

# Study on Indoor Presence Detection Using Wi-Fi and Edge Computing

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## Wi-Fi 와 에지 컴퓨팅을 활용한 실내 존재 감지 기술 연구

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### Abstract

This paper presents a pioneering device-free sensing technology that leverages Wi-Fi signals and edge computing for indoor human presence detection. This system extracts Channel State Information (CSI) from Wi-Fi signals to facilitate non-intrusive presence detection. It emphasizes energy efficiency by optimizing the existing infrastructure and reducing power consumption. The technology addresses privacy concerns by eliminating the need for intrusive sensors, thereby ensuring user confidentiality. Applicable in smart homes, healthcare, and retail environments, this system prioritizes both energy efficiency and privacy preservation.

### I. Introduction

Wi-Fi sensing has recently emerged in scholarly research as an innovative approach for sensing using Wi-Fi radiofrequency (RF) signals in the environment. This paper presents a novel device-free sensing technology that utilizes Wi-Fi signals and employs edge computing for detecting human presence indoors. This system extracts Channel State Information (CSI) from Wi-Fi signals to enable non-intrusive presence detection, eliminating the need for additional devices or sensors. The system emphasizes energy efficiency by optimizing the use of existing Wi-Fi infrastructure to minimize power consumption. Moreover, it addresses privacy concerns by removing the need for cameras or other intrusive sensors, thereby ensuring user confidentiality while maintaining accurate presence detection. This technology offers significant potential for various applications, including in smart homes, healthcare monitoring, and retail analytics, with a focus on enhancing energy efficiency and ensuring privacy.

### II. System Architecture

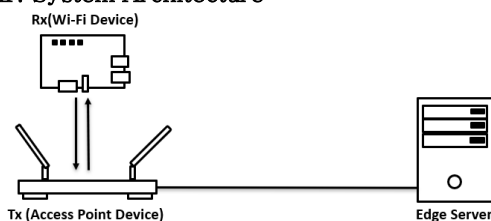


Figure 1. System Architecture Diagram

The system architecture consists of interconnected components designed to enable energy-efficient presence detection and automation. Wi-Fi Access Points (Tx) transmit signals, and Wi-Fi devices (Rx) receive and process these signals. The captured data is processed and stored for further analysis. This processed data is transmitted to an Edge Server for advanced processing to determine human presence. The system employs machine learning to automate control and adjust settings based on detected presence, thus improving energy efficiency and enhancing the user experience (see Figure 1 for the system architecture diagram).

### III. Implementation of Wi-Fi Signal Sensing System

The implementation of the Wi-Fi signal sensing system includes three critical components: Transmitter Setup, Receiver Setup, and Edge Server Setup. Figure 2 illustrates the detailed setup of the Transmitter and Receiver.

#### a) Transmitter Setup:

For Transmitter Setup, the control channel is selected as 157, with the channel bandwidth configured to 40 MHz to optimize signal transmission. Additionally, the Wi-Fi beacon interval is set to 20 ms to ensure timely and efficient communication.

#### b) Receiver Setup:

On the Receiver, Channel State Information (CSI) is extracted. To prevent interference, the `wpa_supplicant` process, responsible for wireless connections, is terminated. Channel information

parameters are generated using specified commands, and the packet extractor is configured to capture CSI data from Wi-Fi packets. Enabling monitor mode on `wlan0` facilitates effective wireless traffic capture, with packets collected using `tcpdump` for subsequent analysis.



Figure 2. Transmitter and Receiver setup

c) Edge Server Setup:

The Edge Server receives the generated heat map image from the Receiver, providing a centralized location for processing and analysis (see Figure 3 for local computing steps).

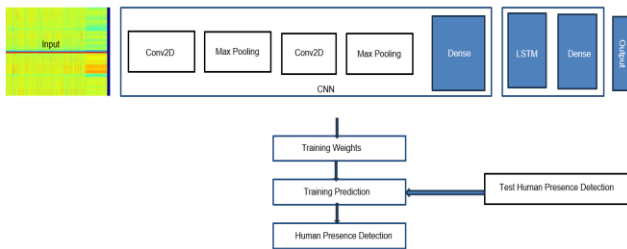


Figure 3. Local computing steps

IV. Results

The results highlight the system's ability to accurately identify patterns of human presence and dynamically control various indoor system aspects in real time using machine learning algorithms on the collected data. This includes the seamless adjustment of lighting based on real-time occupancy information. Figure 4 shows the signal observed with human presence inside the room, and Figure 5 presents a stable channel with no human presence, demonstrating the system's effectiveness and sensitivity.

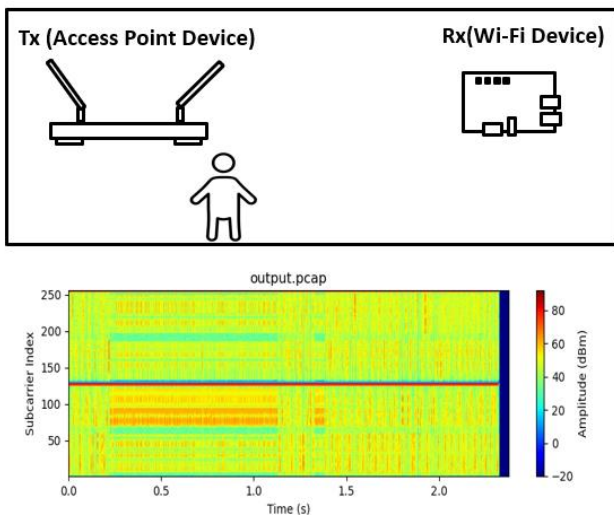


Figure 4. Signal observed with human presence inside the room.

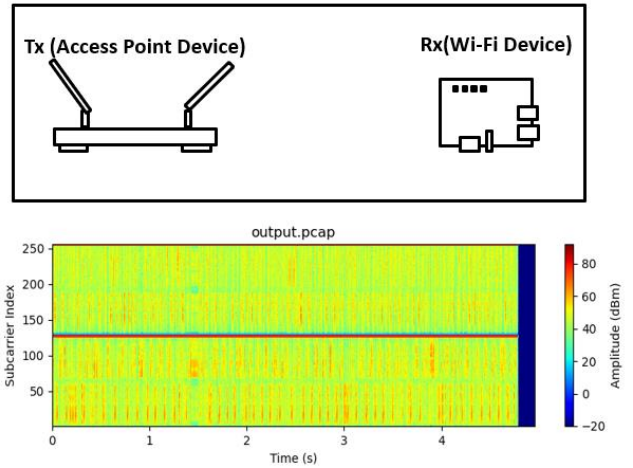


Figure 5. Stable channel with no human presence, inside the room

V. Conclusion

The study confirms the effectiveness of Wi-Fi-based presence detection, emphasizing its potential for enhanced indoor environmental control leveraging edge computing.

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Reference

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