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Video Call Intercom Based on IP System with Vibration Sensor

Harshini S[1], Thasneem Fahira M[2], Bhuvaneswari S[3], Anandh A[4]
[1,2,3] UG Scholar, Department of CSE, Kamaraj College of Engineering & Technology, Virudhunagar, Tamil Nadu, India.
[4] Associate professor, Department. of CSE, Kamaraj College of Engineering & Technology, Virudhunagar, Tamil Nadu, India.
Emails: *s.harshini0903@gmail.com[1], hirafahira11@gmail.com[2], bhuvana171106@gmail.com[3], anandhcse@kamarajengg.edu.in[4]*

Abstract
Security at entry points is a critical requirement in residential and commercial environments. Traditional intercom systems provide only basic audio communication and depend on manual interaction, making them inefficient in detecting unauthorized access or intrusion attempts. Moreover, the absence of real-time video communication limits the ability of users to visually verify visitors. This paper presents a Video Call Intercom Based on IP System with Vibration Sensor, designed to enhance security through automatic intrusion detection and real-time video communication. The proposed system integrates a vibration sensor with an ESP32 microcontroller to continuously monitor abnormal vibrations such as door knocks, tampering, or forced entry. Upon detection, an alert is immediately transmitted to a backend server using IP-based communication. The system enables instant notification and supports live two-way video communication using WebRTC through a web browser. By eliminating the need for dedicated intercom hardware and providing browser-based access, the system offers a cost-effective, scalable, and efficient solution for modern security applications.
Keywords: *IP Intercom System, WebRTC, ESP32, Vibration Sensor, IoT Security, Real-Time Video Communication.*

1. Introduction
1.1.Overview
In recent years, security concerns in residential, commercial, and institutional buildings have increased significantly. Intercom systems are commonly used to enable communication between visitors and occupants before granting access. However, traditional intercom systems rely on wired infrastructure and provide only audio communication, which limits their effectiveness in security-critical situations. With the rapid growth of IP networks, web technologies, and IoT devices, it is possible to design smarter intercom systems that provide real-time video communication and automated intrusion detection. The proposed system integrates vibration-based detection with IP-based video calling to overcome the limitations of conventional intercom systems and improve overall security.

1.2.Motivation
Many existing intercom systems fail to detect unauthorized access attempts such as door tampering or forced entry. Users also lack the ability to remotely verify visitors visually. This often results in delayed responses to potential threats and reduced safety. The motivation behind this project is to develop a low-cost, intelligent intercom solution that provides instant alerts and enables real-time video communication through commonly available devices such as web browsers.

1.3.Objectives
The objective of this work is to design and implement an IP-based video intercom system as an alternative to conventional wired intercom solutions. The proposed system enables real-time, two-way audio and video communication using WebRTC technology and supports browser-based access without requiring dedicated intercom hardware. Additionally, a vibration sensor is integrated to automatically detect intrusion or knock events and generate instant alert notifications. The system is

designed to be cost-effective, scalable, and reliable, making it suitable for deployment in residential and commercial security environments.

2. Related Study

The development of IP-based real-time communication systems has enabled the replacement of traditional wired intercoms with scalable network-based solutions. WebRTC, standardized for low-latency and secure peer-to-peer audio and video communication, plays a key role in such systems [1], while real-time multimedia transmission is supported by the Real-Time Transport Protocol (RTP) [2]. Embedded platforms like the ESP32, with integrated Wi-Fi and low power consumption, are widely used for IoT-based real-time applications [3]. Previous studies highlight the importance of IP-based sensor networks for scalable smart systems [4] and demonstrate reliable IoT automation and security solutions using ESP32 [5]. Security remains a critical concern in IP-based systems, addressed through protocols such as TLS 1.3 for secure and low-latency communication [6], along with authentication and privacy mechanisms in IoT environments [7]. Earlier research on IP-based video intercom systems confirms the feasibility of replacing conventional intercoms but largely focuses only on audio-video communication without intelligent event detection [8]. The concept of IoT, introduced by Ashton [9], and later smart security systems using sensor-based detection [10], emphasize the need for real-time alerts. However, limited work exists on integrating vibration-based intrusion detection with IP-based video intercom systems, and the proposed system addresses this gap by combining WebRTC communication, vibration sensor–based event detection, and secure IP-based alert transmission.

3. Methodology

3.1. System overview

The proposed IP-based video call intercom system integrates sensing hardware with web technologies and consists of three main modules. The sensing module uses a vibration sensor and ESP32 microcontroller to detect door knocks or forced entry attempts; when abnormal vibration is detected, the ESP32 filters noise and sends an alert to the server via Wi-Fi. The backend communication module is implemented using Node.js and Socket.IO, which receives and validates alerts, manages real-time notifications, handles WebRTC signalling, and maintains active client connections. The web application module runs on a standard browser using HTML, CSS, and JavaScript, displaying instant alerts and enabling secure peer-to-peer audio and video communication through WebRTC, allowing users to visually verify visitors before granting access.

3.2. System Architecture

The system follows a layered architecture that separates responsibilities into distinct layers, improving modularity, scalability, and maintainability. The sensing layer consists of a vibration sensor and ESP32, which continuously monitors physical disturbances and generates alerts only when abnormal vibrations are detected, acting as the event origin point of the system. The communication layer is implemented using Node.js and Socket.IO, responsible for transmitting alerts, managing data exchange between hardware and the web application, and handling WebRTC signalling for video call setup with low latency and reliable delivery. The application layer is a browser-based web application that provides user interaction by displaying alerts and live video streams and allowing users to answer calls or ignore alerts. This layered approach enables independent modification of each layer, easy addition of sensors or users, isolation of issues between layers, and seamless hardware or software upgrades without redesigning the entire system.

3.3. Detailed Workflow

3.3.1. Vibration Detection

The vibration sensor continuously monitors the entry point. When vibration exceeds a predefined threshold, it triggers the ESP32 microcontroller.

3.3.2. Alert Transmission

The ESP32 sends alert data to the backend server via Wi-Fi using IP communication.

3.3.3. Notification Delivery

The server uses Socket.IO to deliver real-time alert notifications to connected web clients.

3.3.4. Video Call Establishment

Upon receiving the alert, the user initiates a video call. WebRTC establishes a peer-to-peer connection

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for real-time audio and video streaming.

Figure 1 Data Flow Methodology

4. Implementation

The ESP32 microcontroller continuously monitors the vibration sensor and applies predefined threshold values to distinguish valid knock or intrusion events from noise. Upon detecting a valid vibration, the ESP32 establishes an IP-based connection and transmits alert data to the backend server using lightweight communication protocols. The backend server handles alert validation, session management, and signalling required for initiating video communication. A signalling mechanism is implemented to coordinate WebRTC session establishment between the visitor unit and the user's browser. The server facilitates the exchange of session descriptions and network information required for peer-to-peer connection setup. Secure communication between the devices and the server is ensured using standard encryption mechanisms. The frontend web application is designed to provide a responsive user interface that displays real-time alerts and allows users to accept or reject incoming video calls. Audio and video streams are captured using browser media APIs and transmitted through WebRTC for low-latency communication. The system follows an event-driven architecture, enabling immediate alert delivery and seamless video call initiation upon vibration detection. Overall, the modular design of the system allows easy scalability and future integration of additional sensors or security features without significant modification to the existing architecture. Figure 2 clearly illustrates the integration of the ESP32 microcontroller with the vibration sensor.

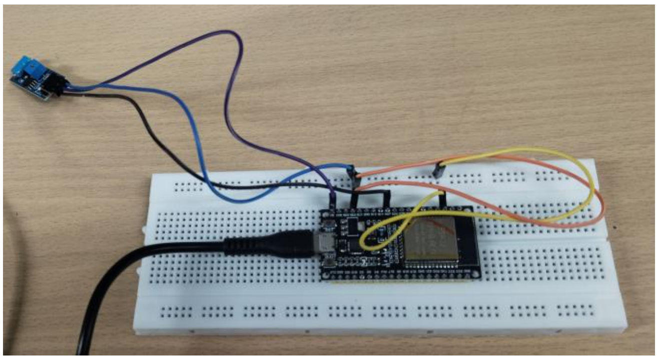

Figure 2 Integration of ESP32 and Vibration Sensor

5. Performance Analysis and Results

The performance of the proposed Video Call Intercom Based on IP System with Vibration Sensor was evaluated by measuring system response time at different distances between the vibration sensor unit and the user interface. The response time represents the duration required to detect vibration, transmit the alert over the IP network, and notify the user through the web application. The table below shows the distance and the corresponding response time to transmit the alert to the user through the web application. A graph is obtained with these data.

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Table 1 Measure of The Vibration Sensor Unit and User Interface

Distance (Meters)	Response Time (M/S)
5	180
10	220
15	260
20	310

Experiments were conducted at distances of 5 m, 10 m, 15 m, and 20 m. The recorded response times were 180 m/s, 220 m/s, 260 m/s, and 310 m/s respectively. The results show a gradual increase in response time with distance due to network latency and signal propagation delay. However, even at the maximum distance of 20 m, the response time remained within an acceptable range for real-time security applications, ensuring timely alert delivery and video call initiation.

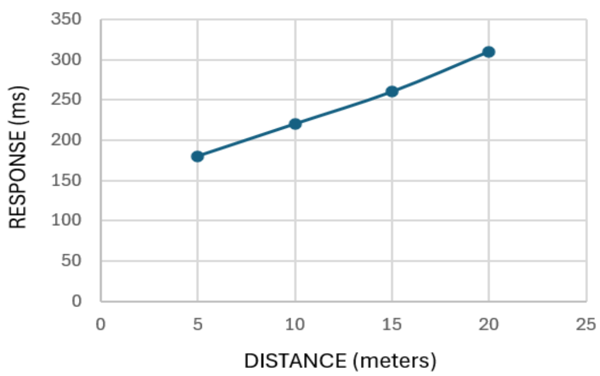

Figure 3 User Interface Evaluation

Experiments were conducted at distances of 5 m, 10 m, 15 m, and 20 m. The recorded response times were 180 m/s, 220 m/s, 260 m/s, and 310 m/s respectively. The results show a gradual increase in response time with distance due to network latency and signal propagation delay. However, even at the maximum distance of 20 m, the response time remained within an acceptable range for real-time security applications, ensuring timely alert delivery and video call initiation. Overall, the system demonstrates stable and reliable performance across varying distances, confirming the effectiveness of IP-based communication for real-time monitoring and alerting.

The vibration intensity is measured and the below table consists of the different detection accuracies. A graph is obtained based on the system's accuracy detection.

Table 2 Detection Accuracy for Different Vibration Intensities

Event Type	Detection Accuracy (%)
Light knock	92
Medium knock	97
Strong knock	99

The system's detection accuracy was evaluated for different vibration intensities, categorized as light, medium, and strong knocks. The measured detection accuracies were 92% for light knocks, 97% for medium knocks, and 99% for strong knocks.

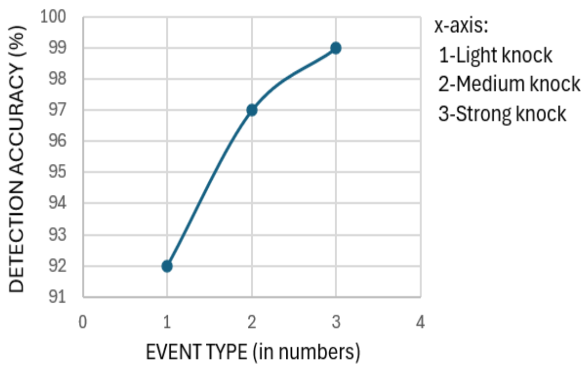

Figure 4 Variation of Real-Work Knocks and Their Accuracies

Low-intensity vibrations resulted in slightly higher alert delivery time due to additional signal validation required to avoid false triggering. As vibration intensity increased, the sensor output crossed threshold values more quickly, leading to faster detection and reduced alert delivery time. The figure 5 visualises the web interface of this project. These results demonstrate that the system effectively adapts to varying real-world knock conditions. The integration of the vibration sensor with the ESP32 microcontroller enables fast and reliable event detection and alert transmission, making the proposed system suitable for smart home and security

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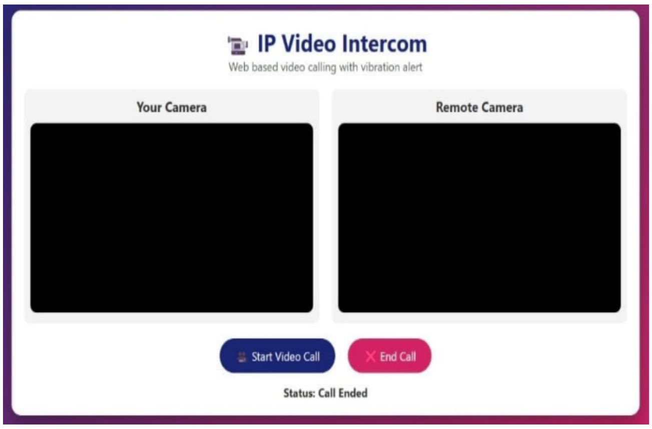

Figure 5 **User's Web Interface**

Conclusion and Future Scope

This paper presented a Video Call Intercom Based on IP System with Vibration Sensor that integrates IoT-based intrusion detection with real-time, web-based video communication. By leveraging IP networking, WebRTC technology, and vibration sensing, the proposed system enhances security while reducing installation cost and improving user convenience. The system is suitable for deployment in both residential and commercial environments due to its scalability, low latency, and hardware independence. Future enhancements may include automatic video call initiation upon event detection, integration of face recognition for visitor identification, mobile application support for remote access, cloud-based deployment for improved availability and data management, and smart door lock integration to enable secure access control.

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