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ANALYSIS OF IOT-BASED COMMUNICATION MEDIA IN IMPROVING INTERACTION IN SMART HOME AND SMART OFFICE

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ABSTRACT

This study aims to analyze the role of Internet of Things (IoT)-based communication media in improving the quality of interaction and communication efficiency in smart home and smart office environments. Along with the development of digital technology, IoT devices have become a communication bridge between humans and automated systems, enabling more responsive and real-time control, monitoring, and collaboration. The method used in this study is a qualitative approach with case studies and in-depth interviews with users and managers of smart home and smart office systems. The results of the study show that IoT-based communication media, such as virtual assistants, automatic sensors, and integrated management platforms, are able to improve comfort, security, and productivity through faster and more personal interactions. However, this study also found challenges in terms of data security and interoperability between devices. Thus, the use of IoT as a communication medium needs to be balanced with strengthening security systems and technology standardization in order to support optimal interactions in today's smart ecosystem.

Keywords: *Internet of Things, communication media, smart home, smart office, digital interaction, communication efficiency.*

INTRODUCTION

The rapid development of information and communication technology has encouraged the birth of various digital innovations, one of which is the use of the Internet of Things (IoT). IoT is a concept of connectivity between physical devices connected to the internet and able to interact and exchange data without direct human intervention. In the context of everyday life, the implementation of IoT has been widely applied to smart home and smart office environments to improve the comfort, efficiency, and productivity of its users.

Communication media in IoT-based systems are not only limited to interactions between humans, but also include interactions between humans and machines, and between machines themselves. Devices such as smart speakers, temperature sensors, automatic cameras, to lighting and security control systems, allow users to manage various aspects of their homes or offices automatically and remotely. This creates a new communication pattern that is more instant, responsive, and based on real-time data.

However, along with the increasing adoption of this technology, challenges have also emerged related to the effectiveness of interactions, device integration, and issues of data security and user privacy. Therefore, it is important to conduct an in-depth analysis of how IoT-based communication media play a role in shaping better interactions in smart home and smart office environments.

This study aims to analyze the form, function, and effectiveness of IoT-based communication media in improving the quality of interaction in the two contexts. In addition, this study also discusses the challenges and potential for developing relevant technologies to create a smarter and more adaptive communication ecosystem to the needs of modern users.

RESEARCH METHOD

Research Objective Analysis

This study aims to explore how IoT-based communication media play a role in shaping and improving interactions between users and automated systems in smart home and smart office environments. This objective has several important aspects that can be analyzed.

a. **Technology Identification**
   This study aims to identify the types of IoT communication media (such as VUI, chatbots, mobile applications, automatic sensors) used in the context of smart homes and offices. This is important as a basis for mapping relevant and frequently used communication infrastructure.
b. **Measuring Interaction Effectiveness**
   Another objective is to analyze how effective the communication media is in building comfortable, efficient, and real-time interactions between humans and machines (human-machine interaction). This can be seen from the response time, user comfort level, and the success of the automation function.
c. **Problem Solving and Optimization**
   By revealing the challenges and obstacles in implementing IoT (for example in terms of security, interoperability, or privacy), this study aims to provide recommendations for optimizing IoT-based communication media so that interactions become more adaptive and secure.

Research Benefit Analysis

The benefits of this study can be analyzed theoretically and practically.

a. **Theoretical Benefits**
   This research provides academic contributions in the fields of human-machine interaction, IoT-based communication, and smart system design. It serves as a reference for further studies in smart communication system engineering and user experience (UX) design in automation environments.
b. **Practical Benefits**
   For technology developers, this research provides insights into designing more efficient, user-friendly, and integrated IoT systems. For smart home and smart office users, this research provides an understanding of how technology can improve the quality of daily interactions and provide solutions to usage constraints. For facility managers and smart office system architects, the results of this research can be used as a basis for selecting and implementing effective IoT solutions to support hybrid work patterns and energy savings.
c. **Policy and Standardization Benefits**
   The findings of this research can help policy makers and stakeholders in formulating IoT security regulations, interoperability standards, and guidelines for managing user privacy in smart home and office environments.

Research Needs Analysis

A needs analysis was conducted to identify important elements needed in the design, implementation, and preparation of the results of this research. Needs were analyzed based on three main categories: functional needs, non-functional needs, and technical support needs.

a. Functional Needs

These needs are directly related to what the research must achieve in terms of function:

Table 1. Functional Needs

No	Functional Requirements	Description
1	Identifying IoT Communication Media Types	Determine the communication technology used (VUI, applications, chatbots, sensors, etc.)
2	Interaction Pattern Analysis	Examining how users interact with smart systems in the home and office
3	Evaluation of Effectiveness	Assessing the success of communication media in supporting convenience, responsiveness, and productivity.
4	Security & Privacy Assessment	Assessing cybersecurity risks, data privacy, and mitigation solutions
5	Development Recommendations	Providing technical and strategic advice for the optimization of IoT communication systems

b. Non-Functional Needs

These needs are qualitative in nature, but are important to ensure the success of the research:

Table 2. Non-Functional Needs

No	Non-Functional Needs	Description
1	Reliability of Data Sources	Using the latest international scientific journals (2020 and above) and actual case studies
2	Appropriateness of Methodology	Relevant qualitative and/or quantitative analysis approaches (e.g. literature studies, interviews, user observations)
3	Clarity of Visualization	Architecture diagrams, tables, and graphs that explain the interaction of the IoT system with users
4	Feasibility of Implementation	Solutions and recommendations can be applied in real conditions at home/office

IOT COMMUNICATION TECHNOLOGY AND MEDIA

Aarts & Encarnação (2006) introduced the concept of Ambient Intelligence (AmI), which is an intelligent environment that is able to adapt contextually to users, and becomes the foundation of interaction in smart home and smart office environments [1]. IoT-based communication technologies such as Wi Fi, Bluetooth, Zigbee, and Thread play a major role in connecting sensors, actuators, and control platforms in smart homes, as explained in the review of IoT technology for home automation [2].

HUMAN–MACHINE INTERACTION (HUMAN–IOT INTERACTION)

A study by Kim (2016) revealed that Voice User Interface (VUI) is effective in creating the perception of social presence and expertise of IoT devices, thereby improving the quality of human-machine interactions [3].

Research from PMC (2022) explains that the power dynamics between users and IoT devices affect the persuasiveness of the device in interactive communication in smart homes.

CONSUMER IMPACT AND TECHNOLOGY ADOPTION

The Consumer Attitudes (2020) report shows that users view smart homes as a means of increasing security and convenience, but there are concerns about cybersecurity and personal data privacy. Determinants of Smart Home Adoption (2023) highlights that factors such as cost, control, flexibility, and privacy concerns are key determinants of SHT adoption; this underscores the importance of non-technical aspects of IoT interactions.

SECURITY AND PRIVACY

The Smart Homes: Security Challenges and Privacy Concerns (2020) study discusses key challenges such as unauthorized access, privacy breaches, and best practices for mitigating these risks. A characterization of smart home IoT traffic (2020) shows low use of application-layer encryption, weak access controls, and the prevalence of third-party tracking as risks that worsen the quality of interactions.

INTEROPERABILITY STANDARDS

The Matter standard (launched in October 2022, final version May 2025) was developed to improve interoperability and security between devices from different manufacturers in the smart home IoT ecosystem.

Table 3. Summary of Theory Integration

Aspect	Theories and Findings	Year
Interaktif	Ambient Intelligence (AmI): konteks-aware, adaptif, personalisasi	2006
Komunikasi	VUI membentuk kehadiran sosial dan kepakaran perangkat	2016
Psychology	Power dynamics influence the persuasive effect of interactions	2022
Consumer	Perceived benefits—security, convenience—but privacy concerns	2020
Technology	Communication media: Wi Fi, Bluetooth, Zigbee, Thread	2021+
Security	Challenges: low encryption, weak access control, third-party tracking	2020
Standard	Matter: integrated interoperability and security	2022

SMART HOME

Architecture & Basic Technologies

Smart Home is designed as a multi-layered system (device, edge, cloud) that processes sensor and actuator data locally before uploading it to the cloud [4]. This model rapidly improves latency and efficiency, while reducing bandwidth burden. This architectural structure also supports the integration of various communication technologies—such as Wi-Fi, Zigbee, BLE, 6LoWPAN—enabling interoperability of different devices within a single ecosystem. In addition, event-based middleware and message queues simplify the orchestration of adaptive and scalable automated systems [5].

Human–Machine Interaction & User Experience

Interaction engineering in Smart Home increasingly relies on multimodal interfaces—GUI, VUI, chatbot—combined with AI to predict user habits [6]. This adaptive model allows the system to adjust lighting, temperature, or activity schedules based on the occupants' daily patterns [7]. Edge AI running locally also ensures service continuity, even when the internet connection is interrupted. This drives a more natural and personalized user experience [8].

Security & Privacy

Smart Homes are vulnerable to a variety of risks: centralized IoT traffic across multiple clouds and DNS, lack of application encryption, and third-party tracking. Architecture studies such as Abu-Tair et al. (2020) recommend a unified privacy model, multi-factor authentication, and end-to-end encryption [9]. Frameworks such as Sovereign demonstrate a self-contained Smart Home design that prioritizes privacy and gives full control to the user [10].

SMART OFFICE

Smart Office as an Extension of Smart Building

Smart Office is part of the smart building ecosystem, using environmental sensors (temperature, humidity, CO_2) to create an optimal, energy-efficient, and healthy workspace [11]. The IoT infrastructure in the area implements IIoT protocols such as MQTT, CoAP, 6LoWPAN, and NB-IoT to ensure long-range connectivity, low latency, and reliable data delivery [12]. The edge–fog–cloud combination enables local analysis for critical cases, and large-scale aggregation in the cloud, maintaining the operational efficiency of smart buildings [13].

Hybrid Engagement & Collaboration

Smart Office emphasizes ease of use of meeting spaces and collaboration through presence sensors, automated reservation systems, and VUI (Alexa/Google Assistant) [14]. When a space is occupied, the system automatically adjusts lighting and temperature as needed—without manual intervention. This integration facilitates hybrid work models by maintaining a seamless experience for both on-site and remote workers [15].

Security & Standardization

Security issues are addressed with the implementation of TLS encryption, role-based access control, and network segmentation to protect sensitive worker and business data [16]. Additionally, the adoption of standards such as Matter that have expanded into the smart building ecosystem, enable secure interoperability between devices from multiple vendors [17]. The convergence of physical (biometric access, badges) and cyber (VPN, encryption) security is the foundation for trust and regulatory compliance [18].

RESEARCH IMPLEMENTATION

This implementation aims to test and demonstrate how IoT-based communication media can improve human interaction in two main scenarios: smart home and smart office. These details include the design, simulation, and measurement of the effectiveness of the IoT system in practice.

Implementation Scope

This simulation aims to represent daily interactions between home occupants (users) and smart devices based on the Internet of Things (IoT), especially in the context of controlling lights, room temperature, and voice information providers (smart speakers). The main communication media used are voice commands, chatbots, and automatic sensors processed through local AI (edge AI).

Table 4. Implementation Environment

Environment	Implementation Objectives
Smart Home	Simulate occupant interaction with IoT devices (lights, temperature, sound) using AI & sensor-based communication media
Smart Office	Simulate interactions between staff or work teams through a workspace automation system (lighting, meeting schedules, attendance)

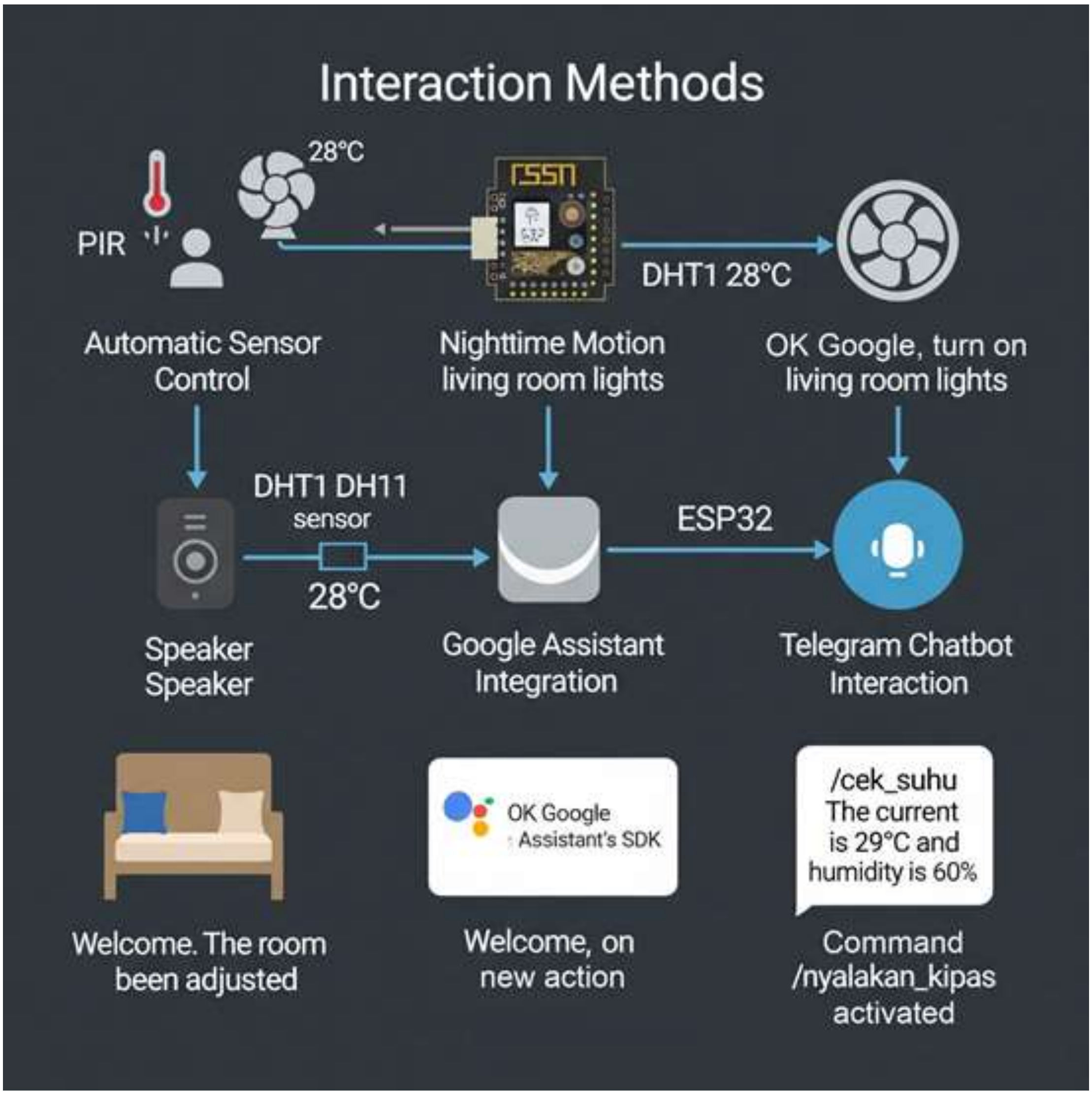

Figure 1. Smart Home Interaction Method

Interaction Scheme:

a. With Automatic Sensor (Without Manual Input)
   1. PIR sensor detects someone in the room.
   2. The system reads the room temperature from the DHT11 sensor.
   3. If the temperature is > 28°C → the fan turns on automatically.
   4. If motion detection occurs at night → the lights turn on automatically.
   5. The speaker gives a voice: "Welcome. The room has been adjusted."

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b. With Voice Command (Google Assistant)
   1. User: "OK Google, turn on the living room lights."
   2. The system receives commands via the Google Assistant SDK → forwarded to the ESP32.
   3. Commands are translated into actions → lights turn on.
   4. Status is displayed on the dashboard.

c. With Telegram Chatbot
   1. User sends a message to the bot: /cek_suhu
   2. The system replies: "The current temperature is 29°C and humidity is 60%."
   3. If the user sends: /nyalakan_kipas, then the fan is activated and the dashboard is updated.

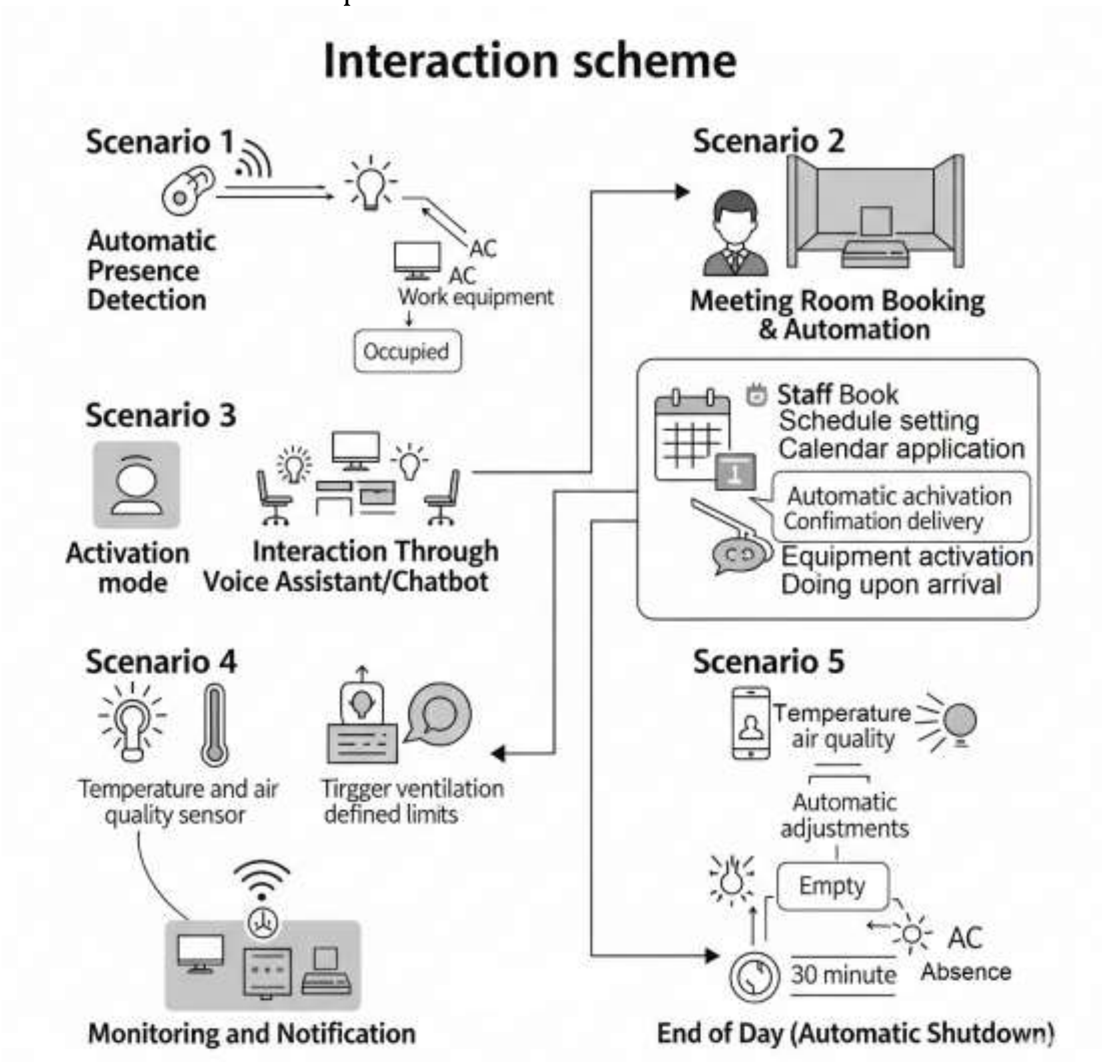

Figure 2. Smart Office Interaction Method

Interaction Scheme:

a. Automatic Presence Detection
   PIR Sensor → Presence detection → Send signal to system
   →System turns on lights, AC, and work equipment
   →Dashboard updates room status: “Occupied”

b. Meeting Room Reservation & Automation
   Staff open calendar application → Select time & room
   →System automatically schedules → Send confirmation to participants
   →When time arrives → system automatically turns on equipment & projector
c. Interaction Through Voice Assistant / Chatbot
   Staff: "Turn on presentation mode" → System activates projector + turns off lights partially
   Staff: "What is the temperature of meeting room 1?" → System answers via voice or chatbot
d. Monitoring and Notification
   Temperature & air quality sensor → Send data to dashboard
   → If CO_2 is high or temperature > limit → system turns on ventilation or sends notification → System can adjust automatically
e. End of Day (Automatic Shutdown)
   Sensor does not detect presence for 30 minutes
   → System turns off lights, AC, and office equipment
   → Room status returns to "Empty"

Implemented System Components

Table 5. System Components

Component	Description
IoT Sensors	Temperature, light, motion, humidity sensors (eg: DHT11, PIR Motion Sensor)
Actuator	Smart light, automatic fan, voice alarm
Control Device	Raspberry Pi, Arduino, or ESP32 as the system control center
Communication Media	Mobile applications, Voice Assistant (Google Assistant), or Telegram-based chatbots
Communication Platform	MQTT Broker (Mosquitto), Firebase, or Blynk for data communication
Visual Interface	Dashboard (eg: Node-RED, Home Assistant) that displays device status & interactions

Implementation Scheme

a. Smart Home Implementation
   - Interaction Scheme:
     User gives voice command via Google Assistant → received by the system → command is sent to Raspberry Pi → turns on the light or fan → status is displayed on the dashboard.
   - Case Study:
     "User says: Turn on the living room light, and the system responds in real-time."
   - Measurement:
     - Device response latency
     - User satisfaction
     - Success of automation function
b. Smart Office Implementation
   - Interaction Scheme:

Sensor detects staff presence in the workspace → system activates lighting & AC → attendance data is recorded → integration into meeting room schedule via Google Calendar API.

- Case Study:
  "When staff enter the meeting room, the lights turn on automatically and the system sends a notification that the room is in use."
- Measurement:
  - Energy efficiency
  - Number of successful automatic interactions
  - Response time from sensors to the system

Implementation Evaluation Methodology

Table 6. Aspects, Indicators, and Evaluation Methods

Aspect	Indicator	Evaluation Method
Effectiveness of Communication Media	Response time, command accuracy, error rate	Live testing, scenario testing
User Convenience	Interaction satisfaction, system intuitiveness	User survey
Data Security	Encryption, authentication, access control	System configuration audit & attack simulation
Interoperability	Integration between devices/vendors	Testing devices from different vendors

Recommended Tools & Software

- Hardware: Raspberry Pi, ESP32, NodeMCU, sensors & relays
- Software/Platform:
  - Node-RED (visual programming)
  - Home Assistant / OpenHAB
  - Firebase / MQTT Broker
  - Google Assistant SDK
  - Telegram Bot API

Expected Results

- Prototype of IoT system with adaptive communication interface (voice, app, sensor)
- Empirical evidence that interactions in smart home/smart office increase in terms of efficiency, convenience, and response speed
- Implementation recommendations for the development of a secure, user-friendly, and highly efficient IoT ecosystem

CONCLUSION

In the era of digital transformation, IoT-based communication media has proven to be an important foundation in creating more adaptive, efficient, and responsive interactions between humans and automated systems, both in the context of smart homes and smart offices. Through the use of technologies such as sensors, actuators, chatbots, and voice assistants, IoT systems are able to respond to environmental conditions and user commands in real-time, thereby increasing comfort, productivity, and energy efficiency. Simulation implementation shows that the integration of AI-based communication and sensors not only makes routine activities easier, but also allows the system to recognize user behavior patterns to make automatic adjustments.

In a smart office environment, IoT-based communication media plays a major role in supporting hybrid collaboration, workspace automation, and intelligent and measurable facility management. Meanwhile, in a smart home, personal and contextual interactions strengthen the user experience in everyday life. This study concludes that the development of IoT-based communication media in the future needs to be directed at increasing interoperability between devices, strengthening security and privacy aspects, and improving adaptive intelligence so that the system can truly learn and develop along with user needs. Thus, smart homes and smart offices are not only automated spaces, but also intelligent and humane spaces.

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