telecom

Article

Design and Implementation of a Smart Intercom System through Web Services on Web of Things

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Abstract: In this paper, an embedded system is used as a host for the intercom and as a chatbot server for this system. The chatbot server controls door locks, cameras, buzzers, and related devices through web services on the WoT (Web of Things) to provide residents and visitors with better functionality and integrational services. This system can greatly improve the security and convenience of the system compared with the traditional intercom system. The resident uses the instant messaging software of the smartphone to replace the handset function, and there is no need to install and learn new apps, reducing the cost of the handset and the wiring indoors and outdoors. Whether or not the residents are at home, they can check whether there are visitors and check the status of their doors through their smartphones. Conversely, any visitor can also contact the resident through this intercom, while there is no way to confirm whether the resident is at home or not, which enhances the security of the house. This system provides flexibility in wireless installation and use and sufficient mobility for residents. The system architecture strikes a good balance between user convenience and home security and between performance and cost, effectively improving home security and reducing costs.

Keywords: web of things; embedded system; web service; instant messaging software

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1. Introduction

As the increase in crime incidents has led to concerns about home security, it is important to have an intercom system that can help residents to understand all visitors and then allow them to enter their homes accurately [1]. The intercom systems are electronic doormen for apartments and buildings [2], but intercoms are also used to confirm that the residents are not at home before the burglars burglarize a house. On the other hand, when visitors call the intercom, the resident may be in the bathroom, kitchen, or bedroom and cannot immediately pick up the handset to answer, and the visitor will think that the resident is not at home. If the visitor is a delivery man or a postman, the resident will not receive the goods or mail immediately, which is a great inconvenience for all. The schematic diagram of the traditional intercom system is shown in Figure 1.

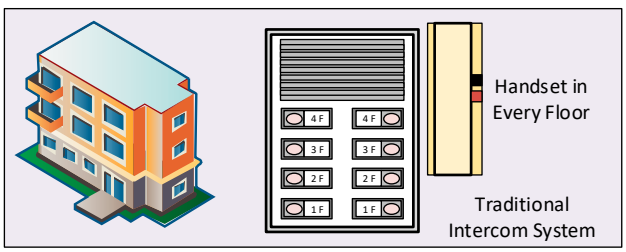


Figure 1. Schematic diagram of the traditional intercom system.

There has been a lot of research on improving these problems of traditional intercoms. Door lock systems have been a hot topic in smart homes, offices, the military, and banks. Behind doors are our valuable assets, and these systems need to protect them from unauthorized people. There is a lot of research and development on security door locks based on IoT (Internet of Things) technology [3]. Users exchange information over the network using secure encryption algorithms based on IoT [4]. There is also the use of RFID and fingerprints as a dual security system [5], blockchain-based systems to establish security control mechanisms [6], and IoT-based doorbells to remotely monitor visitors in real time [7]. These articles above focuses on using various technologies to create a more secure door system, which does not solve these problems of traditional intercoms but does provide much insight.

The chatbot is very useful for the practical operation of smart security systems at home and for office automation systems through the use of chatbots to alert employees when they are allowed to turn on or off the device and to notify them to turn on the fan when the temperature is high [8]. Most people use Messenger regularly to control their devices even when they are not at home, and chatbots can lock or unlock doors and check who is at the door [9].

This system deploys a chatbot server in an embedded system. It integrates a chatbot of instant messaging software to generate standardized responses through web services to build a smart intercom system on the WoT. A resident uses a menu of instant messaging software, such as "Open Door", "Watch", "Alarm", and "Busy" to communicate directly with visitors through various services and to perform the functions of door lock, camera, buzzer, and related devices, as shown in Figure 2. When a visitor presses a floor button, the resident receives a notification through the instant messaging software of the smartphone.

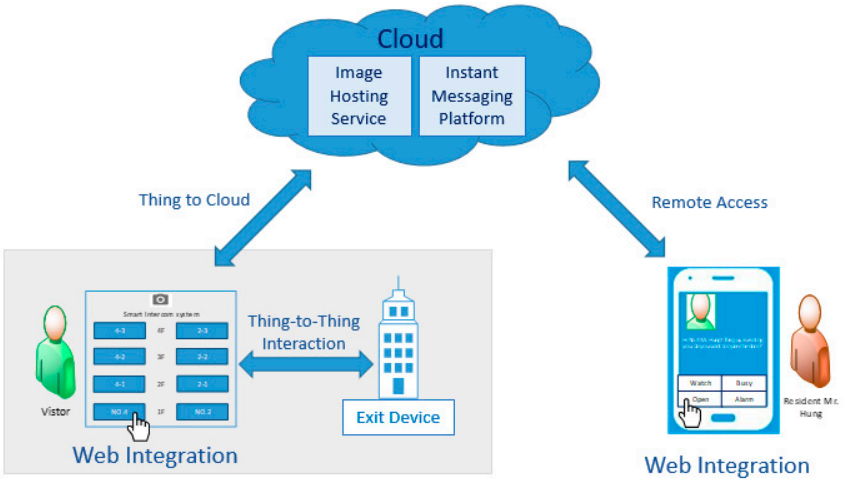


Figure 2. Schematic diagram of the smart intercom system.

This paper is an extension of our previous study [10]. This system adds two functions to the prototype, the camera function and alarm function, and the software framework is completely updated. This system architecture strikes a good balance between resident convenience and home security, as well as between performance and cost, effectively improving home security and reducing costs. The system allows residents to know the status of the visitors to their homes without missing any visitor messages from anywhere by using the instant messaging software on their smartphones. This paper is to integrate the chatbot server with the embedded system as the intercom host and to replace the home intercom function with the use by residents of the instant messaging software on their smartphones to realize the WoT function of the smart building. There is no need to install and learn new apps, reducing the cost of mobile phones and indoor and outdoor wiring. Whether the residents are at home or not, they can communicate with the visitors and control the status of the door through their smartphones. However, the visitors will not

be able to check whether the residents are at home through the intercom of the buildings, which will improve home security. Its contributions are listed below:

1. This system deploys a chatbot server for door locks, cameras, buzzers, and related devices and provides various functional services to residents and visitors through web services on the WoT.
2. The system deploys a chatbot server in an embedded system to provide web services that combine with instant messaging software to promote home security and convenience.
3. The resident can control the door lock, camera, buzzer, and related devices by the instant messaging software of a smartphone through web services on the WoT. The system does not need to develop additional apps; a resident does not need to install and learn new apps.
4. Residents can communicate with visitors remotely using instant messaging software on smartphones, and visitors cannot confirm whether a resident is at home by pressing an intercom button.
5. The resident's smartphone replaces the home handset; so, no additional equipment is needed at home. The system does not require a handset, reducing the cost of the handset and wiring between indoors and outdoors.

The remainder of this article is organized as follows. Section 2 is a review of related work. Section 3 describes the proposed system's hardware architecture, including the used embedded devices and the communication between various sensors and electronic comments. The software framework and its functionality are described in Section 4. Section 5 presents the implementation results of the system, and discussion and analysis are shown in Section 6. Finally, the conclusion is given in Section 7.

2. Related Research

In order to improve the problem of the traditional intercom, an article created a door phone prototype using an IP network system with a SIP (Session Initiation Protocol) server and many SIP clients. The IP door phone is one of the SIP clients in the system and provides basic door phone functionality. Visitors can use voice and video calls to talk to residents and control the device during the ring [11]. There is also a purpose in designing and implementing a free intercom system that uses cell phones and IP phones for free through a wireless network, which uses a SIP to allow users to make voice, video, and SMS conversations [12]. The IP phone is used as a door phone system under the SIP server, called VoIP Intercom (Voice over Internet Protocol). Once IP telephony (Internet Protocol telephony) software is installed on a resident's or a visitor's smartphone, they can talk to each other through the system at any time. However, since there is still a fixed device in the house, it is impossible to know that a visitor is calling if the resident is not at the handset. Another important issue is that if the visitors do not register and install the software beforehand, there is no way to contact the residents.

Another study used a wireless transceiver module to implement a cost-effective home door intercom [13]. Furthermore, a smart intercom has been constructed to provide live video feeds from a visitor to the resident by cell phone so that the resident can remotely control the visitor's movement [14]. One paper designed an Android smartphone-based instant messaging application that enables users to enter their user data on the login screen. The system verifies the information and displays the intercom interface. Users can select a channel to enter the specified channel and talk within the channel without interfering with each other, and users can choose any channel and exit after talking. In addition, users can invite other online users to enter the temporary channel to achieve the function of intercom communication [15]. The use of apps on smartphones as intercoms is referred to in this paper as a mobile intercom. Although this system eliminates the need for a handset in the home, it allows residents to receive visitor notifications from anywhere. However, it does lose the functionality of the original intercom to view visitors and open the door. The visitors cannot contact the resident without prior installation of the intercom software.

There are three types of intercoms: the traditional intercom, the VoIP intercom, and the mobile intercom, as listed in Table 1. The traditional intercom has the highest cost, and the mobile intercom is the lowest solution. Traditional intercom systems usually have a dedicated system. In contrast, the VoIP intercom and the mobile intercom can be installed with a specific app on the mobile phone, allowing visitors and residents to contact each other easily. However, visitors or residents who do not have the app cannot contact each other.

Table 1. Comparison list of the properties of three types of intercoms.

Type	Network	Connection Method	User	Device Location	Operation System
Traditional intercom [1]	P2P	Wired	Resident/Visitor	Fixed	Dedicated system
VoIP intercom [11,12]	IP network	Wired/Wireless	SIP user	Fixed/Mobility	General system
Mobile intercom [15]	IP network	Wireless	Apps user	Mobility	General system

In addition, a laboratory cloud-based video intercom access control system based on NFC (Near-field communication) technology was designed, and the experimental results proved that the combination of NFC technology and the cloud platform enhanced the load capacity and security of the system [16]. As a simple password is no longer foolproof, it is important for homeowners to provide tenants with a secure door-locking system. Some smart door lock systems are designed to set a code for a new tenant each time, and the tenant can use a one-time password from an Android app to unlock the door. Another is an automated door lock system designed using a chatbot that uses a PIN (personal identification number) instead of a lock key. Keyless approaches are convenient for both the owner and the tenant because they utilize IoT capabilities to monitor and grant access to visitors [17]. The user can also open or close the lock by installing a developed application on the cell phone. If the username and password are verified in the internet database, the door can be opened successfully. If the verification is unavailable, a buzzer will sound and send an SMS alert to the homeowner to enhance home security [18]. Security is the main issue in a home. Letting the right people, such as family, into the house and keeping intruders out is very important. Studies are using a facial recognition door lock system; the visitor looks at the camera, and the electromagnetic lock will unlock the door if the image exists in the database. Otherwise, an alarm message will be sent to the owner in the form of an email [19]. There is a security door lock system based on embedded system technology, which uses a camera and a keypad to identify visitors and residents and can notify the homeowner that only authorized individuals have permission to enter the door [20]. These arguments are intended to address the issue of people with access rights being able to easily and securely open and close door locks without losing or duplicating door keys, causing security problems in controlled areas. This is different from the purpose of this paper, which is to allow the occupants to know that someone is visiting even if they are not home and to communicate with the visitor at any place so that the thief cannot determine whether someone is home through the intercom used.

Access control systems can also be operated from a cell phone using an Android application, which is controlled by facial detection and recognition according to a camera installed outside the door. The system can also control all the appliances by the user's voice [21]. In addition, the system can allow users to control home appliances through instant messaging software without the need to install an app on the smartphone [22]. There are also embedded systems and programming languages working with motors and sensors to develop a prototype system for controlling air conditioners and contacting the user through a chatbot. One of the advantages of a chatbot for controlling air conditioners is that it is easy to use since the user interface is designed to be very user-friendly and

can be used anywhere, anytime, as long as there is an internet connection [23]. The voice system can also be used for home appliance control, entertainment systems, lobby facility monitoring, and home security [24].

Instant messaging software has replaced the function of making phone calls as a tool for talking to friends and is the primary tool for communicating with customers in business. Chatbots are an essential feature of instant messaging platforms that deliver customers' information and replace human response efforts. An embedded system is a computer system with real-time computing capability, usually to perform some specific tasks. Due to its convenience, it is widely used in various research, and many papers also mention that embedded systems can be remotely monitored for research. With the integration of embedded systems, instant messaging platforms, and WoT technologies, the residents using these technologies can control door locks, cameras, and buzzers through instant messaging software and use chatbots to drive embedded systems. The system also hopes to integrate these technologies to provide visitors with the possibility to talk directly to residents through the integration of the web services.

The technologies used in the three types of intercom are listed in Table 2. Early traditional intercoms relied on telephone technology, and wireless communication technology was adopted later. Traditional intercoms are not listed in the table because they do not use the various technologies listed. Although the VoIP intercom, the mobile intercom, and this system all use a wireless connection to the internet and need to deploy app technology, this system does not need to develop new apps. Users directly use the apps of instant messaging software without the need to install an app. The main difference between the VoIP intercom and the mobile intercom is that the VoIP intercom uses VoIP technology to build a VoIP server to provide mobile phones, desktops, laptops, and embedded systems that can install SIP client systems. This system deploys a chatbot server in an embedded system and integrates instant messaging software and WoT technology to design a smart intercom system through web services.

Table 2. Intercom use technology list.

Type	Deploy Apps	Deploy VoIP	Deployed Chatbot	Web Integration	Computer Vision	Internet Access	Embedded System
VoIP intercom [11,12]	V	V	-	-	-	V	V
Mobile intercom [15]	V	-	-	-	-	V	-
Smart intercom	V	-	V	V	V	V	V

-: Not supportive. V: Supportive.

3. Hardware Architecture

This system uses an embedded computer built on a single circuit board. This is a complete computer built on a single circuit board with a microprocessor, memory, input/output (I/O), and other functions; it is the main working platform for the intercom. The hardware of this system is built into the embedded system, including an MCU (microcontroller unit), a wireless module, an SD card (secure digital card) slot, a touch panel, a camera, a relay, an electronic lock, a buzzer, and a speaker. The use of microprocessors can be used to open doors and activate buzzers to sound warnings. However, to make it easier for residents to communicate with visitors, the system uses an instant messaging platform as a bridge. The hardware architecture is shown in Figure 3.

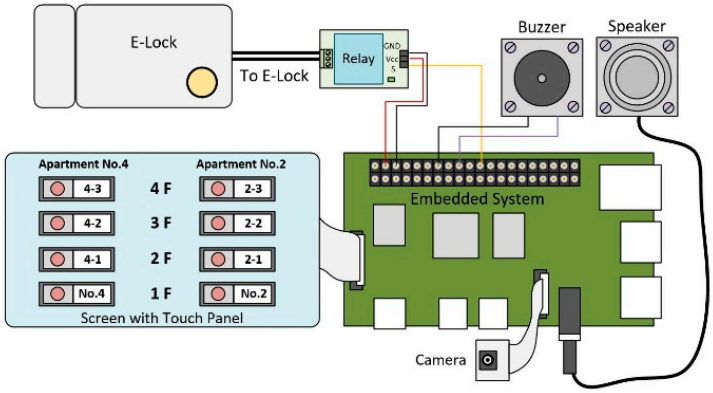


Figure 3. Hardware architecture of smart intercom system.

Although the stability of a wired network connection is higher than that of a wireless network, considering that the intercom is usually installed outside the apartment or in the lobby of a building, there may not be a wired network interface. The wireless transmission module of the embedded system is used in the intercom, and the system can be restarted remotely in case of errors.

As the content of the standby screen displayed on the touch panel is similar to that of a traditional intercom, visitors can easily use the system without training. Once the visitor presses the floor number on the touch panel, the system will send system information to the resident through the MCU of the embedded system according to the resident ID set by the system. The resident receives messages and photos of the visitor through the instant messaging software of the smartphone, which will decide whether to open the door, activate an alarm, or send a picture or text messages after confirmation by the resident. The visitor's photo will be sent to the cloud through the wireless transmission module and forwarded to the resident. When a visitor's photo is received, it can be clearly identified, and the resident who wants to open the door can do so by clicking "Open Door" on the menu of the instant messaging software. If the resident cannot be clearly identified, he or she can click the "Watch" button, and the system will take the photo back from the camera on the intercom.

The traditional intercom system does not allow the resident to know that a visitor is coming to the house when the resident is not home. In this system, if the resident does not respond immediately, they can still use the instant messaging software of the smartphone to know who has visited. This system not only reduces the cost of handsets and wiring indoors and outdoors but also reduces the cost of maintenance for future line failures.

This system uses a cathode lock, which requires an external power supply and locks the door without power. However, the power supply of the embedded system is not enough to drive the cathode lock; so, it needs to rely on the small current output of the embedded system to control the switch with a higher current. When the relay is energized, it can open the lock body to open the door, thereby controlling the opening and closing of the door. If a resident finds an outsider, then he or she can press the "Alarm" button in the instant messaging software, which will immediately activate the buzzer to emit an alarm sound to draw the attention of neighbors and make the outsider leave.

4. Software Framework

The system integrates an embedded and instant messaging platform to develop various functions through the web services on the WoT. The embedded system is used as a host for the intercom and as a chatbot server for this system. The functionality of the instant messaging software on smartphones is designed through an instant messaging platform, and communication between the platform and the software takes place through messages. The embedded system and the instant messaging software platform collaborate through the webhook mechanism. The software framework of this system is shown in Figure 4.

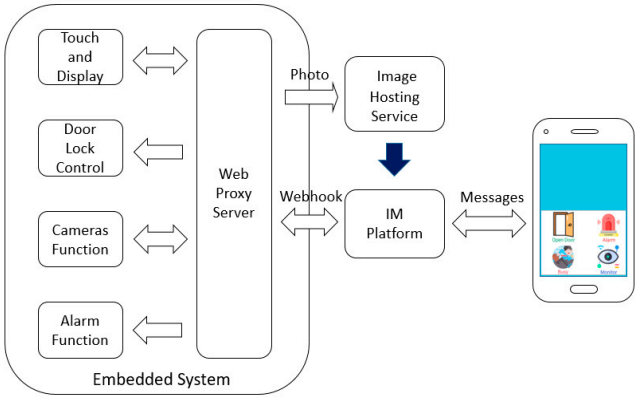


Figure 4. The software framework of this system.

The developed functions of the embedded system use a common programming language that provides a touch and display function, a door lock control function, a camera function, and an alarm function. The system functions by integrating the embedded system's web proxy server and wireless network module with cloud services such as image hosting services and instant messaging platforms to provide web services for the residents and visitors.

The embedded system provides visitors with an intercom interface that uses touch screens instead of the traditional pushbutton switches. Visitors click on the touch screen as if they were using a keyboard or a mouse, and the system is programmed to activate the relevant software functions in an event-driven manner. The system not only allows visitors to send messages and photos to the residents' smartphone instant messaging software after pressing the floor number, it also allows residents to use the instant messaging software to generate a standardized interface through the instant messaging platform to trigger the chatbot server to control various devices, such as door locks, cameras, buzzers, etc. The touchscreen layout of this system is shown in Figure 5.

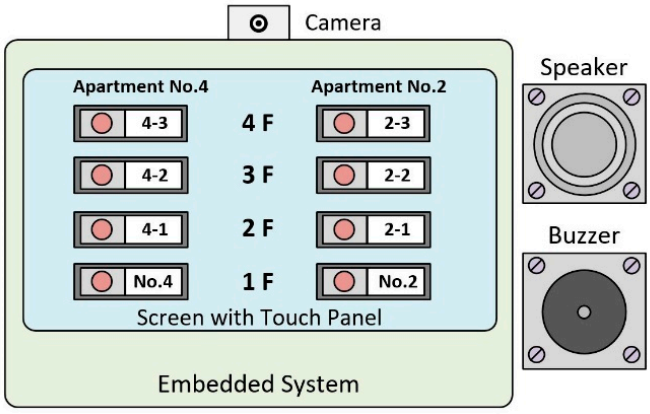


Figure 5. The touch screen layout of this system.

Any apps on smartphones need to be installed before use. If written as a web application, there are concerns about information security, such as anonymous attacks on web pages. In this study, the instant messaging software already installed on the smartphone successfully integrates with the embedded system to control the WoT devices through the instant messaging platform, thus enhancing the smart control capability of the residents' smartphones without needing to install an app. The system uses web services as the integration interface, activates the webhook service in the channel of the instant messaging platform, and then integrates the embedded system's chatbot server to ensure the system's security. The system mainly uses the chatbot of the instant messaging platform and designs

"Open Door", "Watch", "Alarm", and "Busy" menus for the resident to use by the instant messaging software of a smartphone. The proposed functional flow is described as follows.

4.1. Function Flow of the Intercom

After the power is on, the intelligent intercom system will be in standby mode. When the visitor presses the floor number, the system will obtain the resident's ID and send a system message to the resident through instant messaging software. Then, the visitor presses the take photo button, the photo is uploaded to the image host, and the instant messaging platform obtains the photo URL (uniform resource locator) to send to the resident through the image hosting service. If the visitor does not click the photo button after the time limit, the system will return to the standby screen by itself. The function flow of the intercom is shown in Figure 6.

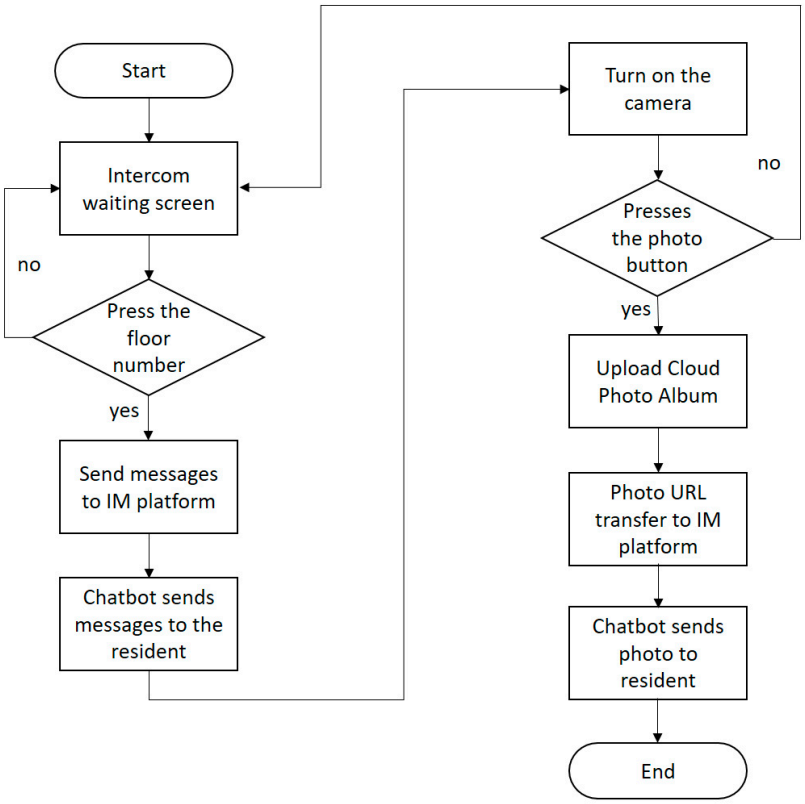


Figure 6. Function flow of the intercom.

4.2. Function Flow of the Chatbot Service

The resident can click on one of the "Open Door", "Watch", "Alarm", and "Busy" menus on the instant messaging software, and the system will perform the corresponding programming functions of the chatbot server through the instant messaging platform.

These functions of the chatbot service are described as follows:

1. Door lock control function: when the chatbot server receives the "Open Door" message from the resident, the system can successfully drive the relay to control the door lock. The door can be locked automatically when the door is closed.
2. Camera function: when the chatbot server receives the "Watch" message from the resident, the system can drive the camera to take pictures and send back the doorway photos to the resident in real time.
3. Alarm function: when the chatbot server receives the "Alarm" message, the buzzer can make a sound in time.

4. Touch and display function: when the chatbot server receives a "busy" or not reserved system message from the resident, the system can display the message directly on the touch screen of the intercom.

After executing the above actions, the chatbot service will return to a standby mode. The function flow of the chatbot service is shown in Figure 7.

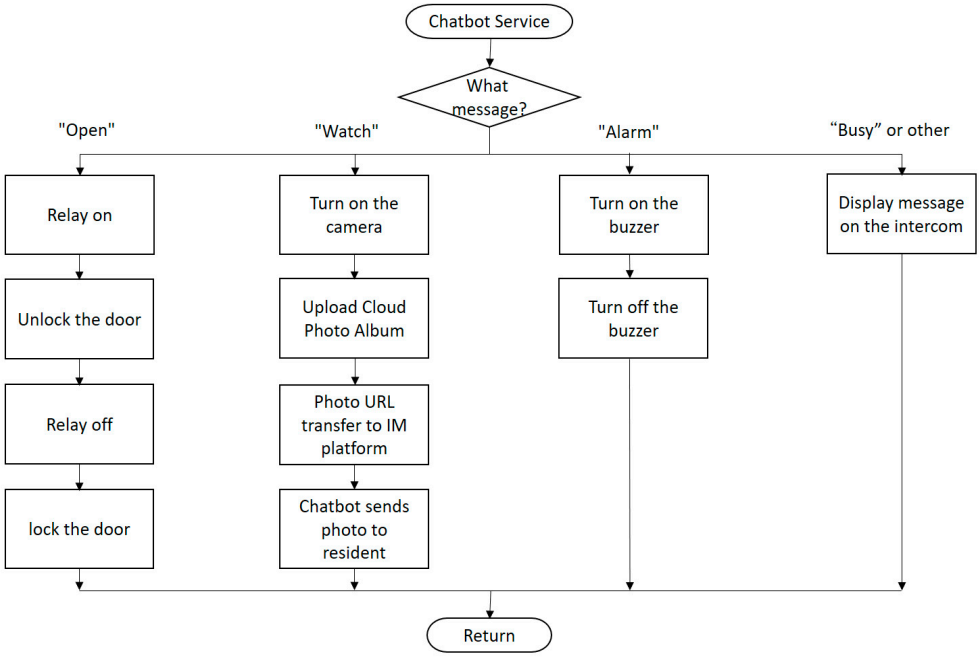


Figure 7. Function flow of the chatbot service.

5. Implementation

5.1. Hardware Implementation

The system was constructed using hardware devices such as an embedded system, a touch panel, a camera, a relay, an electronic lock, and a buzzer. In addition, there is also a touch panel with a built-in speaker, and the electronic lock uses a cathode lock as the control of the lock. The prototype of the system hardware is assembled from the embedded system, the touch panel, and the camera components, as shown in Figure 8.

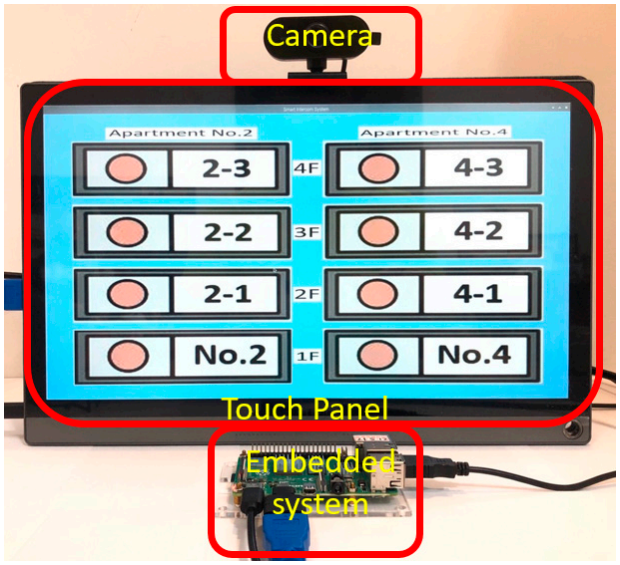


Figure 8. The prototype of this system hardware.

As the voltage of the GPIO (general-purpose input/output) pin of the embedded system is not sufficient to drive the door lock switch, this system therefore needs an external power supply provided to the door lock. The system uses relays to drive the door lock switch using the high and low levels of the relays that use small currents to control large currents. The 5 V output of the embedded system provides power to the relay. The IN pin of the relay is connected to the GPIO 4 of the embedded system, and a ground wire is connected to any ground pin of the embedded system. Next, the buzzer power supply is set in the GPIO 21 of the embedded system, and a ground wire is connected to any ground pin of the embedded system. The embedded system and external wiring diagram are shown in Figure 9.

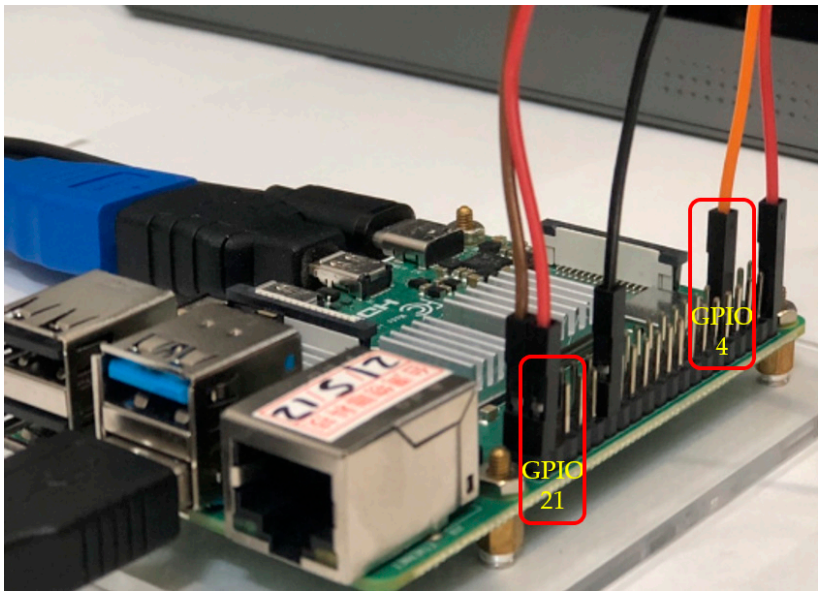


Figure 9. The embedded system and external wiring diagram.

The power supply provides the power to the cathode lock, and the ground wire connects to the relay's COM pin and connects the cathode lock's positive terminal to the NO pin of the relay. After the prototype of the embedded system hardware is wired, it is necessary to download the IMG file obtained after decompression of the OS, import it to the SD card, and install the hardware version of the operating system to provide the deployment of the various functions of the system.

5.2. Software Deployment

5.2.1. Setup Image Hosting Service

The image hosting service provides a new album function using OAuth 2 and does not require a callback URL. The site offers developers to store photos, and the client side obtains photos through the application using client ID and secret authentication.

5.2.2. Setup Bot Function on the Channel of the Instant Messaging Platform

The instant messaging platform allows the developer to create a channel and use the bot function. Implementation requires two securely linked channels to the resident's smartphone and the visitor's intercom through the webhook service.

5.2.3. Setup Web Proxy Service

Due to the embedded system's limited resources, to collaborate with the resident smartphone through the internet this system uses a lightweight and free web proxy server to connect the embedded system to the internet and provide web service capability. As shown in Figure 10, the web proxy service establishes a public address that translates to

the local host port, through which it can connect to the chatbot server on the embedded system.

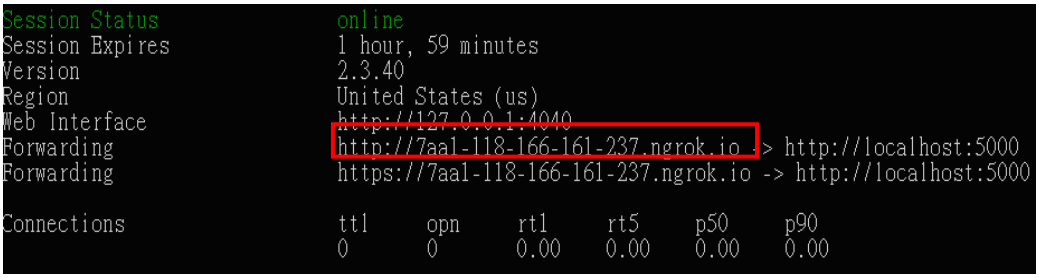


Figure 10. The startup screen of the web proxy service.

5.2.4. Software Operational Architecture

The software's functional architecture is shown in Figure 11. This system has two main web services: an instant messaging platform and a chatbot server. The instant messaging platform provides a way for the instant messaging software on the resident's smartphone to communicate with the platform through messages. The instant messaging platform activates different bot services according to the messages from the residents and uses a webhook service to notify the chatbot server on the embedded system and then executes the specific codes of the chatbot server to control devices in an event-driven manner. If a visitor presses a floor button, the chatbot server executes specific codes in an event-driven manner and triggers a webhook service to notify residents.

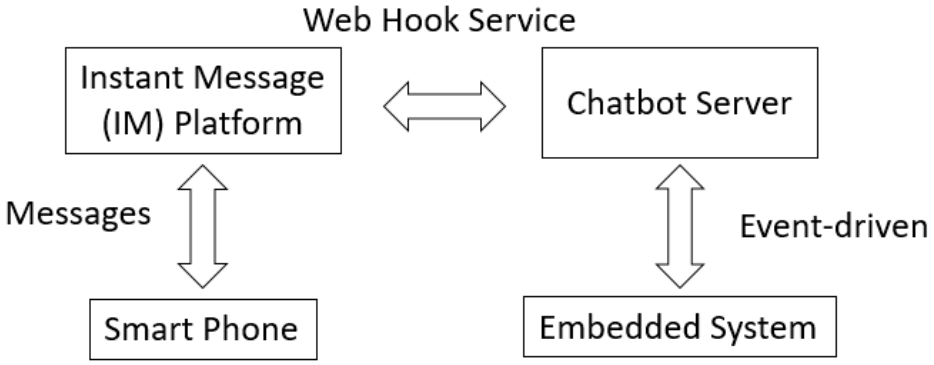


Figure 11. The software's functional architecture of this system.

The chatbot server is programmed in an event-driven programming language and collaborates with other web services over the internet. The system is designed to perform the chatbot service of the embedded system through the bot of the instant messaging platform when the resident clicks on one of the "Open Door", "Watch", "Alarm", and "Busy" menus on the instant messaging software.

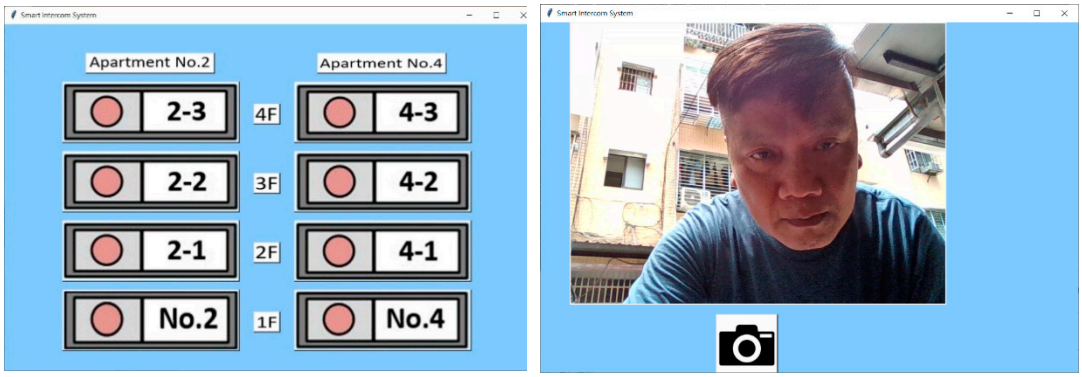
When a user sends a message from a smartphone, the message is sent back to the instant messaging platform through the messaging API (application programming interface). The instant messaging platform obtains the message first, sends it to the embedded system by the webhook URL, executes and drives the chatbot function according to the message, and then replies to the visitor. Reply and push are the two ways to send messages from the messaging API of the instant messaging platform, as shown in Table 3.

Table 3. Two ways to send messages on instant messaging platforms.

Method	Sender	Receiver	Sending Method
Reply	Bot	Sent message user	Chatbot passively replies to user messages
Push	Bot	Specific users or groups	Chatbot proactive push

5.3. System Implementation and Results

The standby screen of the system is shown in Figure 12a. When the visitor presses the floor number button, the system finds the user ID according to the floor number, runs the program of this system, and sends the system message to the resident's smartphone through messaging API. Then, the system activates the camera to take a picture of the visitor, and the image is displayed on the system screen, as shown in Figure 12b.



(**a**) (**b**)

Figure 12. (**a**) The standby screen of the system. (**b**) The camera to take a picture.

After the visitor presses the make photo button, the system uploads the photo to the image hosting service website. It then notifies the chatbot server to run the program to obtain the visitor's photo and to send it to the resident according to the image URL.

The resident receives a photo of the visitor, as shown in Figure 13, and then decides whether to open the door. The resident can click on one of the "Open Door", "Watch", "Alarm", and "Busy" menus on the instant messaging software. After the resident presses any of the buttons, the instant messaging platform will execute the program code that is mapped to the message.

The system has two separate channels in the implementation, each with a webhook URL corresponding to the chatbot function. The push function is a system that sends messages to the resident after the visitor presses the floor number. The callback function is used after the resident sends a message by the chatbot server to control a door lock, buzzer, or related device.

When the instant messaging platform receives messages from residents who want to control door locks, buzzers, or related devices, it executes different messaging APIs based on different event messages. These messages are passed to the chatbot server of the embedded system through a webhook service that can determine the object and type of various messages and execute the codes to control each pin circuit of the embedded system to achieve the purpose of the set execution function.

The resident clicks the "Open" button when the instant messaging software sends a text message to the messaging API. The text message is then transmitted to the chatbot server through the instant messaging platform, and the event is triggered to execute a specific function according to the message. The system will give high power to the GPIO 4 pin to allow the relay to energize. The relay will trigger the door lock to open and then automatically disconnect after 5 s, and then, the door can be locked automatically, as shown in Figure 14.

When a resident clicks the "Alarm" button, the instant messaging software uses messaging API to send a text message through the messaging platform to the chatbot server to trigger an alert event and perform specific program functions based on the message. This alert event will control the GPIO 21-pin high power to activate the buzzer for 5 s, as shown in Figure 15.

Figure 13. The screenshot of the resident's smartphone.

```
if event.message.text=="Open Door":
    message = TextSendMessage(text="The door already opened.")
    GPIO.output(4,GPIO.HIGH)
    line_bot_api.reply_message(event.reply_token, message)
    time.sleep(2)
    GPIO.output(4,GPIO.LOW)
```

Figure 14. The code corresponds to the "Open Door" message.

```
if event.message.text=="Alarm":
    GPIO.output(21,GPIO.HIGH)
    time.sleep(2)
    GPIO.output(21,GPIO.LOW)
```

Figure 15. The code corresponds to the "Alarm" message.

6. Discussion

The system is based on a chatbot server in an embedded system that integrates an instant messaging platform to control door locks, cameras, and related devices through web services on the WoT. The system also provides a platform for communication between

visitors and residents through instant messaging software on smartphones as the primary contact and communication software for residents who do not need to install an additional dedicated app.

The chatbot server performs complete control of the door lock, camera, and buzzer through the instant messaging platform. This system lets the resident know the door's status and whether there is a visitor through the system without the resident being at home; so, the visitor cannot know whether the resident is at home or not through the intercom. Moreover, the residents can use the instant messaging software to open the door for themselves and their family members directly, without the need to bring extra keys and sensors.

The functions of this system are indeed better than those of the traditional intercoms, and the solutions to improve the functions of the traditional intercoms with VoIP intercoms and mobile intercoms are shown in Table 4.

Table 4. Intercom use functions list.

Type	Call/Send Voice	Send Text	Send Picture	Send Video	Open Door	Activate Alarm	Take Picture
Traditional intercom [1]	Call	-	-	V	V	-	-
VoIP intercom [11,12]	Call	-	-	V	-	-	-
Mobile intercom [15]	Send Voice	V	V	V	-	-	-
Smart intercom	Send Voice	V	V	V	V	V	V

-: Not supportive. V: Supportive.

The comparative advantages and disadvantages of the existing intercoms are shown in Table 5. The advantages and disadvantages of the existing intercoms can be seen in Table 5, as follows.

Table 5. Intercom advantages and disadvantages comparison list.

Type	Use in Any Place by Resident	By Any Visitor	Mobility	Wireless	Flexibility	Home Security
Traditional intercom [1]	X	V	X	X	X	X
VoIP intercom [11,12]	Δ	V	X	X	Δ	Δ
Mobile intercom [15]	V	X	V	V	V	V
Smart intercom	V	V	V	V	V	V

X: Not available. Δ: Possibly available. V: Available

1. Only the mobile intercom and this system can be used by residents at any time and place, while the VOIP intercom is possible. Any visitor can use all three systems except the mobile intercom.
2. Only the mobile intercom and this system can provide a wireless way to install use and give the residents sufficient mobility.
3. Only the mobile intercom and this system can provide sufficient flexibility and home security, while the VOIP intercom needs to be set up separately before it can be provided.

In summary, this system provides the ability to know if someone is visiting the home when the resident is not at home, and it also provides the ability for the resident to use the system at any time and any place, which also provides flexibility in wireless installation and use and provides sufficient mobility for the residents. Any visitor can also contact the resident through this intercom, while there is no way to confirm whether the resident is at home, which enhances the home's security. While this system is more convenient and secure than traditional intercoms and existing solutions, there are many issues to discuss.

1. Although using instant messaging software eliminates the need to install and learn new apps, it is easy for users to accept and significantly reduce the cost of developing new apps. However, because none of the current instant messaging software opens API to provide a real-time call function from a third party, the current system notifies residents and visitors with text, photo, video, or audio files. Still, there is no way to provide a real-time voice call function.
2. However, since the system is integrated with third-party instant messaging software, when some of the features of the instant messaging software are updated, the features of this system may need to be updated as well.

7. Conclusions

In this study, a remotely controlled smart intercom system based on an embedded system is designed and integrated with the chatbot function of an instant messaging platform. The embedded system is the intercom host and the chatbot server of this system. This system does not require a handset in the home, but only the instant messaging software of a smartphone, without the need to install an app. This can reduce the cost of codes and wiring between the interior and exterior of the system.

The instant messaging software of the smartphone replaces the handset, and the chatbot function is triggered through the messaging API of the instant messaging platform. The resident can use the existing instant messaging software of the smartphone to click on one of "Open Door", "Watch", "Alarm", and "Busy" menus to remotely control the WoT devices through the web services.

Residents can receive system notifications through their smartphones, whether they are at home or not, without installing new apps, and they can communicate with visitors. Visitors cannot confirm if a resident is at home by pressing a button on the intercom, which promotes home security. For security reasons, the system uses a cathode lock that cannot be tampered with from the outside and will not unlock in the event of a power failure. The system is designed to install a buzzer as an alarm to keep outsiders away.

All kinds of web services used in this system are executed within the closed system to meet the security requirements. The smart intercom is available for visitors and receives an instant messaging platform to drive various chatbot functions which smooth the operation of various devices, such as the touch panel, the camera, the buzzer, and the relay, through web services.

This study combines an embedded system with an instant messaging platform to build a chatbot server that controls door locks, cameras, buzzers, and related devices through the web services on the WoT, making the system significantly safer and more convenient than the traditional intercom systems.

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