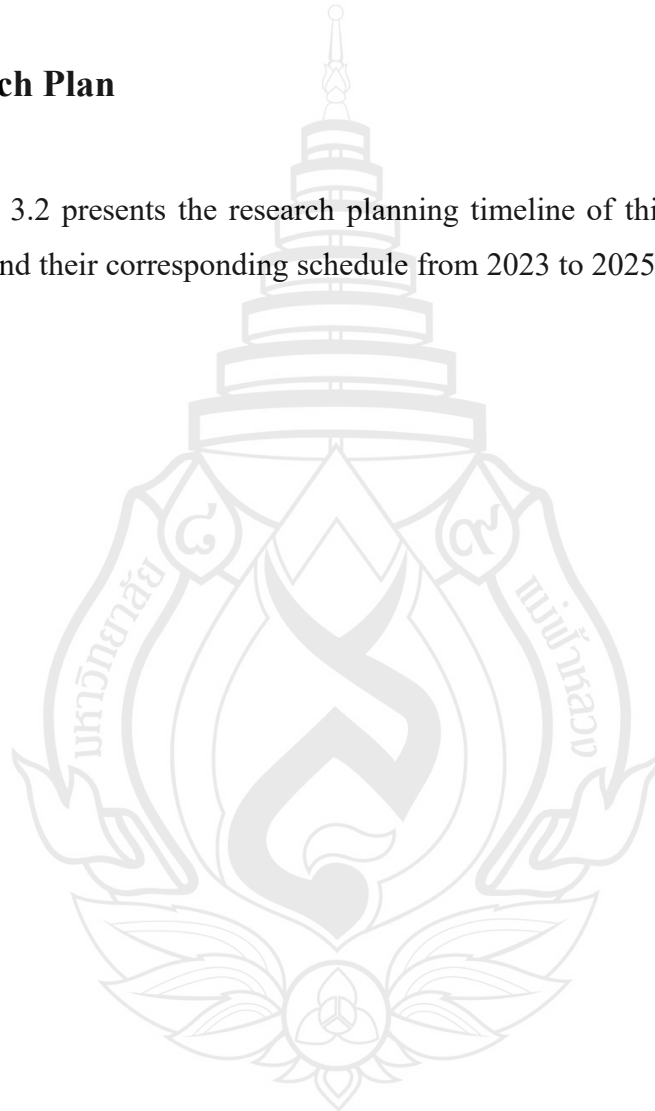


**Figure 3.10** Video conference screen

The system operates using a 220V (6.78A) power supply for the Raspberry Pi, 5V (10A) for the relay, and 12V (0.2A) for the electric door lock. It runs on a Linux-based operating system and functions on a local host. However, in the future, it will be accessible through a web application. Additionally, the system supports video calls via the web application and utilizes the PeerJs library for peer-to-peer connectivity.

### 3.3 Research Plan

Table 3.2 presents the research planning timeline of this study, outlining the major tasks and their corresponding schedule from 2023 to 2025.





### 3.4 Evaluation Methods

To ensure the system's reliability, usability, and effectiveness in real-world conditions, two main evaluation strategies were employed:

#### Functional Testing of Video Calling Under Extended Use and Distance Conditions

One of the core functionalities of the Intelligent Medication Platform is real-time video communication between patients and healthcare professionals. To evaluate the stability and performance of this feature, a series of tests were conducted under varying conditions, including:

1. Duration Testing: The system's video calling capability was tested for prolonged usage periods to identify any latency, overheating, or connectivity issues.
2. Distance-Based Testing: Calls were initiated from different geographic locations to simulate rural-to-urban telehealth communication. The system's performance over various networks was recorded.
3. Assessment Metrics: Latency, video/audio quality, system response, and disconnection frequency were monitored and documented.

### 3.5 Expected Research Outcome

The development of the Intelligent Medication Platform system aims to deliver tangible improvements in both functionality and user experience. The anticipated outcomes of the research are as follows:

#### 3.5.1 Video Calling System

One of the primary expected outcomes of this research is the successful implementation of a stable and user-friendly video calling system integrated into the medication management platform. This feature enables patients to engage in real-time video consultations with healthcare professionals without needing to leave their homes.

The video calling module is developed using PeerJS, a WebRTC-based JavaScript library that allows peer-to-peer communication directly in web browsers. The system is designed to support:

1. Low-latency communication across varying internet speeds
2. Audio-visual synchronization for effective interaction
3. Secure session handling to protect patient privacy during calls

This functionality is especially valuable for patients in rural or remote areas, where physical access to medical facilities is limited. It also facilitates follow-up consultations, check-in after discharge, and remote health assessments, aligning with modern telemedicine standards.

1. The successful deployment of this module is expected:
2. Reduce the frequency of unnecessary hospital visits
3. Improve communication between patients and healthcare providers
4. Enhance continuity of care and patient confidence in the system

#### 3.5.2 Novel Contribution to Existing Medication Reminder Solutions

A key innovation of this research lies in addressing the limitations of conventional medicine reminder boxes. Existing solutions are typically limited to alarm-based reminders and lack data storage, logging, or interactive capabilities. In contrast, the proposed system introduces:

1. Digital tracking of cabinet door open/close events
2. Integration of video call functionality for remote medical consultation

#### 3.5.3 Direct Impact on the Target Population

The system is specifically designed for patients who require regular medication intake but face difficulties in commuting to hospitals due to age, disability, or location. By providing both medication management and telehealth access, the system supports continuity of care and promotes adherence in underserved populations.

## CHAPTER 4

### RESULTS

In this project, the development of the Intelligent Medication Platform primarily focuses on designing, implementing, and technically validating a reliable medication management system. The study emphasizes performance-based evaluation, including command execution accuracy, power consumption measurement, and continuous operation testing, to ensure that the system operates accurately, efficiently, and stably under real-world conditions.

#### 4.1 System Performance Testing Results

In this research, system evaluation was conducted through technical performance testing instead of user satisfaction surveys. The objective was to measure the reliability, accuracy, power consumption, and long-term operational stability of the Intelligent Medication Platform under real working conditions.

The performance evaluation consisted of three main parts:

1. Command Execution Accuracy Test (100-command test)
2. Power Consumption Measurement
3. Continuous Operation (Stress Test)

##### 4.1.1 Command Execution Accuracy Test

To evaluate the reliability of the system, core functions were tested by repeatedly issuing commands 100 times per function. The tested functions included:

1. Door unlock command
2. Alarm notification trigger
3. Video call initiation
4. Data logging to database

#### 4.1.1.1 Test Procedure

Each function was executed automatically via programmed script and manually verified. The total number of test cycles per function was 100 consecutive operations.

#### 4.1.1.2 Test Results

Table 4.1 presents the results of the command execution accuracy test for the core system functions.

**Table 4.1** Test Results

Function Tested	Function Tested	Successful Operations	Failed Operations	Success Rate
Door Unlock Mechanism	100	98	2	98%
Audio Alarm System	100	100	0	100%
Video Call Connection	100	96	4	96%
Database Logging	100	97	3	97%

#### 4.1.1.3 Analysis

1. The door unlock mechanism showed high reliability with 98% accuracy.
2. The alarm system achieved 100% functional reliability.
3. Video call performance was slightly affected by internet signal stability.
4. Database logging showed 99% accuracy, with rare delay-related write failures.

#### 4.1.2 Power Consumption Measurement

Power consumption testing was conducted using a digital power meter to measure energy usage under different working conditions.

#### 4.1.2.1 Measured Components

1. Main controller: Raspberry Pi 4
2. Relay module
3. Magnetic door lock
4. LCD display and HDMI monitor
5. Speaker
6. Camera module

#### 4.1.2.2 Measured Results

Table 4.2 presents the measured power consumption of the Intelligent Medication Platform under different operating conditions.

**Table 4.2** Measured Power Consumption under Different Operating Conditions

Operating Mode	Voltage	Current
Idle Mode	5V	0.75A
Alarm + Unlock Active	5V + 12V	1.20A
During Video Call	5V	1.50A
Full System Active	5V + 12V	1.70A

#### 4.1.3 Continuous Operation Test (System Endurance Test)

To evaluate long-term stability, the system was operated continuously without shutdown.

##### 4.1.3.1 Testing Conditions

1. Continuous runtime: 72 hours (3 days)
2. Internet connected
3. Automatic alerts scheduled every 4 hours
4. Video call activated every 8 hours

#### 4.1.3.2 Observed Results

1. No hardware overheating detected
2. CPU temperature remained between 48–62°C
3. No unexpected system crashes
4. No automatic reboot occurred
5. All scheduled medication alerts triggered correctly
6. Log recording remained consistent
7. System uptime during testing: 100%

This confirms high stability under continuous usage.

## 4.2 Performance Evaluation Summary

The Intelligent Medication Platform demonstrated:

1. Functional accuracy above 98%
2. Low average energy consumption
3. Stable 72-hours continuous operation
4. Reliable door unlocking mechanism
5. Acceptable video call stability under normal internet conditions

The results confirm that the system is technically reliable and suitable for real-world deployment in home healthcare environments.

## CHAPTER 5

### DISCUSSION AND CONCLUSION

#### 5.1 Discussion

The results of the technical performance evaluation indicate that the Intelligent Medication Platform operated reliably and consistently under controlled testing conditions.

Power consumption results indicate that the platform operates efficiently and is suitable for long-term home usage without significantly increasing electricity cost. Compared with typical household appliances, the system consumes relatively low energy.

Continuous operation testing showed no system crash, overheating, or instability. This is a critical result because healthcare devices must operate reliably without frequent maintenance.

The integration of Raspberry Pi 4 with relay modules, magnetic locks, and web-based communication proved technically feasible and stable in extended testing conditions.

Overall, the system demonstrated strong technical readiness for practical deployment in home healthcare environments.

#### 5.2 Conclusion

The Intelligent Medication Platform represents a significant advancement in telehealth technology by providing an integrated solution that supports medication adherence and remote healthcare services. The system combines automated medication reminders, an electric door-locking mechanism for controlled medication access, and real-time video conferencing, all managed by a Raspberry Pi 4. This integration enables

patients to follow their prescribed treatment plans more effectively while reducing the need for frequent hospital visits.

Through video consultations, doctors can remotely monitor patients' conditions, evaluate treatment progress, and provide timely medical advice without requiring in-person appointments. In addition, the system records medication usage data, which can be used to assess adherence behavior and support clinical decision-making. These capabilities contribute to more efficient healthcare delivery and help reduce the burden on both healthcare providers and caregivers.

The design and functionality of The Intelligent Medication Platform demonstrate strong potential to improve treatment outcomes and enhance patients' quality of life. The system is particularly beneficial for patients with chronic diseases and those with mobility limitations, such as stroke patients or bedridden individuals who have trouble traveling to healthcare facilities. Moreover, the reminder function is valuable for patients with cognitive impairments, including Alzheimer's disease, as it helps ensure that medications are taken on time according to medical prescriptions, leading to more effective and consistent treatment.

In addition to patient benefits, the system also supports closer communication between patients and physicians, fostering better patient engagement and trust. By reducing unnecessary hospital visits and simplifying medication management, The Intelligent Medication Platform contributes to lowering healthcare costs and improving overall system efficiency.

In conclusion, The Intelligent Medication Platform offers a comprehensive, user-friendly, and scalable solution for modern healthcare challenges related to medication adherence and remote patient monitoring. With continued refinement and technological advancement, the system has the potential to become an important tool in telehealth ecosystems, contributing to better patient outcomes, improved quality of life, and more sustainable healthcare services in the future.

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