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IOT BASED SMART HOME SIMULATION (INTERNET OF THINGS)

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Abstract: The development of Internet of Things (IoT) technology has significantly impacted life, particularly in creating more efficient and secure smart homes. Smart homes integrate various electronic devices to enhance comfort and energy efficiency. However, cost, integration complexity, and security issues remain. This study will simulate an IoT-based smart home system to analyse and evaluate device performance before real-world implementation. The simulation method involves testing connectivity and evaluating delay and packet loss using the ping method on each device. Results show the highest delay on CCTV devices at 41.8 ms and the lowest on motion detector 2 at 32.8 ms, with 0% packet loss. According to TIPHON standards, the network is rated excellent with an index of 4. The designed smart home system demonstrates optimal performance and is feasible for implementation but requires further development in configuration using AI and machine learning technologies.

Keywords: internet of things; simulation; smart home; testing

Abstrak: Perkembangan teknologi Internet of Things (IoT) telah membawa perubahan signifikan dalam kehidupan, terutama dalam pengembangan rumah pintar (smart home) yang lebih efisien dan aman. Smart home mengintegrasikan berbagai perangkat elektronik untuk meningkatkan kenyamanan dan efisiensi energi. Meskipun demikian, tantangan seperti biaya, kompleksitas integrasi, dan isu keamanan masih ada. Penelitian ini bertujuan untuk mensimulasikan sistem smart home berbasis IoT guna menganalisis dan mengevaluasi kinerja perangkat sebelum implementasi nyata. Metode simulasi yang digunakan melibatkan pengujian konektivitas dan evaluasi delay serta packet loss dengan metode ping pada setiap perangkat. Hasil menunjukkan delay tertinggi pada perangkat CCTV sebesar 41.8 ms dan terendah pada motion detector 2 sebesar 32.8 ms, dengan packet loss 0%. Berdasarkan standar TIPHON, jaringan dinilai sangat baik dengan indeks 4. Sistem smart home yang dirancang menunjukkan kinerja optimal dan layak diimplementasikan, namun masih memerlukan pengembangan lebih lanjut dalam konfigurasi menggunakan teknologi AI dan machine learning.

Keywords: internet of things; pengujian; simulasi; smart home

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INTRODUCTION

Internet of Things (IoT) technology has introduced significant changes in human life, including developing a more effective and efficient smart home. The smart home is equipped with various electronic systems and intelligent technology designed to improve efficiency, comfort, security, and energy efficiency [1], [2]. Different electronic devices such as lights, air conditioners, televisions, and other electronic equipment can be connected and integrated into a smart home system based on Internet of Things (IoT) technology [3].

These smart home systems offer innovative features such as remote control, automation, and monitoring and analysing energy usage. [4], [5] . Home marketing with the label "Smart Home Inside" has become a trend among property developers. Based on a Statista survey, until February 2022, 7.28 million homes were using one to 5 Smart home products, which have the potential to increase by 1 million per year so that in 2026, smart home revenue in Indonesia will reach USD 730.40 million [6]. However, with public interest in smart homes, Indonesia still has several issues, including high costs, the complexity of system integration, and concerns about security systems.

One of the main issues is the responsiveness of IoT devices, which can be affected by delay and packet loss in the network. Uncontrolled delay and packet loss in IoT-based smart home systems can hinder automation and decision-making [7]. In addition, delay and packet loss can cause security and safety issues in smart home environments [8]. To overcome these problems, an IoT-based smart home simulation is needed to help analyse and evaluate smart home concepts before they are implemented in the real world.

Research entitled "Design and simulation of an IoT-based smart office" in 2021. In his study, he produced an intelligent office system design with a remote control system, where the office's IoT system can be remotely controlled via smartphone and laptop [9].

In a study entitled "IoT network design at the Surabaya Aviation Polytechnic." He produced a simulation of an IoT device that can detect temperature conditions and turn an AC device on according to the conditions in the room [10].

The research "Simulation of Smart Home Networks with IoT-Based Systems" (P 2023). In it, he describes how IoT can make it easier for users to control devices in the home efficiently and positively impact resource use [11].

"Smart Home System using IoT" research in 2022. In his study, he explained that the results of the IoT system simulation run when opening the door using an RFID card; the IoT system on the AC will detect using a Thermostat, which will detect the existing room temperature and turn on the AC as needed. With that system, when entering the room, the air conditioner will turn on automatically [12].

This research simulates an IoT-based Smart Home system, focusing on well-defined structures and workflows in the Office Network, Cloud Network, and Cell Network. It uses the ping test method to evaluate simulation performance and automatically implements a Microcontroller Unit (MCU) to control the gate based on RFID readings. The goal is to provide a clear picture of how the Smart Home system works and evaluate the optimisation and integrity of the devices used in the simulation.

METHODS

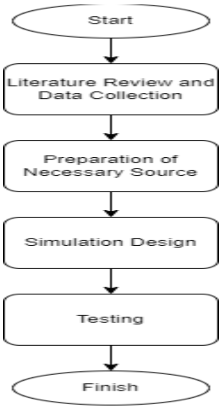

Image 1. Research Stages

This research begins with a literature study to collect information from various sources and journals related to simulation, IoT, Smart Home, Cisco Packet Tracer, and others. Next, preparations are made, such as determining the IP address for simulation. Then, the IoT-based Smart Home simulation design is carried out, including positioning the devices to be used.

The final stage is simulation testing, which includes checking the functionality of IoT devices and measuring delay and packet loss to assess device performance. The flow diagram of the Smart Home system plays an essential role in visualising and describing the structure of the simulated system, making it easier to understand, analyse, and evaluate the system in the context of the research.

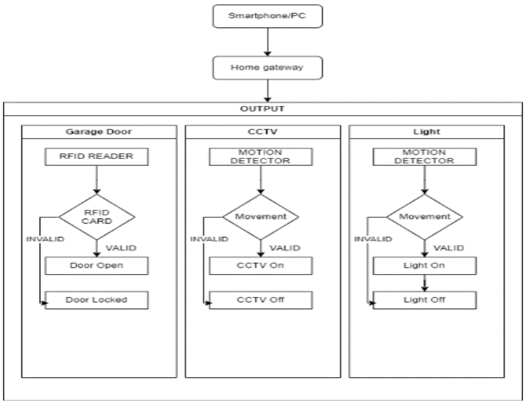

Image 2. System Flow Diagram

Image 2 illustrates a Smart home system designed to be controlled remotely via a smartphone or PC. This system will be divided into three main components: doors, CCTV, and lights, which are connected to a central control unit called a home gateway. A home gateway has an address or IP address that is connected and can access which is used to access the internet network [13]. It is connected to a remote server, which links the input device and the equipment or IoT device [14], [15].

This Smart Home system uses RFID to open the door, where a valid RFID card opens the door, while an invalid RFID keeps the door locked. Motion detectors activate CCTV and lights, so they turn on when there is motion and stay off when there is no motion. The system sends information from each component to a home gateway, which then sends the information to the user's smartphone or PC for remote monitoring and control.

RESULTS AND DISCUSSION

Smart Home Design

In this simulation, create a Smart home design with several main components or devices: fences, lights, and CCTV. Each device or component

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uses a different protocol or path. The network topology design used in this simulation can be seen in Image 3.

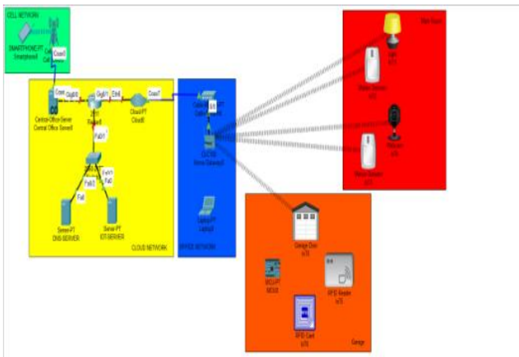

Image 3. Network Topology Design

Image 3 shows the design of the Smart Home simulation network topology, which is divided into four parts. The Cell Network consists of the Cell Tower and Smartphone, where the Cell Tower connects the Smartphone with the Cloud Network, enabling Smart Home control from different locations. The Cloud Network includes the Central Office (CO) Server, Router, Switch, IoT Server, and DNS Server, which are interconnected and perform their respective functions. Office Network consists of Office Gateway, Modem, Laptop, and Smart Device, with Office Gateway connecting Office Network with Smart Device, while Modem connects Office Gateway with Cloud Network.

Router Configuration

Router configuration connects several devices on the Cloud Network, namely the central office network, Switch, and Cloud. Table 1 is the Router IP address data. Gig0/0 is the IP connected to the Central Office Server. Gig0/1 is an IP connected to the Cloud. Gig0/2 is an IP connected to the switch.

Table 1. Router IP Address Data

Router	IP Address	Subnet mask	DNS
Gig0/0	200.165.86.252	255.255.255.224	10.20.30.254
Gig0/1	200.165.87.252	255.255.255.224	10.20.30.254
Gig0/2	10.20.30.1	255.255.255.0	10.20.30.254

Server Configuration

The servers used are DNS and IoT servers, which store DNS and IP addresses. Table 2 shows the IP address data for DNS and IoT Servers.

Table 2. IP Address of DNS and IoT Server

Identity	Server DNS	Server IoT
IP Address	10.20.30.254	10.20.30.253
Subnet mask	255.255.255.0	255.255.255.0
Gateway	10.20.30.1	10.20.30.1
DNS	10.20.30.254	10.20.30.253
Web Name	IOTServer.com	-
Username	-	rumahku
Password	-	rumahku

Home Gateway Configuration

Through the home gateway, users can monitor and control IoT devices. In addition, the home gateway distributes IP addresses and internet connections to IoT devices.

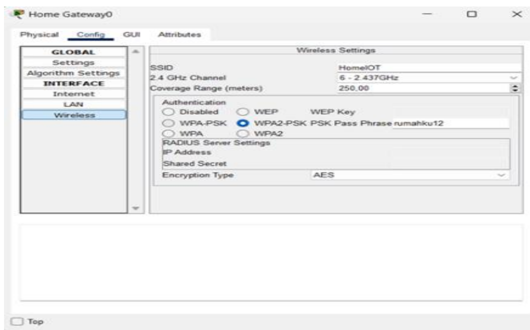

Image 4. Wireless Network Configuration for IoT Devices

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Image 4 shows the wireless network configuration that allows all devices to connect to the Home Gateway and obtain the IP address required for remote control. This network uses SSID "HomeIOT" with password "rumahku12" for security. Table 3 shows the IP address data and the remote server IP used in the research.

Table 3. IoT Device IP Address Data

IoT Devices	IP Address	Remote Server
Lights	DHCP	10.20.30.253
CCTV	DHCP	10.20.30.253
Motion Detector 1 and 2	DHCP	10.20.30.253
Garage Door	DHCP	10.20.30.253
RFID Reader	DHCP	10.20.30.253

IoT Device Configuration

Image 5 shows the configuration of the IoT devices. MD 1 is connected to detect motion and turn on the lights automatically. MD 2 is also connected to detect motion but will turn on the lights and CCTV simultaneously. The RFID reader must be programmed to recognise the card being used, and the MCU will receive a command to open the gate automatically when the RFID reader reads the corresponding card.

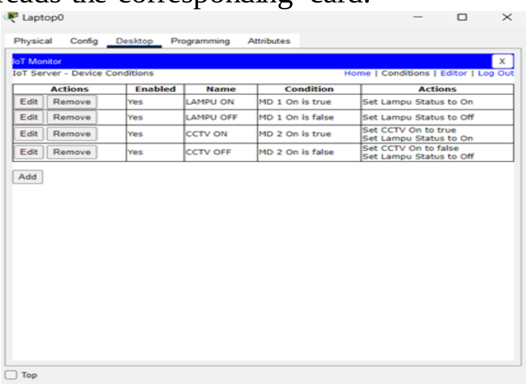

Image 5. IoT Device Configuration

IoT Device Testing

Testing IoT devices aims to determine whether the configuration that has been done can work correctly and as needed. Testing is done on one of the devices, namely on a laptop, by accessing the URL or IP address that has been connected previously. Image 6 shows the result of accessing the URL after login.

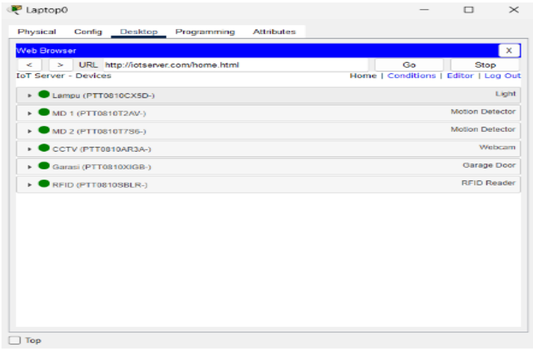

Image 6. Testing IoT Devices Using URL

After testing or trying to log in, the next step is to try the configuration done on the IoT devices. Image 7 illustrates when all IoT devices are run simultaneously.

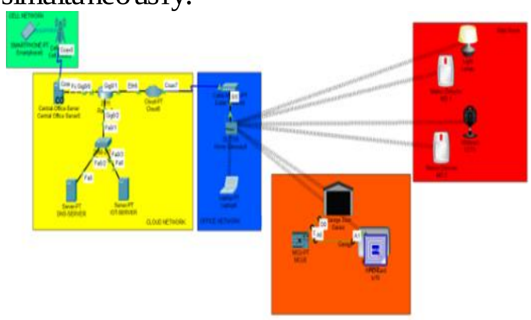

Image 7. Network Topology After All Devices Get Movement

Network Connection Testing

After testing the IoT devices, network connection testing was conducted to assess network optimisation in the Smart Home simulation. Testing involves pinging each device using a laptop, measuring delay and packet loss. The test results are compared with the

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TIPHON standard—table 4 for delay and packet loss.

Table 4. Delay and Packet Loss Categories

Category	Large Delay	Large Packet Loss	Index
Very Good	<150ms	0 - 2%	4
Good	150 - 300ms	3 - 14%	3
Simply	300 - 450ms	15 - 24%	2
Bad	>450ms	<25%	1

Testing is done at night to evaluate the effectiveness and optimisation of the network in busy conditions. Each device will be tested five times for two hours using the average value. For example, the RFID reader with IP 191.168.86.106/24 was tested with the ping test in Image 8.

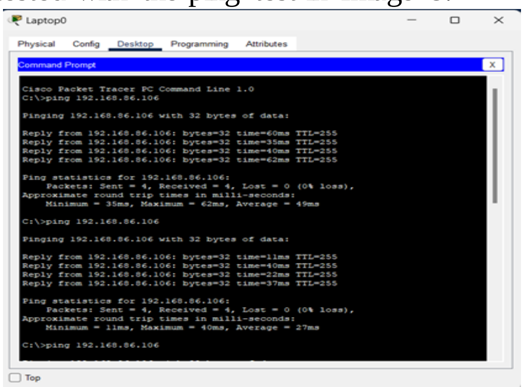

Image 8. Ping Results on RFID Reader

Each ping experiment's delay and packet loss data are recorded to calculate the average value. Data is taken from the average results on each ping experiment and then averaged again by combining all trials. The test results obtained are delay 36.4 and 0% packet loss.

The next step is to experiment with all IoT devices in the same way and at the same time at night. Table 5 shows the results of the average experiment conducted on all IoT devices.

Table 5. IoT Device Testing Results

Devices	Delay (ms)	Packet Loss (%)
Lights	35.8	0
MD 1	34.2	0
MD 2	32.8	0
CCTV	41.8	0
Garage Door	40.4	0
RFID Reader	36.4	0

From the results of nighttime testing, the highest delay results can be obtained on CCTV devices with a delay of 41.8, and the lowest delay can be obtained on motion detector 2 devices with a delay of 32.8. Then, packet loss on all IoT devices results in 0%. Concerning the THIPON standard, the value obtained in the experiment gets excellent results with an index of 4.

CONCLUSION

The IoT tests conducted were successfully accessed and controlled via the Internet. The tested network topology works well before and after all devices are active. Connectivity testing showed the highest delay on CCTV 41.8ms and the lowest on motion detector 2 32.8ms, with 0% packet loss on all devices. Based on TIPHON standards, the network built is rated excellent with an index of 4. The smart home system designed and tested shows optimal performance and can be implemented. However, this research still needs to be developed, especially on device configuration, which can be improved using controllers and technologies such as AI and machine learning.

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