Comparative Analysis of Smart Home with SMS, IoT and PIC Microcontroller Technology

Heryanto
e-mail: hhery314@yahoo.com
Adi Sastra Pengalaman Tarigan
e-mail: adisastra@dosen.pancabudi.ac.id
Dicky Lesmana
e-mail: dickylesmana24@gmail.com

ABSTRACT
This study discusses the comparative analysis of smart home systems using three main technologies, namely SMS, IoT (Internet of Things), and PIC Microcontrollers. The purpose of this study is to evaluate the advantages, disadvantages, and performance of each technology in supporting the implementation of smart home systems. SMS technology allows device control via text messages, which is simple and suitable for areas with limited internet access, but has disadvantages in terms of operational costs and relatively slow response times. IoT offers real-time control with multi-device integration through the internet network, providing easy global access and high flexibility, although it requires a stable internet infrastructure and higher implementation costs. Meanwhile, PIC Microcontrollers support local control with low cost and fast response times, but are limited in long-distance communication capabilities. The results of the study show that IoT excels in terms of flexibility, scalability, and performance for modern smart home development, while SMS is more reliable for simple applications in areas with limited internet. PIC Microcontrollers are ideal for local systems with basic needs, but are less suitable for large-scale development. The conclusion of this study is that the choice of technology must be adjusted to user needs and infrastructure conditions. IoT is recommended for smart home implementations that require broad connectivity and advanced features, while SMS and PIC Microcontrollers remain relevant for simpler and more specific applications.

Keywords: Smart Home, SMS, IoT, PIC Microcontroller, Control Technology.

Introduction

In recent years, the concept of *Smart Home* has become an increasingly popular trend in the field of home technology. *Smart Home* combines information and communication technology to create a digitally connected home environment that can be controlled automatically or remotely via electronic devices. The presence of *Smart Home* not only offers convenience and efficiency, but also increases the security and comfort of home occupants. Various technologies have been implemented in the development of *Smart Home, including Short Message Service* (SMS) technology, *Internet of Things* (IoT), and *Programmable Integrated Circuit* (PIC) microcontrollers. These three technologies have a significant role in the *Smart Home system*, with their respective characteristics, advantages, and limitations that affect their implementation and use.

SMS technology enables simple communication between users and *Smart Home devices* via text messages. This technology can be accessed by almost all types of mobile phones, thus offering convenience and wide reach. However, its limitations lie in the speed of communication and capacity that do not support complex applications. In contrast, IoT technology provides high flexibility in connecting devices at home via the internet network. With IoT, devices can be controlled in real-time from anywhere, although it requires a reliable network infrastructure and strict data security. On the other hand, the PIC microcontroller is a device that is often used in programmable electronic systems, with good processing capabilities.

This technology allows detailed control over household devices, but requires special expertise in programming and configuration (Ref. 4, 6).

Comparative analysis between SMS, IoT, and PIC microcontroller technologies in *Smart Home implementation* is important to provide guidance to developers and users in choosing the technology that suits their needs and preferences. A deep understanding of the advantages and limitations of each technology can help optimize the implementation of *Smart Home*, both in terms of efficiency, security, and comfort (Ref. 3, 5).

In addition, rapid technological developments, especially in the Industrial Revolution 4.0 era, are increasingly driving automation and digitalization in various aspects of life, including the home environment. This concept offers innovative solutions to modern needs, such as a home security system that can provide real-time notifications via smartphones, automatic control of electronic devices, and remote home monitoring. With the increasing need for integrated technology in society, this analysis is expected to provide strategic insights in designing and implementing an effective and adaptive *Smart Home to technological developments.*

Formulation of the problem:

1) How do the functionality and performance compare between SMS-based Smart Home systems, Internet of Things (IoT), and PIC microcontrollers?
2) What are the advantages and disadvantages of each technology in implementing a Smart Home?
3) How do cost and complexity affect the use of SMS, IoT, and PIC microcontroller technologies in the context of a Smart Home?

Literature Review

1) Smart Home Technology

The Smart Home concept refers to a home that uses technology to automate, monitor, and control household devices. This technology aims to improve comfort, efficiency, and security for its users. Some of the main elements in the development of a Smart Home include security systems, electronic device control, and real-time notifications. Technologies such as SMS, IoT, and PIC microcontrollers have been applied in various Smart Home implementations, each with unique characteristics.

2) SMS Technology in Smart Home

Short Message Service (SMS) technology is used in Smart Home to enable communication between users and devices via text messages. SMS-based systems are considered simple and accessible because almost all mobile phones support this technology. SMS allows remote control of household devices with relatively low communication costs. However, SMS has limitations in terms of speed and data capacity, making it unsuitable for applications that require real-time responses or complex data processing (Ref. 3, 5).

3) IoT Technology in Smart Home

IoT (Internet of Things) is a technology that connects electronic devices to the internet to enable real-time control and communication. In the context of Smart Home, IoT enables the integration of various devices such as sensors, cameras, and other electronic devices into one centralized system. IoT technology provides high flexibility because it can be accessed remotely via the internet network, and enables better automation and personalization. However, IoT implementation requires reliable network infrastructure and strict data security measures, because the risk of data leakage and privacy violations is quite high.

4) PIC Microcontroller in Smart Home

PIC (Programmable Integrated Circuit) microcontrollers are hardware that is often used to control electronic devices in Smart Home systems. This microcontroller has good processing capabilities, so it can be used to control specific functions such as temperature control, lighting, and security. PIC microcontrollers are also known for being power efficient and suitable for small applications with low power requirements (Ref. 4, 6). However, this technology requires advanced programming and complex configuration, so it can only be used by individuals with adequate technical expertise.

Research Method

Planning the workflow of a Smart Home system based on IoT and Microcontrollers:

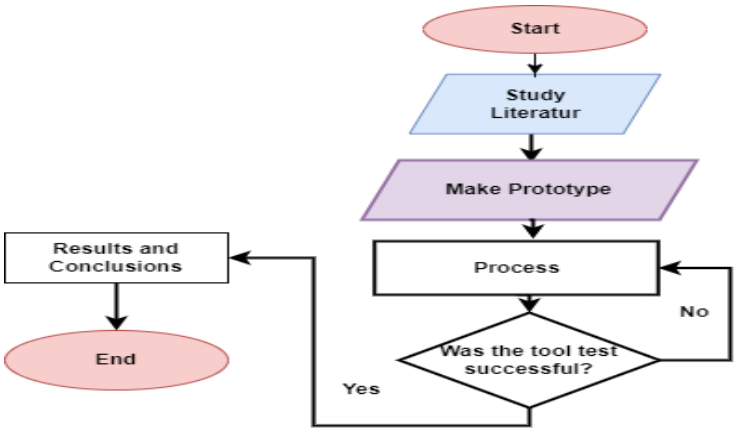

Figure 2. Flowchat Diagram

IoT and Microcontroller Based Smart Home Development Project Flow

1) Start: Initiation
   Project Start a project by planning the work stages, setting goals, and organizing the team involved in system development.
2) Literature Review
   smart home applications. Identifying previous research, relevant theories, and implementation of similar systems to support system development.
3) Prototype Development
   a. *smart home* system based on IoT and microcontroller. Develop system features, components, and workflow.
   b. Prototype Implementation: Developing the design into a physical and software prototype that functions as planned.
4) Testing Process
   a. Prototype Testing: Testing prototypes in a controlled environment to ensure system functionality and stability.
   b. Test Result Evaluation: Analyze test results to identify strengths, weaknesses, and areas for improvement.
5) Was the Test Successful?
   a. If Yes:
      Proceed to the next process, including documentation, user training, and system implementation in a real environment.
   b. If not:

b. Corrective Action: Address issues found during testing and improve the prototype.

Retesting: Performing retesting after repairs are completed.

6) Implementation
   a. System Implementation: Implementing a *smart home system* based on IoT and microcontroller in the target home or environment.
   b. User Training: Providing training to users on how to use the new system.
7) Monitoring and Evaluation
   a. System Performance Monitoring: Routinely monitor system performance to ensure its functionality and effectiveness.
   b. Performance Evaluation: Assess the impact of the system and identify opportunities for further improvement.
8) End:
   CompletionCompleting the project after the system is running smoothly and all research and development objectives have been achieved.

Results and Discussion

Distance Testing on the tool

Distance testing is conducted to determine the effectiveness of communication between the transmitter (Android smartphone) and the receiver (Bluetooth HC-05 module). In this test, electronic devices are tested at a distance of 1-10 meters by pressing the "ON" button on the smartphone application to turn on or off household devices.

The test results show:

1) The Bluetooth module can receive signals from Android smartphones up to a maximum distance of 10 meters, provided there are no obstacles between the two.
2) When the distance between the smartphone and the Bluetooth module exceeds 10 meters, the connection is lost so that the electronic device cannot be controlled.

System response time:

1) For a distance of 1-5 meters: 0.3 seconds.
2) For a distance of 5-10 meters: 0.5 seconds.

Table 1. Results

Distance (Meters)	Connectivity	Response Time (Seconds)
1-5	Connected	0.3
5-10	Connected	0.5
>10	Not Connected	-

After the communication between the Android Smartphone and the Bluetooth HC-05 is successfully connected, the user can press the "Done" button on the Android application. This indicates that the connection between the Android device and the Bluetooth module has been successfully established, and the application is ready to be used to control or interact with other devices connected via the Bluetooth system. This process ensures that data communication can be carried out stably between the two devices, allowing control of electronic devices in *smart home systems* or other applications that use the Bluetooth HC-05 module.

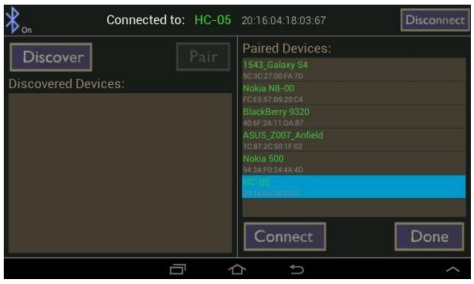

Figure 1. Android Smartphone with Bluetooth HC-05 Connected

After the communication between the Android Smartphone and the Bluetooth HC-05 is connected, select Done. So that the Android application used is ready to use.

In Figure 2, if the switch for Lamp 1 is in the ON position, then Lamp 1 will turn on. Conversely, if the switch is moved to the OFF position, then Lamp 1 will turn off. This system relies on the interaction between the switch connected to the microcontroller or system that controls the lamp, allowing manual or automatic lamp settings according to the switch status. This description illustrates how the lamp control system works in a *smart home*, which can be operated through devices such as Android applications or other settings.

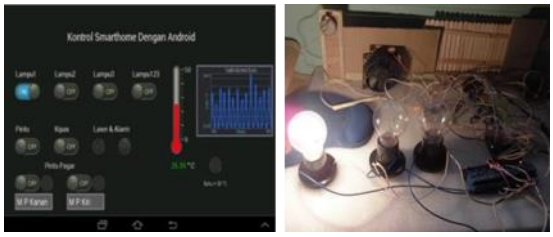

Figure 2. Light Switch 1 ON Light 1 is ON

In Figure 2. If the switch is on for lamp 1, lamp 1 will light up, if the switch is off, lamp 1 will go out.

In Figure 3, when the switch for Lamp 2 is in the ON position, Lamp 2 will turn on. Conversely, if the switch is moved to the OFF position, Lamp 2 will turn off. This system allows direct control of the lights through the switch, which is connected to the control system in *the smart home*. This arrangement makes it easy to adjust the lighting according to needs, either manually or automatically, through an application or other control device.

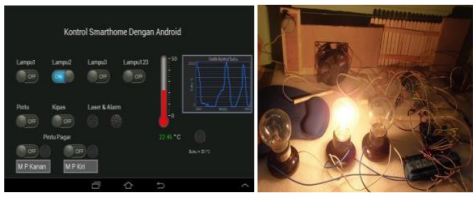

Figure 3. Light Switch 2 ON Lights 2 On

In Figure 3. If the switch is on for the lights, the lights will light up, if the switch is off, the lights will go out.

Smart Home Control System Analysis

Smart Home control system using an Android application and Arduino Uno shows that this system can function well in controlling various electronic devices at home. Based on the test results, there are several main components that support the performance of this system, such as an Android smartphone, a Bluetooth HC-05 module, and an Arduino Uno that functions as a control center.

Application Requirements

This system utilizes an Android application as a user interface (UI) to control household devices such as lights, fans, house doors, laser sensors, LED/alarms, gates, and temperature sensors. This application allows users to turn devices on or off remotely via a Bluetooth connection.

Smart Home Control Needs

Some of the devices used in this system include:

1) Lights (3 pieces): These lights are connected to pins 2, 3, and 4 of the Arduino, which can be controlled via the app to provide lighting in the house.
2) House Door: The house door is connected to pin 5 and can be controlled to open or close the house access, providing comfort and security for the occupants.
3) Fan (Pin 7): The fan is used to maintain a comfortable room temperature. Users can turn it on or off remotely.
4) Laser Sensor and LED/Alarm (Pins 6 and 8): This component is used to enhance home security. The laser sensor detects movement around the home, while the alarm/LED provides alerts if any threats or abnormalities are detected.
5) Gate and DC Motor Driver: The gate is controlled using a DC motor that can rotate to open or close the door, with the help of a limit switch to stop the motor when the door is in a certain position.
6) Temperature Sensor: Used to monitor temperature conditions inside a room, allowing users to adjust other devices, such as fans or air conditioners.
7) Relay Driver (8 pieces): Used to control other electronic devices that require more power, such as lights and fans.
8) Arduino Uno: As a control center, Arduino Uno is tasked with receiving data from Android applications via Bluetooth and sending commands to connected electronic devices.

System Testing

Testing was conducted to measure the range of the Bluetooth signal between an Android smartphone and the HC-05 Bluetooth module. The test results showed that the system can function well at a distance of up to 10 meters without any physical obstacles. The system response time is quite good at a distance of 1-5 meters with a response time of about 0.3 seconds, and slightly slower at a distance of 5-10 meters with a response time of about 0.5 seconds. This shows that the system has optimal performance at short distances and can be used effectively in most household situations.

Overall, the implementation of a smart home control system based on Android applications and Arduino Uno can function well in controlling household devices. This system utilizes Bluetooth technology for communication between Android smartphones and electronic devices connected to Arduino, providing convenience, efficiency, and security for users. With a fairly fast response time at close range, this system offers a practical and effective solution for managing home devices automatically.

Here is a comparison table that can be used to analyze smart home systems with SMS, IoT, and PIC Microcontroller technology:

Criteria	SMS Technology	IoT Technology	PIC Microcontroller
Communication	Using SMS for communication between devices and users.	Using the internet network for communication between devices	Using serial or parallel communication (e.g. UART, SPI).
Response Speed	Tends to be slower as it depends on SMS delivery.	Fast response, depending on internet connection and device used.	Very fast because it uses direct communication with the microcontroller.
Range	Depends on GSM network coverage and mobile phone signal.	Wide reach, can be accessed from anywhere as long as there is internet access.	Depends on the physical device directly connected (e.g. cable or local network).
Ease of Use	Easy to use because it uses the familiar SMS.	Requires more complex additional applications or software.	Requires additional programming and hardware for communication.
Cost	The cost is relatively cheaper if you use regular SMS.	Costs are higher because they require IoT devices and internet access.	Low cost for microcontroller and additional components.
Security	Low security as SMS is vulnerable to interception.	Security can be managed with encryption and secure protocols (e.g. HTTPS, MQTT).	Security is better, depending on protocol and system implementation.
Flexibility and Scalability	Limited to sending commands via SMS.	Highly flexible and scalable, it can be integrated with various devices and systems.	Limited to the functionality of the programmed microcontroller.
System Maintenance	Relatively easy, only requires maintenance of the GSM device.	Requires maintenance of devices and internet network, including software updates.	Microcontroller hardware and software maintenance.
Implementation Complexity	Simple and straightforward implementation.	More complex because it requires IoT devices and network configuration.	Relatively simple but requires special programming for the microcontroller.
Integration with Other Devices	Limited to devices that can receive SMS.	Can be integrated with various other IoT devices.	Integration is limited to devices compatible with the microcontroller.

This table provides an overview of the advantages and disadvantages of each technology in the context of smart home use.

Conclusion

Important findings related to the efficiency, performance, and capabilities of each technology in implementing a *smart home system*. SMS technology allows device control via text messages, making it suitable for areas with limited internet access. However, this technology has limitations in terms of slow response time and additional costs due to the use of SMS services. In contrast, IoT (Internet of Things) offers more efficient real-time control by utilizing the internet network. This technology supports multi-device integration, global access, and fast response time, although it depends on a stable internet connection. On the other hand, PIC Microcontrollers provide a cost-effective and reliable local solution for electronic device control, but have limitations in long-distance communication capabilities compared to IoT technology.

In terms of implementation and scalability, SMS-based technology is relatively easy to implement because it requires little infrastructure, but lacks support for modern features such as data analysis or artificial intelligence integration. Meanwhile, IoT is more flexible and supports large-scale development, although it requires higher initial costs and more complex infrastructure. PIC Microcontrollers, although simple and fast to implement, are only ideal for local applications with basic needs, without the ability to support larger system development.

In terms of performance and response time, IoT performs best due to its ability to send data in real-time. In contrast, SMS technology has the slowest response time due to its dependence on sending messages via cellular operators. PIC Microcontrollers offer fast response times in local applications, but are limited in long-distance communication capabilities. The reliability of each technology also varies. SMS is more reliable in areas with good cellular network coverage, while IoT relies heavily on the stability of the internet network. PIC Microcontrollers, which do not rely on external networks, are more suitable for applications that require a stand-alone system, although their control scope is limited.

smart home systems must be adjusted to user needs and infrastructure conditions. IoT is a superior choice for applications that require global connectivity, real-time access, and smart device integration, although it requires greater costs and resources. SMS technology is suitable for areas with limited internet access, while PIC Microcontrollers are ideal for simple controls with a low budget. Overall, IoT is considered the best technology to support the development of modern *smart homes* because of the flexibility, connectivity, and high performance it offers.

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