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The Design of Security Device for a Simple House Environment Based on Raspberry Pi

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The present security systems in simple house environments, specifically in remote areas, are not designed using appropriate technologies. Therefore, this research aimed to develop a security device using a Raspberry Pi-based webcam to monitor simple house environments in line with the present advancement in technology. The results showed that the software and monitoring tools developed to monitor and secure electrical devices both remotely and locally using a smartphone functioned effectively.

Keywords: security monitoring device, simple house environment, Raspberry Pi, smartphone.

1. Introduction

The rapid development of technology enables practitioners to constantly generate new ideas that enhance human work and address common societal issues. Meanwhile, rural communities and villages in Indonesia still rely on manual security and surveillance systems using traditional methods such as "SISKAMLING" (Community Security System) or patrols by local authorities despite technological advancement. These traditional methods are often accompanied by the use of bamboo sirens in case of emergencies such as thefts or natural disasters, leading to some weaknesses despite the long-standing application in rural areas. The first is the lack of appropriate equipment to critically assess cases of theft, robbery, or fires. The second is the limited range of bamboo sirens which only covers communities near the incident locations. The third is the lack of official records of incidents occurring in these communities.

Considering the present technological advancements, it is highly feasible to improve the old system to be more efficient by integrating relevant technology into several sectors. The improvement can be achieved through the development of a simple house environment security monitoring device in strategic areas based on Raspberry Pi to monitor the overall

condition of the region, specifically the residential areas. Moreover, the emergency incidents occurring can be recorded more systematically for future evaluations by the government or the community, and more specifically for the residents of Simple Housing Complexes. The system is also expected to display images in real-time to ensure the residents are aware of every activity occurring at the house when on a trip or outside.

1.1 Research Objectives

The general objective of this research is to develop an appropriate technology in the form of a Raspberry Pi-based monitoring security device. The technology is intended to assist residents in managing and monitoring their environment in order to avoid the threat of theft that often disrupts residential houses, specifically the simple ones in remote areas. Therefore, the specific objectives are stated as follows:

1. To produce a prototype of Raspberry Pi-based monitoring system software that monitors a simple house environment using a smartphone.

2. To produce a prototype of a Raspberry Pi-based monitoring device that uses a smartphone to monitor a simple house environment.

3. To build an interface and application for a Raspberry Pi-based monitoring system that allows using smartphones to monitor a simple house environment.

1.2 Research Urgency

Several urgent factors are observed to have influenced this research. The first is the need to develop an appropriate technology for housing consumers to secure their environment from unmonitored malicious activities. The second is focused on the utilization and development of existing technology to be applied to common activities in the social life of Indonesian communities, particularly in residential complexes in remote areas. Meanwhile, the third is the need to monitor the surrounding area of residential complexes in order to observe uncontrolled theft and ensure perpetrators are swiftly apprehended by the authorities.

1.3 Theoretical Review

Design is the preparation stage that describes the formation of a website for implementation. This stage focuses on illustrating, planning, and developing sketches to arrange different elements into a single functional unit, such as configuring software and hardware components. Meanwhile, the growing complexity of network services has increased the demand for methods that support effective network design and architecture. This led Cisco to introduce the PPDIOO model which consists of Prepare, Plan, Design, Implement, Operate, and Optimize.[13]

The lifecycle of network development using the PPDIOO model provides important steps for successful network planning, covering the design, implementation, and operational phases. This top-down design method directs the network infrastructure to adapt to the applications required. The trend is associated with the information provided by the CCDA 640-864 Official Cert Guide that Cisco has developed a network planning lifecycle formula comprising six phases, including Prepare, Plan,[13] Design, Implement, Operate, and Optimize.

1.4 Webcam

A webcam or USB camera is an electronic device that captures objects through a PC or laptop. It is also used for visual communication, allowing users to interact face-to-face over the Internet [2].

Figure 1. Webcam

1.5 IP Address [6]

Internet Protocol Address, often abbreviated as IP, is a series of binary numbers ranging from 32 bits to 128 bits which are used to identify the address for each host computer in an Internet network. The length of the binary numbers is based on the division of the addresses, including 32 bits for IPv4 or Internet Protocol version 4 and 128 bits for IPv6 or Internet Protocol version 6, which can be applied to determine the address of the computer on TCP/IP-based Internet network. Moreover, the Internet Assigned Numbers Authority (IANA) manages the allocation of global IP addresses. The process is achieved by working on computers participating in networks utilizing IP for communication between nodes. It is important to state that although IP addresses are stored as binary numbers, they are typically displayed in a format considered easier for humans to use, including 208.77.188.166 for IPv4 and 2001:db8:0:1234:0:567:1:1 for IPv6.

IP handles the task of routing data packets between networks, assigning appropriate addresses, and determining the location of source and destination nodes in the topology of the routing system. To achieve this, certain bits in the IP address are used to specify a subnetwork with the number presented in CIDR notation, for example, 208.77.188.166/24. Moreover, data transmission in TCP/IP networks depends on the IP addresses of the sending and receiving computers. It is important to state that the IP address consists of the address for both the network and the local host. Routers use the network address to locate the network where a local computer resides while the local host is often applied to identify a specific computer in the local network.

1.6 Access Point [9]

Access points are available in several places, including houses, businesses, and public locations. In most houses, it is a wireless router connected to a DSL or cable modem. However, some modems have wireless capability which shows the possibility of using the device as an access point. Large companies often provide multiple access points, allowing employees to connect wirelessly to the network center from different locations. This shows that an access point is a hub or switch connecting a local wired network to a wireless network. It can also be explained as the place where data or internet connections are broadcasted or transmitted via

radio waves. Moreover, the strength of the signal which is measured in dBm or mW affects the coverage area. The trend is based on the observation that a stronger signal strength can lead to the coverage of a larger area.

1.7 HTML [1,7,10]

HTML is an acronym for Hyper-Text Markup Language which is a standard programming language often used to develop web pages to display different information through an Internet web browser. It can also be used to develop links between files on a website or computer using localhost as well as to ensure connection between sites on the Internet. To produce a combined display appearance, simple hypertext formatting is written in ASCII format files and transformed into a web page through HTML commands. Moreover, HTML originates from a language previously used in printing and publishing called Standard Generalized Markup Language (SGML) which is currently an internet standard controlled and defined by the World Wide Web Consortium (W3C). The language was developed in 1989 in collaboration with Caillau TIM when working at CERN, a high-energy physics research institution in Geneva.

1.8 Server

A server is a computer system that provides specific services to consumers in a network. It is equipped with a specialized operating system, commonly referred to as a network operating system, to control access and resources.

1.9 Raspberry [8,11,12]

Raspberry Pi is an incredibly practical credit card-sized computer. The operating system is integrated into an SD Flash Card, making it easy to change and swap. The potential of the device is important and unexplored but has been tested as a multimedia player with streaming capabilities, a gaming device, an internet browser, and a hardware development mainboard. This allows the device to be an educational tool for people of all ages and skill levels. Moreover, the interest in Raspberry Pi is extraordinary and has far exceeded expectations considering the fact that IT professionals, electronics experts, and newcomers are all eager to explore the small device. Everyone has also agreed that the device has significant potential for growth and advancement. The activities and operations of Raspberry Pi are explained in the following sub-sections.

1.9.1 General Purpose Computing

Raspberry Pi is a computer and can be used to perform relevant functions. The readiness of the device allows users to boot directly into a GUI (Graphical User Interface) environment, including the web browser which is a computer application widely used in the present world. The device can also install several free applications, such as LibreOffice, normally applied for office work.

1.9.2 Project Platform

The device is different from regular computers in terms of price and size as well as the ability to be integrated into electronic projects.

1.9.3 Learning to Program

Raspberry Pi is fundamentally designed as an educational tool to encourage children to

experiment with computers. This is identified from the pre-installed interpreters and compilers integrated into the device for different programming languages.

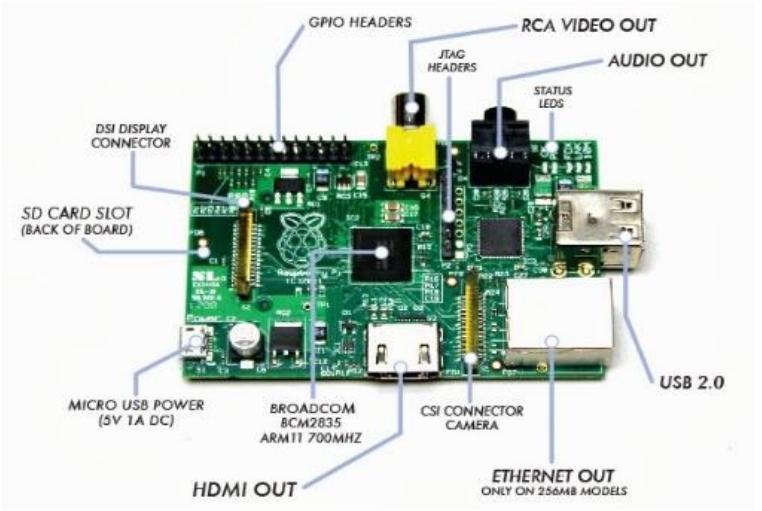

Figure 2. Raspberry [8,11,12]

2. METHOD

This research was conducted using the experimental method which was considered suitable for producing and testing the feasibility of the product developed. Moreover, specific steps were required to produce a monitoring device using a smartphone based on Raspberry Pi technology.

2.1 Research Design

Research design is an important aspect of conducting any scientific study. Therefore, the structure used is presented in the following information:

1) Independent variables were environmental conditions, disasters, emergencies, or other similar events.

2) Dependent variables were represented by the community in a simple house environment.

3) Control variables included Webcam equipment, smartphones, wireless media for connecting Webcam, PC servers, the software developed and used, as well as the electrical power required by the device produced.

2.2 Design and Installation of Infrastructure

1) Installation of Webcam and Access Points at predefined positions on Board House.

2) Design of wireless network topology to connect Webcam and PC Servers.

3) Wireless network installation according to the designed topology which was in the form of Board House.

2.3 Development of Software

1) Design and development of an application to receive, process, and store data received by GSM/CDMA modems/smartphones connected to a PC Server.

2) Design and development of an administrative application for system configuration and monitoring.

2.4 Research Tool

The tools used in this research were:

1) PC Server.
2) Wireless Media.
3) GSM/CDMA Modem or Smartphone.
4) Several units of Webcam.
5) UTP cables.
6) Switch/Hub.
7) Programming tools: C++, Java, PHP, and JavaScript.
8) Debian 7 Linux Operating System.
9) Apache Web Server.
10) MySQL Server.

2.5 System Architecture

The system was generally divided into internal and external. The external system included outdoor equipment such as a webcam and the residents of the housing environment that acted as users. It was important to state that Webcam was used to capture images in predetermined areas and the data were stored on Raspberry server and Hard Disk/Flash Drive (FD).

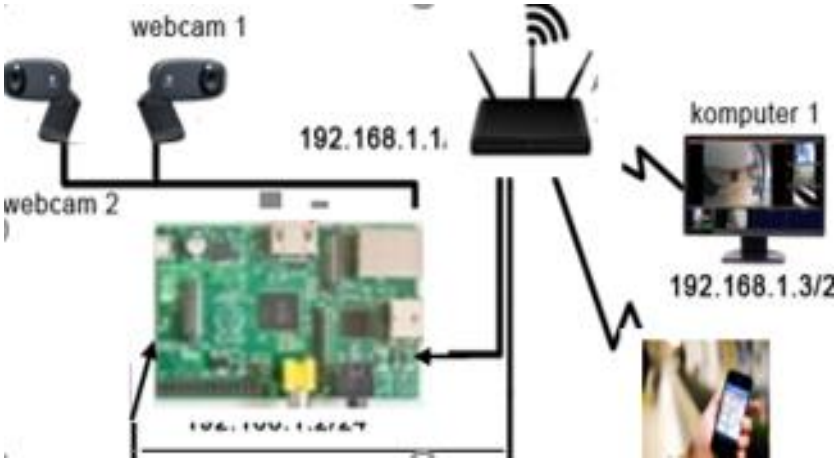

Figure 3. Monitoring System Architecture

2.6 Data Collection Methods

The data collection methods applied in this research were expert interviews, literature review, direct measurement, and documentation.

2.7 System Control Testing

1). Using Local Network

Figure 4. Local Network Architecture

The access point was used as the medium to connect smartphones and Raspberry Pi in Figure 4. The device acted as the server and monitored Webcam devices installed on Board House. Meanwhile, the smartphone served as a controller to send instructions to Raspberry Pi through a web application using IP address 192.168.1.2 to control the monitored devices according to consumer preferences.

2). Using Internet Network

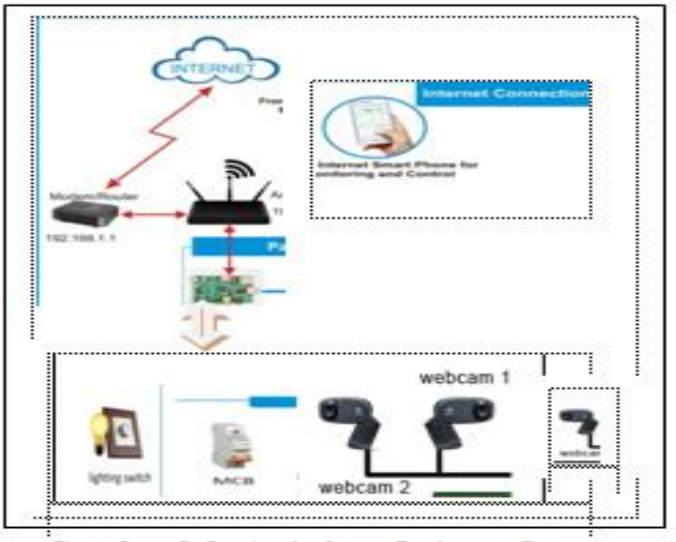

Figure 5. Internet Network Architecture

An extension of the local connection developed to enable consumers to monitor Webcam devices through the Internet is presented in Figure 5. A modem router was used as the medium to connect the local network to the Internet and users were allowed to access through smartphones using the address http://www.penelitianmonitoringgedung.ngrok.com.

3. Results and Discussion

3. Result

The application design was developed and tested using the configurations in Figures 4 and 5. The refined software was later downloaded to Raspberry Pi device which was ready for operation. The results obtained after testing the monitoring devices are presented in the following in Tables 1 and 2.

Table 1 Test for Short Circuit Protection Device (MCB)

MCB	Smartphone Status	Description
	ON	All Electrical Devices Functioning, operating at 220V.
	OFF	All Electrical Devices Not Functioning, operating at 0V.

Table 2 Test for Webcam Monitoring Device

Webcam 1	Smartphone Status	Description
	ON	Webcam 1 Device: Functions to capture all objects at the front for subsequent storage in an FD or Hard Disk.
	OFF	Webcam 1 Device: Not Functioning due to lack of power supply from Raspberry Pi.
Webcam 2	ON	Webcam 2 Device: Functions to capture all objects at the front for subsequent storage in an FD or Hard Disk.
	OFF	Webcam 2 Device: Not Functioning due to lack of power supply from Raspberry Pi.

3.2. Discussion

The test conducted on the monitoring system showed that Webcam devices and circuit breakers (MCB) functioned effectively as presented in Table 1. This was confirmed by the fact that all electrical devices on Board House, including the webcam, worked effectively when MCB was ON. These devices were designed to be controlled manually, automatically, and remotely using a smartphone.

The results presented in Table 2 showed that when the smartphone was turned ON or activated, Webcam 1 monitored the surroundings in the operational range. Meanwhile, when the smartphone was turned OFF, Webcam 1 automatically stopped functioning or switched OFF. ON-OFF state could be controlled remotely or locally using a smartphone. The same principles applied to several other electrical devices not yet installed on Board House.

4. Conclusions and Recommendations

4.1. Conclusion

In conclusion, the results obtained from this research are explained as follows:

1. Raspberry Pi-based monitoring system software functioned effectively by monitoring all installed devices, such as multiple Webcam and MCB security devices in a simple house, using a smartphone.

2. The Raspberry Pi-based Monitoring Device prototype developed was able to control the webcam and MCB security devices effectively. It successfully monitored and secured a simple house environment (through Board House) from short circuit hazards, both remotely and locally, using a smartphone.

3. The interface and application of the Raspberry Pi-based monitoring system developed for monitoring simple house environments were functional in observing and securing all devices installed, including MCB and Webcam.

4.2. Suggestions

The results and conclusions were used to formulate the following suggestions in the process of implementing the security device for a simple house environment.

1. The monitoring devices, Webcam, developed for surveillance should be installed at different points, considering the vastness of the respective residential block.

2. The monitoring devices should be placed in every simple house to monitor the entire environment.

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