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Room Monitoring System Using OpenWRT-Based Webcam

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***Abstract*— The development of Closed Circuit Television (CCTV) technology makes it easier for a user to monitor a room. However, the use of CCTV still cannot reach all levels of society due to the price is relatively expensive. Therefore, it is necessary to build a new system that has the same features as CCTV devices in general but at a more affordable price. This system was built using the OpenWRT operating system. The operating system will be installed on a wireless router with several additional tools to support its functionality such as speakers, GSM modems, webcams, and flash drives. The resulting system has the ability to detect movement and store images and videos when suspicious movements are detected. In addition, this system also has several other features such as alarm alerts, Short Message Service (SMS) warnings, user email reports, and easy access via WIFI and the internet.**

Keywords-CCTV; OpenWRT; Router Wireless

I. INTRODUCTION

Globalization and economic growth encourage people to become consumptive. Even this consumptive habit does not consider whether the property consumed is his property or the property of others, which triggers criminal acts, such as theft and robbery.

On the other hand, technological advancements give birth to a monitoring system using CCTV devices. The use of this device makes it easy to monitor the situation and condition of a room so it can prevent the occurrence of a crime. However, the price of expensive CCTV makes this device not accessible to everyone.

With these two backgrounds, a system is able to monitor rooms easily to be built. This home monitoring system uses wireless devices that will be modified and adapted to user needs. It is expected that with this wireless technology the system will be more practical, inexpensive and easy to access from anywhere.

II. METHODS

This study aims to produce a room monitoring system that is able to facilitate users in carrying out supervision and taking precautionary measures before things happen that are not desirable. This system is built on a router with the OpenWRT operating system [1]. Sensor input on this system uses webcam and motion applications. Whereas as a warning feature to users, the system uses Short Message Service (SMS). In order for monitoring results to be widely accessed, SSH tunnel is used as a local network link on a router with an outside network [2].

A. Data Collection

The process of data collection was carried out in two ways, namely literature study and interview. Literature studies are conducted by searching for and studying various information about OpenWRT through reference books, papers, scientific journals, e-books, papers, internet documentation, website and final assignments that have similar topics. Interviews were conducted directly to the resource persons to obtain data and information related to the research theme. While the software used includes:

B. System Development Requirements

This study requires several tools so that research can run smoothly and in accordance with the research theme. The device is divided into two, namely hardware and software. The hardware used include: monitoring system hardware (Router Wireless TP-LINK MR3420, Sandisk 8GB USB drive, Modem GSM Sierra AT&T, Webcam X-Tech, Generic USB Soundcard, and USB Hub Mumuksu) and Virtual Private Server (VPS) hardware (Intel Xeon E3-1230 v2, Harddisk 10GB, RAM 256 MB, IP Address = 192.211.51.42, and 100 Gb Data Transfer)

While the software used is OpenWRT Attitude Adjustment 12.09 Beta. This application also install packages include: Alsa-lib 1.0.24, Ffmpeg 0.8.7, Lighttpd 1.4.30, Madplay 0.15, Mjpg_streamer r184, Motion 20110806, Msmtp 1.4.27, Mysql Server 5.1, Php 5.43, Samba Server 3.6, and Sdparm 1.04. besides, some of the software used is Windows 7, Putty 0.62, WinSCP 5.10, Sublime Text Editor 2, Mozilla Firefox 18.02, and Google Chrome 24.0.

C. System Development Method

The system development method in this study refers to the SDLC (System Development Life Cycle) method, using the waterfall model or Linear Sequential Model [3]. The Waterfall method has several processes which are run sequentially: analysis, design, implementation, testing, and maintenance.

III. IMPLEMENTATION

A. Analysis

Room monitoring and security systems, or often called CCTV, which are currently being developed, are mostly still dependent on PCs and DVRs as a control center. The prices of PCs and DVRs that have not been reached by everyone have resulted in the monitoring system not being used by all levels of society, still limited to government agencies, hotels, malls, and large companies. In addition, not all outstanding CCTV systems have supporting sensors to tighten security. Another disadvantage is that there is no realtime warning system when things happen that are suspicious.

Based on this background, the authors developed a new stand-alone system using the TP-LINK MR3420 and OpenWRT routers as the operating system. The sensor used is a motion detector using a webcam tool. This webcam also functions as an image taker for documentation. This system also has its own warning system when things happen that are suspicious, this warning system is between alarms, real-time warnings via SMS and daily log records through email.

B. Design

The room monitoring system built is a new alternative in the field of security. This system is built embedded in a router with the OpenWRT operating system so this system will be more concise and practical when compared to systems that have been built before.

Another advantage of the system to be built is the ease of accessing and controlling the system. The web-based interface will make it easier for users because it can be accessed using computers, laptops, tablets or mobile phones. The existence of wireless features and direct access from the internet will make it easier for users to control the state of the room. Thus, the room/house that has been installed this system will remain safe because it has a remote feature.

This system has several advantages such as:

- SMS alert to users
- Daily Log Report via Email
- Alarm when motion is detected
- Capture images of the state of the room when motion is detected
- Record the state of the room when motion is detected

- Access Control Panel using WIFI and the Internet

For more details of the concept of this room monitoring system can be seen in Fig 1.

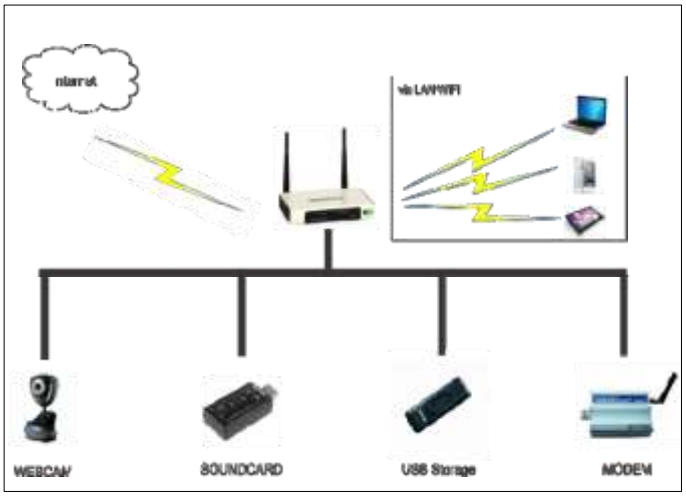

Figure 1. Concept Design of Room Monitoring System

The design shows that the router is in charge of controlling the functions of the tools below which are divided into several modules. Sensor module with a Webcam tool as a motion sensor and recording device. Alarm module with a soundcard tool as a means of sound output. Storage Module with a USB Storage tool as storage for recording and also an SMS Module with a modem device that functions as an SMS sender. While access to the router can be done through 3 ways, using LAN cable, wifi network, and internet [4].

1. System Design

The user will be faced with the date set when first turning on the system (Fig 2). Date settings are needed because the router does not have a hardware clock like on most PCs. So when the router is off, the date will return to default settings.

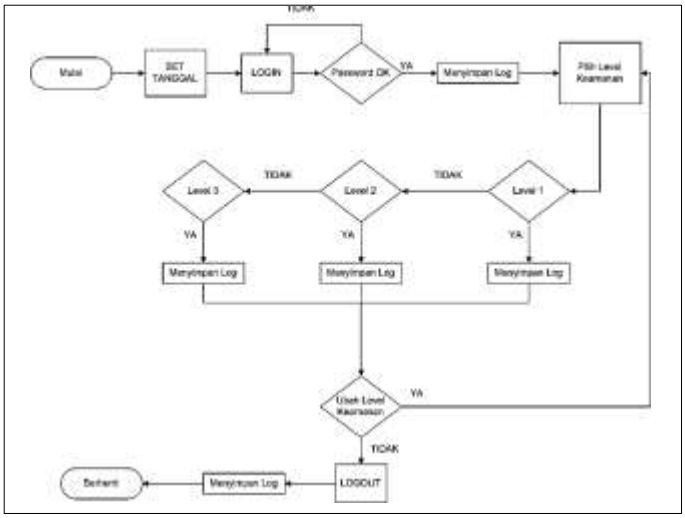

Figure 2. Flowchart of The Monitoring System

This monitoring system will have 3 function levels. At level 1, the system has a function as a room streaming tool. At level 2, the system will have a function as a streaming tool with additional alarm sounds when motion is detected. At Level 3, the system has a streaming, alarm and SMS function to the user.

Level 1 is the lowest level in this system. The monitoring system will work like a CCTV without any additional facilities. At this level, the tool that functions only is the webcam as a means of streaming. As for other devices such as GSM and soundcard modems, they will be temporarily turned off. Streaming results from level 1 can be accessed through the browser. At level 2, there are 3 modules that work, namely the sensor module as a motion detector, the alarm module as a means of typing sound output is detected and also a storage module that will store the recording when motion is detected. At level 3, all modules will work or in other words, this level is the maximum level.

To work optimally, several modules will be built that will support system performance. The modules include:

a. Sensor Module

The Sensor module has 2 roles, namely as a motion detection device and also as a video input tool for streaming. This module uses a webcam as its input device. As a motion detection processor used in motion applications. As for the streaming process, use the application mjpg-streamer.v. Apart from being a sensor, the webcam also serves to store photos of the display of the room when motion is detected. The results of this photo will then be saved on the flash drive.

b. Alarm Module

This Alarm Module will work after movement is detected, and will continue to work as long as the motion is still detected. Because the router does not have an internal soundcard, a USB soundcard is used as an additional tool. This USB soundcard is then connected to a mini speaker so that the sound produced is louder.

c. Storage Module

Storage on this module uses 8GB of the flash drive. This flash drive functions as a limited increase in router storage capacity. This flash drive is partitioned into 2, namely ext4 and swap. The ext4 partition is used for the OpenWRT operating system and the storage of the results of image capture from the sensor and video modules, while the swap partition is used as a memory backup when the router's internal memory is full. Inside the storage module, the samba server is also configured. Samba server functions to facilitate users in viewing the results of shooting. With this samba server, the results of images stored on the router can be seen directly through the user's computer without having to go through the download process.

d. SMS Module

The SMS module will work depending on the time specified. The SMS will be sent when the motion is detected, while the second SMS will be sent at the specified time. The time to send

an SMS has a choice of 1 to 10 minutes after the first motion is detected.

e. Video Module

This video module serves to combine photos taken by webcam into 1 video. The photos that are combined are the results of taking in 1 day. In order not to overload the system, the merging process is done once a day at 00:01.

f. Email Module

The email module serves to send the log records in one day to the admin email. By default, OpenWRT does not support the e-mail sending function. So it is necessary to install the SMTP server application, msmtp.

g. Scheduling Module

The Scheduling Module functions to arrange other modules to run automatically at the specified time. Modules that work under the Scheduling Module are Video modules and Email Modules. Both of these Modules will be run automatically at 00.01.

h. Log Module

The Log Module functions to record all activities carried out by users on the system.

i. SSH Tunnel Modul

The router in the monitoring system will be connected to the VPS that has been configured as an SSH path. VPS serves to bridge users who want to access the monitoring system via the internet. SSH Tunnel will work by forwarding the connection that enters the IP VPS to the IP on the router monitoring system. With this SSH Tunnel, the monitoring system can be accessed from anywhere. The scheme of the VPS module can be seen in Fig 3.

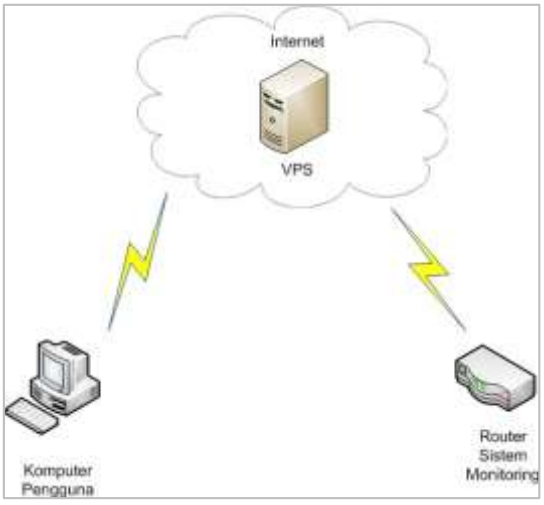

Figure 3. SSH Tunnel Module Schema

1. Interface Design

The system interface design is intended as a display template for the system to be built. The system interface is an intermediary between users as system users with existing systems. System interface design is divided into 5 main parts (Fig 4), namely:

- Title (Judul) = Contains system name / logo
- Navigation Menu (Menu Navigasi) = Contains menus used for navigation
- Menu = Contains menus from existing modules
- Contents (Isi) = Contains entries from the selected menu
- Footer = Contains the identity of the author

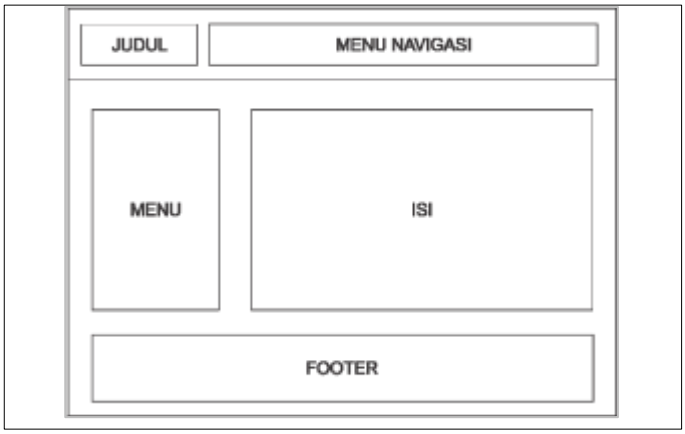

Figure 4. System Interface System

C. Implementation

The implementation phase explains how the steps taken to build a monitoring system are in accordance with those described in the design stage.

1. Router Configuration

The default firmware owned by the TP-LINK MR 3420 router does not support being used as a monitoring system, therefore the original firmware of the router needs to be replaced with the Open WRT operating system.

The TP-LINK MR 3420 router by default has a gateway IP of 192.168.1.1, so in order to be able to access the router control panel, it is necessary to configure the IP address on the client side. The IP address entered into the client must be one network with the IP address on the router as shown in Figure 5. After the IP address configuration is complete can be done using the form as shown in Fig 5, the control panel of the router can be accessed through the browser at the IP address 192.168.1.1.

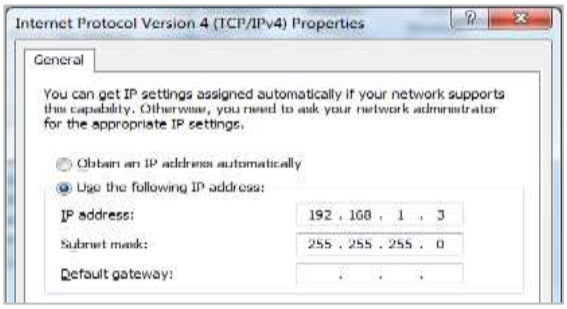

Figure 5. Configuring the IP Address on The Client

To replace the firmware with OpenWRT, then select the System Tool menu then Firmware Upgrade as shown in Fig 6. The OpenWRT firmware itself can be downloaded via the official website www.OpenWRT.org.

Figure 6. The Process of Replacing Firmware into OpenWRT

After the firmware replacement process is complete, the router can be accessed again by entering the IP address 192.168.1.1 in the browser as shown in Fig 7. The control panel display will change because it uses the OpenWRT firmware.

Figure 7. Display of The OpenWRT Control Panel

After the firmware replacement process is complete, the next step is to arrange the tools used in accordance with the room monitoring system scheme that has been described at the design stage. The appearance of monitoring system tools can be seen in Fig 8. In this study, the authors used additional tools namely mini speakers. This speaker is used as a sound dealer for alarm when motion is detected.

Figure 8. Monitoring System Device

2. Module Configuration

a. Sensor Module

The webcam used in the sensor module has 2 functions, namely for streaming and motion detection. These two functions will work according to the level of a security level that is activated. Fig 9 is a page display for replacing the security level to be used. This system has three levels of security levels. For an explanation of each level of security, it has been described at the design stage.

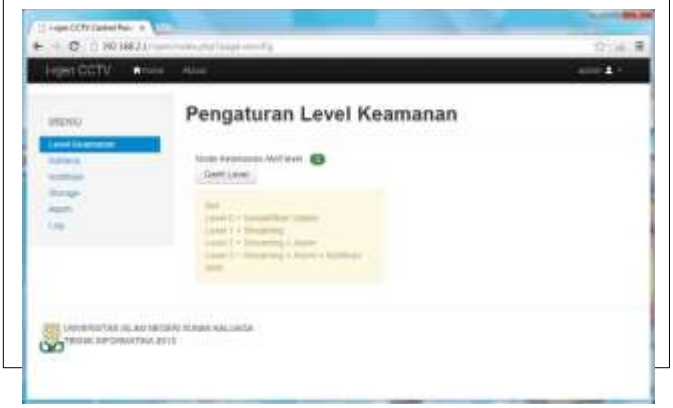

Figure 9. Display of The Security Level Page

When level 1 is activated, the webcam will function as a streaming tool. The following command is used to run the streaming function using Bash Interpreter [5]:

```
# mjpg_streamer -i "input_uvc.so -d
/dev/video0 -r 640x480 -f 30 -y" -o
"output_http.so" -b
```

The above command will run the streaming function using the mjpg_streamer application by taking the video source from the / dev / video0 port with a resolution of 640 x 480 pixels.

When level 2 and 3 are activated, the webcam will function as a motion detection sensor. The motion detection sensor will be set using application motion. This motion application works based on the configuration located in the /etc/motion.conf file.

When motion is detected by this sensor, the capture screen will be marked using a red box as shown in Fig 10.

Figure 10. Display of Detected Motion

b. Alarm Module

Fig 11 shows display of the alarm page. On this page, there are 3 sound choices to be used as alarm sounds when motion is detected. This alarm will sound for 8-12 seconds following every 1 motion detected

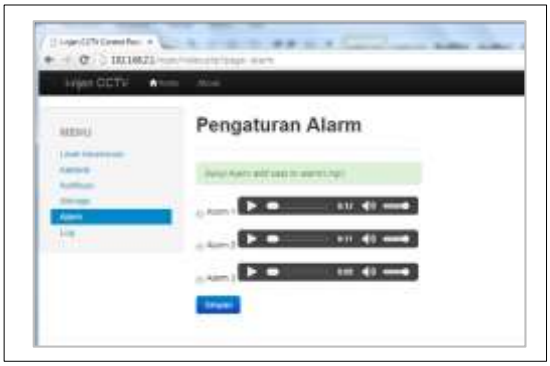

Figure 11. Display of The Alarm Page

c. Storage Module

Fig 12 is a display of Storage Module. Storage module has two main functions, namely for the OpenWRT system itself and the captured data storage from the motion detection sensor. The results of capturing motion detection sensors can be in the form of images with jpg type and video with type mp4. These two backup files will be stored in the logcam folder.

Figure 12. Storage Page Views

In order to easily access these files, the samba server application is installed in this storage module. With this samba server, the files on the storage module will be accessible using the laptop/user's computer directly as shown in Fig 13.

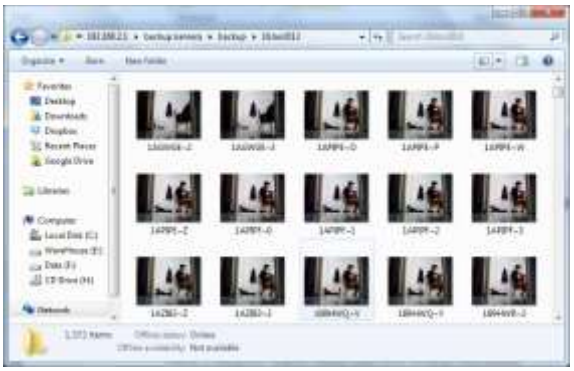

Figure 13. Display of Samba Server Access

d. SMS and Email Module

Fig 14 shows a display on the notification page. This page contains two types of modules, namely the SMS module and e-mail module. The SMS module settings load the destination mobile number and the distance of the SMS when the motion is detected. While setting up the email module contains the destination email address form for daily log shipping.

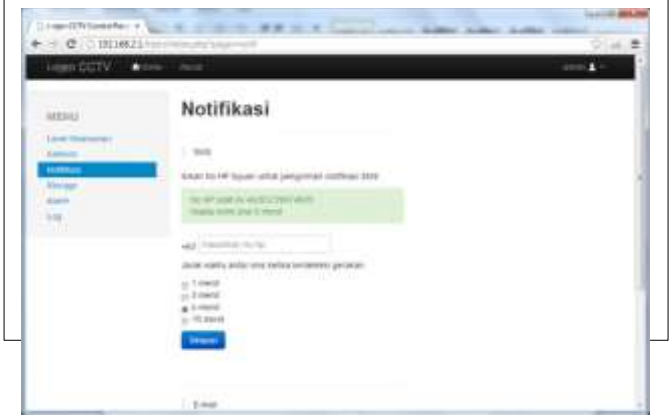

Figure 14. Notification Page Display

Sending SMS works using AT Command [6]. The following is the listing of the SMS delivery script assuming the GSM modem is on / dev / ttyUSB0 port:

```
echo -e -n "AT+CMGF=1 \015" >
/dev/ttyUSB0
echo -e -n "AT+CMGS=\"+62$HP\"
\015" > /dev/ttyUSB0 echo -e -n
"Perhatian, terdeteksi gerakan
mencurigakan pada $(date). Segera
lakukan tindakan lebih lanjut \015"
> /dev/ttyUSB0
echo -e -n "\032" > /dev/ttyUSB0
```

Sending email uses the mail() function from php [7]. By default the mail() function cannot be used because in OpenWRT

there is no SMTP application. For this reason, the msmtp application is installed which functions as SMTP.

e. Video Module

The video module serves to combine the capture motion sensor in the form of an image file into a video file. To perform the merging function, the ffmpeg library is needed. The following commands are used in the process:

```
# cat *.jpg | ffmpeg -f image2pipe -r 1 -
vcodec mjpeg -i - motion_$date.mp4
```

The above command will produce a video with the name motion that contains a collection of image files in 1 day.

f. Scheduling Module

The scheduling module has the task of automatically running e-mail modules and video modules at 00.01 every day. This module uses cronjob [8] to carry out its functions. Following is the listing of the cronjob code to run the 2 modules.

```
01 00*** /www/injen/script/kirimemail.sh
01 00*** /www/injen/script/backup.sh
```

The first and second lines will work at 00.01, the two lines will run the sendemail.sh and backup.sh functions.

g. Log Module

Fig 15 is a view of the log page. On this page, the last 30 logs will appear on this monitoring system. This log is stored using the MySQL database. In addition, a log backup button is also provided.

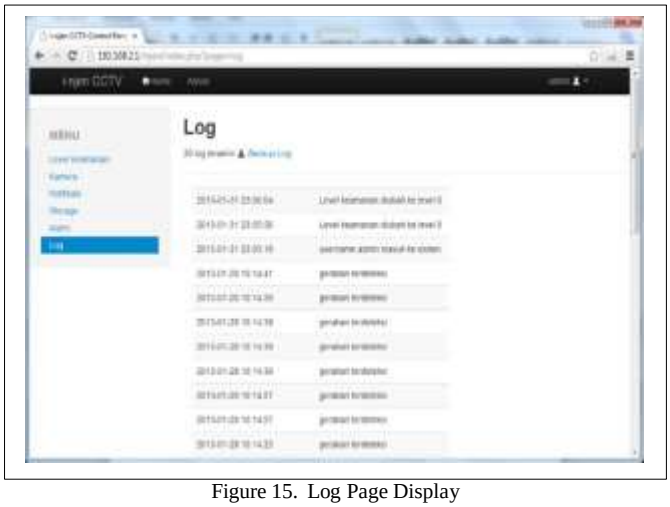

Figure 15. Log Page Display

h. SSH Module

The SSH module is used as a port forwarding path from the public network to the local network. This SSH module uses one VPS server that functions as a connecting line. VPS Public IP is 192.211.51.42 while for IP routers the monitoring system is 192.168.2.1. The following SSH command is used.

```
# SSH -T -N root@192.211.51.42 -R
80:192.168.2.1:80
```

The command above means that every connection to IP address 192.211.51.42 port 80 will be transferred to the local network by IP 192.168.2.1 on port 80.

D. Testing

The next step is testing the system. The purpose of this stage is to find out whether the system created is in accordance with the purpose of manufacture or not. At this stage, two tests were carried out, namely testing system functionality and questionnaire testing to respondents. Both of these tests are carried out in a bright room with a static camera position.

1. System Functionality Testing

This test is divided into two scenarios based on the level that has been determined at the design stage. Scenario 1: Testing using level 2 security level. At this level, the modules that function include Sensor Module, Alarm Module, Storage Module, SMS Module, Email Module, and Log Module.

The results of scenario 1 testing can be seen in Table 1 and Table 2:

TABLE I. RESULT OF THE FIRST SCENARIO TESTING

Testing	Sensor	Alarm	Storage	Log
1	Detected	Ringing	Image saved	Saved
2	Detected	Ringing	Image saved	Saved
3	Detected	Ringing	Image saved	Saved
4	Detected	Ringing	Image saved	Saved
5	Detected	Ringing	Image saved	Saved
6	Detected	Ringing	Image saved	Saved
7	Detected	Ringing	Image saved	Saved
8	Detected	Ringing	Image saved	Saved
9	Detected	Ringing	Image saved	Saved
10	Detected	Ringing	Image saved	Saved

TABLE II. RESULT OF SECOND TEST FOR THE FIRST SCENARIO

Testing	Scheduling	Video	Email	SSH Tunnel
1	Running	Saved	Sent	Running
2	Running	Saved	Sent	Running
3	Running	Saved	Sent	Running
4	Running	Saved	Sent	Running
5	Running	Saved	Not sent	Not running
6	Running	Saved	Not sent	Not running
7	Running	Saved	Not sent	Not running
8	Running	Saved	Sent	Running
9	Running	Saved	Sent	Running
10	Running	Saved	Sent	Running

From the results of testing scenario 1 above, it can be concluded in general that the level of security level 2 is going well. But problems arose in tests 5, 6 and 7 of the email module and SSH tunnel. After checking it is known that the e-mail sending process has been running but does not reach the destination. This is due to the slow internet connection that affects the attachment upload process. Likewise with the SSH Tunnel module which requires a high-speed internet connection to be smoothly accessed from the internet.

Scenario 2: Testing using level 3 security level. The modules tested are the same as scenario 1 with the addition of the SMS

Module. The results of scenario second testing can be seen in Table 3 and Table 4.

TABLE III. RESULT OF SECOND SCENARIO TESTING

Testing	Sensor	Alarm	Storage	SMS	Log
1	Detected	Ringing	Image saved	Sent	saved
2	Detected	Ringing	Image saved	Sent	saved
3	Detected	Ringing	Image saved	Not Sent	saved
4	Detected	Ringing	Image saved	Sent	saved
5	Detected	Ringing	Image saved	Sent	saved
6	Detected	Ringing	Image saved	Sent	saved
7	Detected	Ringing	Image saved	Sent	saved
8	Detected	Ringing	Image saved	Not Sent	saved
9	Detected	Ringing	Image saved	Sent	saved
10	Detected	Ringing	Image saved	Sent	saved

TABLE IV. RESULT OF SECOND TEST FOR THE SECOND SCENARIO

Testing	Scheduling	Video	Email	SSH Tunnel
1	Running	Saved	Sent	Running
2	Running	Saved	Sent	Running
3	Running	Saved	Sent	Running
4	Running	Saved	Sent	Running
5	Running	Saved	Sent	Running
6	Running	Saved	Sent	Running
7	Running	Disimpan	Not sent	Running
8	Running	Disimpan	Not sent	Running
9	Running	Disimpan	Not sent	Running
10	Running	Disimpan	Not sent	Running

From the results of testing scenario 2, it can be concluded that in general, the system runs smoothly at the level 3 security level. Problems are encountered in the SMS module, which failed to send SMS to tests 3 and 8. Problems were also encountered in email modules that were unable to send emails on the 7th, 8th, 9th and 10th tests. After checking, the cause of the SMS module has not yet known why it failed in sending an SMS. In the email module, it is known that the size of the log database that is getting bigger results in the failure of the attachment upload process. This is also influenced by the internet upload speed.

2. Questionnaire Testing

This test aims to obtain objective test results by distributing questionnaires to several respondents with a background in Informatics Engineering students. The questionnaire used in this test focused on system functionality and system interface. The results of testing the system functionality can be seen in table 5, while the results of testing the system interface can be seen in Table 6.

TABLE V. SYSTEM FUNCTIONAL TEST RESULTS

No	Statement	Yes	No
1	The Login and Logout process can run well	10	
2	The process of replacing the security level can run well	10	
3	The process of replacing the alarm goes well	10	
4	The process of replacing the SMS and email destination number works well	10	
5	The camera menu functions at levels 1, 2 and 3	10	
6	At Level 2, the alarm sounds when motion is detected	10	
7	At Level 3, the alarm sounds and the SMS is sent when motion is detected	9	1
8	Emails are sent per day with an attachment log database backup	9	1
9	The results of capturing images by a webcam can be accessed using samba	10	
10	The log works by displaying the last 30 events	10	
11	The monitoring system can be accessed via a local network (LAN and WIFI)	10	
12	The monitoring system can be accessed through public networks (Internet)	9	1
13	This system has functioned properly as an alternative monitoring system	10	
Total		127	3
Percentage		97%	3%

TABLE VI. SYSTEM INTERFACE TEST RESULTS

No	Statement	Strongly Agree	Agree	Disagree
1	The system has easy navigation		10	
2	System appearance is convenient for users	2	7	1
3	Each menu works well	1	9	
4	Controlling the security level is not confusing	1	8	1
5	Streaming videos can be watched comfortably		2	8
Total		4	36	10
Percentage		8%	72%	20%

The results of system testing based on system functionality concluded that most respondents stated that the functionality of the system was functioning properly. From the test results, it is known that 97% state that the system functionality is running well and the remaining 3% states otherwise. The results of system interface testing show that most respondents agree with the system that has been made. Test results show that 8% strongly agree, 72% agree, 20%. Based on the two tests above, it can be concluded that this monitoring system is worthy of being used as a reliable CCTV alternative.

E. Maintenance

To support optimal system performance, maintenance of the system as a whole is needed. This treatment includes the software and hardware used. In software, system maintenance includes checking the configurations used, the capacity of the flash drive whether it is full or not and the connection between the router and VPS. Whereas for hardware maintenance includes checking the camera position, checking the remaining pulses on the modem, checking the sound on the speaker and checking on the USB Hub.

IV. CONCLUSION

After doing the research, some conclusions were taken. A room monitoring system using the OpenWRT operating system has been successfully built. The system has been able to detect movement in the room using a webcam. The system has been able to provide real-time alerts using alarms and SMS. The results of observations in the form of image and video files that can be accessed directly through the user's computer. The system can be accessed locally via LAN and WIFI connections and widely via the internet.

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