TuijinJishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 5 (2023)

A Novel Method To Identify Stronger Wifi Signal For A Pollution Monitoring IoT Gateway

[1*]B. J Raut, [1] G. B. Jirage, [2]V. B. Gaikwad, [3]A. R. Patil, [4]P. A. Kadam

[1] [2] [3] [4] Department of Electronics Shivaji University, Kolhapur

Abstract: Air pollution has become a major concern worldwide, and it is one of the leading causes of several res monitor various environmental parameters such as temperature, humidity, and pollutants in real-time and IoT can enable the collection and analysis of data from these sensors.
Despite the potential benefits of using WSN and IoT in air pollution monitoring, there are several challenges that need to be addressed. One of the primary challenges is the limited range and connectivity of wireless sensor nodes.
In this paper proposes a novel solution where the gateway devices can work in a dynamic master slave configuration mode depending on the strength of the Wifi signal. Thus, ensuring reliable connectivity for the sensor nodes to pass on data to the cloud via the gateway.

Keywords: *IoT, Raspberry-Pi, Wifi, Linux*

1. Introduction

Internet of Things (IoT) refers to the interconnected network of physical devices, vehicles, buildings, and other objects that are embedded with sensors, software, and connectivity, enabling them to collect and exchange data. The use of IoT in pollution monitoring has been gaining significant attention, as it has the potential to revolutionize how we monitor and control pollution levels. This report will elaborate on the role of IoT in pollution monitoring.

IoT has a significant role in pollution monitoring, and it is revolutionizing the way we monitor and manage pollution levels. The IoT-based pollution monitoring system has various advantages over traditional monitoring systems. IoT enables real-time monitoring, which means that the pollution data can be updated in real-time, and the relevant authorities can take necessary actions immediately. IoT-based systems are more cost-effective than traditional monitoring systems, and they can be easily deployed in remote locations. IoT-based systems are also more accurate and reliable than traditional monitoring systems.

IoT in Pollution Monitoring:

IoT has enabled the creation of smart pollution monitoring systems that can collect and analyze data in real-time. These systems consist of a network of sensors and other devices that are deployed in various locations to collect data on different pollutants, such as carbon monoxide, nitrogen oxides, and particulate matter. The collected data is then transmitted to a centralized database, where it is processed and analysed to provide insights into pollution levels [1].

One of the key advantages of IoT-based pollution monitoring systems is their ability to provide real-time data. Traditional pollution monitoring systems are based on manual data collection and analysis, which can take days or even weeks to provide insights into pollution levels. With IoT-based systems, data is collected and processed in real-time, enabling policymakers to make informed decisions on pollution control measures [2].

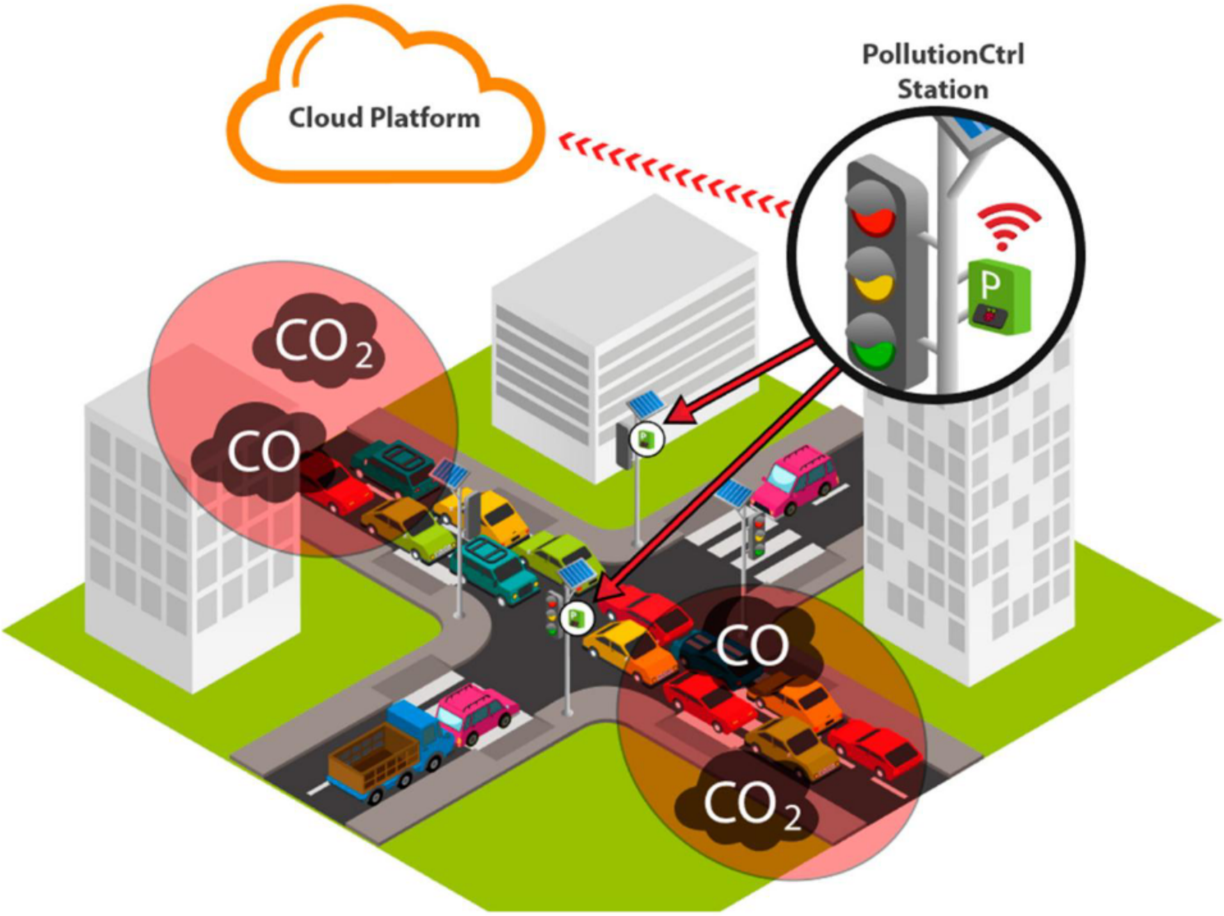

Fig 1: IoT pollution Monitoring System [3]

Another advantage of IoT-based pollution monitoring systems is their ability to collect data from a large number of sources. Traditional monitoring systems are usually limited to a few monitoring stations, which may not be representative of the entire region. With IoT-based systems, sensors can be deployed in various locations, providing a more comprehensive view of pollution levels.

IoT-based pollution monitoring systems can also be used to identify pollution hotspots. By collecting data from multiple sources, these systems can pinpoint areas with high pollution levels, enabling policymakers to take targeted measures to reduce pollution levels in these areas.

IoT-based pollution monitoring systems can also be integrated with other systems, such as traffic management systems, to provide a more holistic view of pollution levels. For example, data from traffic management systems can be used to identify areas with high traffic density, which can be correlated with pollution levels to identify areas with high pollution levels.

IoT has the potential to revolutionize how we monitor and control pollution levels. IoT-based pollution monitoring systems can provide real-time data, collect data from a large number of sources, identify pollution hotspots, and be integrated with other systems to provide a more comprehensive view of pollution levels. With the increasing focus on reducing pollution levels, IoT-based pollution monitoring systems are expected to play a significant role in achieving this goal.

IoT-based pollution monitoring systems consist of various sensors that are deployed in different locations. These sensors can measure various pollutants such as CO2, CO, NO2, temperature, humidity, and pressure. The sensor data is collected by an IoT gateway, which can be a Raspberry Pi, Arduino, or any other microcontroller board. The gateway sends this data to the cloud, where it can be analyzed and visualized using various tools. The data can also be sent to a central server, which can be used by relevant authorities to monitor the pollution levels in real-time.

In this research article, following steps are mainly considered and make prototype.

1. Develop a novel algorithm to solve the problem of connectivity in gateway devices.
2. Experimental setup using Raspberry Pi devices as gateways.
3. Writing code and testing of the program in varying Wifi strength conditions.

2. Literature Survey

In 2015 J. Kim *et al.,*[4]a novel gateway selection method for industrial IoT applications based on the received signal strength indication (RSSI) of wireless sensors. The authors introduced a metric called the RSSI-based gateway selection index (RGSI) to evaluate the suitability of a gateway for a particular application. The RGSI is calculated based on the RSSI values received from each gateway and the distance between the sensor nodes and the gateways. The authors also conducted experiments to validate the effectiveness of the proposed method.

Although the proposed method is shown to be effective in industrial IoT applications, its applicability to other types of IoT systems, such as smart homes or healthcare, is not explored in this paper.

In2020 R. Gharieb*et al.,*[5] an overview of gateway selection techniques in IoT and classifies them into three categories: static, dynamic, and hybrid. The authors also discuss the strengths and weaknesses of each technique and highlight the factors that affect gateway selection in IoT systems. The paper concludes by identifying open research issues in the field of gateway selection in IoT.

The paper does not provide a comprehensive review of recent research on gateway selection techniques in IoT. Some recent techniques, such as machine learning-based approaches, are not covered in this survey.

In 2019 M. B. Abid*et al.,*[6] a comparative study of machine learning-based gateway selection approaches and traditional approaches in IoT environments. The authors conducted experiments using real-world datasets to evaluate the performance of the different approaches. The results showed that the machine learning-based approaches outperformed the traditional approaches in terms of accuracy and scalability.

The paper only considers a limited number of machine learning-based approaches for gateway selection. Other recent machine learning techniques, such as deep learning, are not explored in this study.

In 2019 X. Wang *et al.,*[7]a lightweight gateway selection algorithm for resource-constrained IoT networks. The proposed algorithm takes into account the communication cost, energy consumption, and network congestion to select the optimal gateway for each sensor node. The authors also conducted experiments to evaluate the performance of the proposed algorithm under different scenarios.

Although the proposed algorithm is designed for resource-constrained IoT networks, its effectiveness in more complex IoT systems, such as smart cities or industrial IoT, is not investigated in this paper.

In 2018 K. Z. Chonka*et al.,*[8]a dynamic gateway selection approach for IoT-enabled smart cities. The authors designed a fuzzy logic-based algorithm to dynamically select the optimal gateway based on the traffic load and signal quality of each gateway. The paper also includes a simulation study to validate the proposed approach.

The proposed approach is designed for smart city applications, and its effectiveness in other types of IoT systems, such as healthcare or agriculture, is not explored in this paper.

These papers discuss various techniques for gateway selection in IoT environments, including machine learning, signal strength indication, and lightweight algorithms. Some of the papers also address the challenges of resource constraints and dynamic environments, which are relevant to the problem of identifying stronger Wifi signals for pollution monitoring IoT gateways.But none of them address the solution as proposed by us thus making our solution novel.

3. Problem statement

One of the primary challenges in air pollution monitoring using WSNs and IoT is the limited range and connectivity of wireless sensor nodes. Wireless sensor nodes rely on wireless communication to transmit data to the cloud via a central base station or gateway. However, the range of wireless communication is limited, and obstacles such as walls, buildings, and trees can further reduce the effective range of the network.

This limited range can be particularly problematic in urban areas where air pollution is often concentrated and monitoring is most needed. The high density of buildings, infrastructure, and other obstacles can severely limit the range of wireless communication and make it difficult to establish a reliable network.

Furthermore, the limited range of wireless communication can also lead to issues with data loss and transmission errors. If a gateway is located outside of the effective range of the network, it may not be able to transmit data to the cloud. This can result in missing or incomplete data, which can compromise the accuracy of the monitoring system.

Therefore, the research problem that this study aims to address is: "How can we design and develop an IoT-enabled Wireless Sensor Network that provides accurate and real-time monitoring of air pollution, while overcoming the limitations of connectivity and scalability"

4. System implementation

4.1 Raspberry Pi

Raspberry Pi Model 3B is a single-board computer that is widely used in various applications including the Internet of Things (IoT) and pollution monitoring. The model 3B is the third-generation model that comes with various enhancements and features compared to its predecessors. This paper provides an overview of the Raspberry Pi Model 3B, its basic working of various modules, pin diagram with an explanation, and connection procedures to Arduino and pollution sensors. Additionally, we discuss the role of Raspberry Pi Model 3B as a gateway in pollution monitoring.

4.2 Overview of Raspberry Pi Model 3B

Raspberry Pi Model 3B is a compact single-board computer that is designed to provide a low-cost platform for various computing projects. It comes with a Broadcom BCM2837B0 processor, 1GB LPDDR2 SDRAM, 4 USB 2.0 ports, 40 GPIO pins, HDMI port, Ethernet port, 3.5mm audio jack, and a microSD card slot. It also features built-in Wi-Fi and Bluetooth connectivity that makes it easy to connect to the internet and other devices wirelessly.

4.3 Raspberry Pi used as server

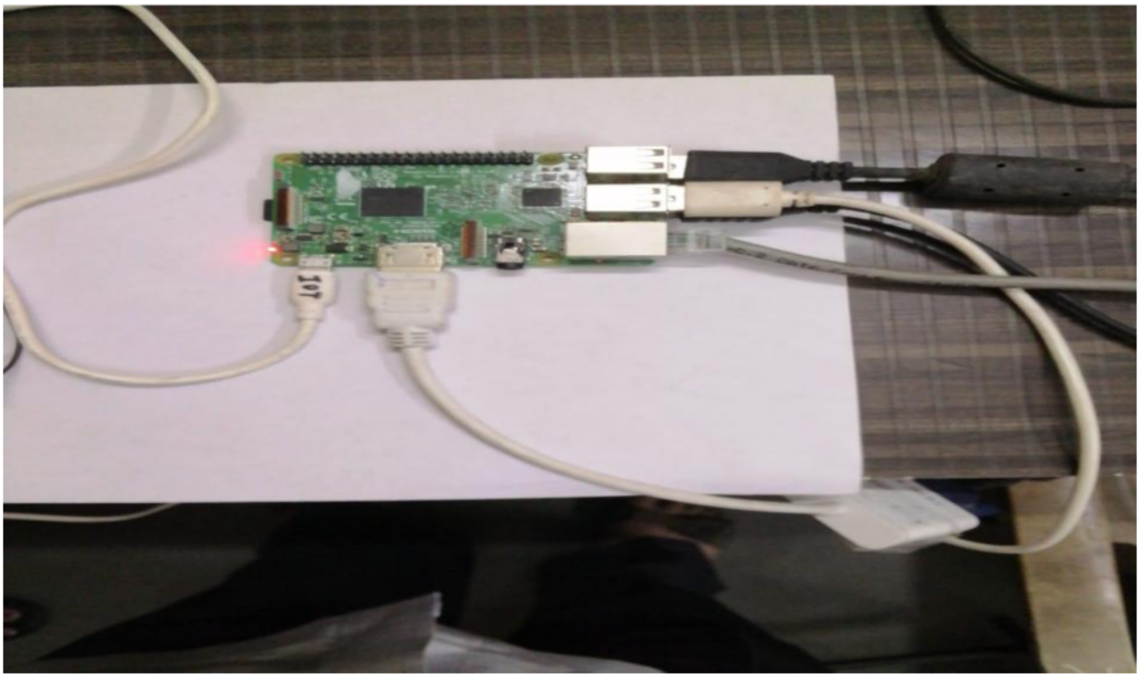

Fig 2: Raspberry Pi connected as server

In this research here used a Raspberry Pi based server that can be used for pollution monitoring to collect data from multiple sensor nodes and store it in a centralized database. The server can also be used to process the data, generate reports and alerts, and provide a web-based interface for users to view the data.

To set up a Raspberry Pi based server for pollution monitoring, the first step is to install an operating system such as Raspbian on the Raspberry Pi. Next, the necessary software and libraries for the server application need to be installed.

Once the software is installed, the Raspberry Pi can be configured to receive data from the sensor nodes. This can be done using wireless communication protocols using Wi-Fi. The sensor nodes can send data in real-time or at scheduled intervals.

The data received from the sensor nodes can then be processed and stored in a database on the Raspberry Pi. The database can be designed to store information such as the pollutant concentration, location, time, and sensor ID. The server can also be configured to generate alerts or notifications when certain pollutant levels are exceeded.

4.4 Node and servers connected for data transfer of sensor data

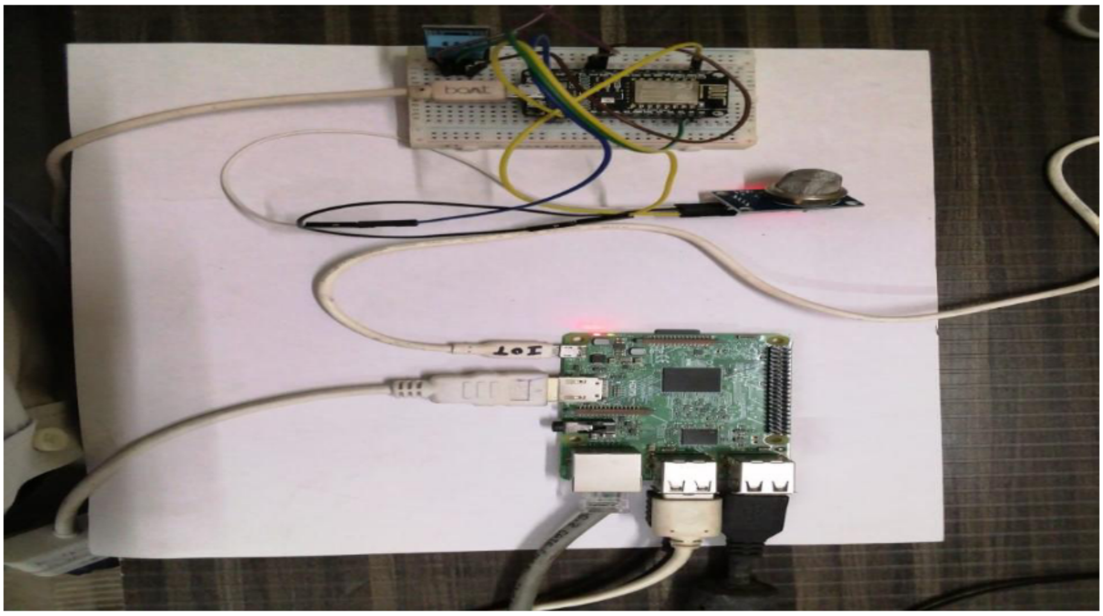

Fig3: Sensors connected to Raspberry Pi

4.4.1 Steps to setting up a master slave configuration for 2 Raspberry Pi

a. To connect two Raspberry Pi devices in a master-slave mode and connect to the WiFi network with the strongest signal, you can use the following steps:

b.Connect both Raspberry Pi devices to the same WiFi network.

c. Install the ssh and net-tools packages on both Raspberry Pi devices using the following command:

```
sudo apt-get update
sudo apt-get install ssh net-tools
```

d. Determine the IP addresses of both Raspberry Pi devices using the ifconfig command on both devices. Note down the IP address of the device with the stronger WiFi signal.

On the device with the stronger WiFi signal, start the sshd daemon using the following command:

```
sudo service ssh start
```

e. On the other Raspberry Pi device, open a terminal window and establish an SSH connection to the device with the stronger WiFi signal using the following command:

```
sshusername@ip_address
```

TuijinJishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 44 No. 5 (2023)

Replace username with the username of the device with the stronger WiFi signal and

```
ip_address with its IP address.
```

f. Once the SSH connection is established, you can use the Raspberry Pi with the stronger WiFi signal as the master device, and the other Raspberry Pi as the slave device.

4.4.2 Shell scripting Linux program for switching between master and slave mode.

To switch between master and slave mode, you can use the iwconfig command to check the signal strength of the available WiFi networks and set the Raspberry Pi to connect to the one with the stronger signal.
The shell program in Linux that checks the WiFi signal strength and switches the Raspberry Pi between master and slave mode based on the WiFi network signal strength:

```
#!/bin/bash
# set the Raspberry Pi as a master or slave based on signal
strength
function set_mode() {
  # get the signal strength of available wifi networks
wifi_signal=$(iwlist wlan0 scan | grep "Signal level" | awk
'{print $4}')
# check if the signal strength of the current network is
stronger than the threshold (e.g., -70)
  if [ "$wifi_signal" -gt -70 ]; then
    # switch to master mode
sudohciconfig hci0 piscan
    echo "Switched to master mode - WiFi signal strength is
$wifi_signal"
  else
    # switch to slave mode
sudohciconfig hci0 noscan
    echo "Switched to slave mode - WiFi signal strength is
$wifi_signal"
  fi
}
# run the set_mode function every 5 seconds
while sleep 5; do set_mode; done
```

This program sets the Raspberry Pi to master mode when the WiFi signal strength is greater than -70 and sets it to slave mode when the signal strength is less than -70. The program then outputs a message indicating the mode change and the current signal strength.
Afterexecution the program in the terminal with the command ./filename.sh where filename.sh is the name of the file you saved the program in. We can view the switching between master and slave mode by monitoring the output of the program in the terminal.

5. Results

After setting up both the Raspberry pi as shown in above figures the below output shows the second Raspberry pi going below the set threshold level of 100 dBm and automatically switching to slave mode. This means that the first Raspberry pi is now acting as the master and sending data of the sensor nodes to the cloud.

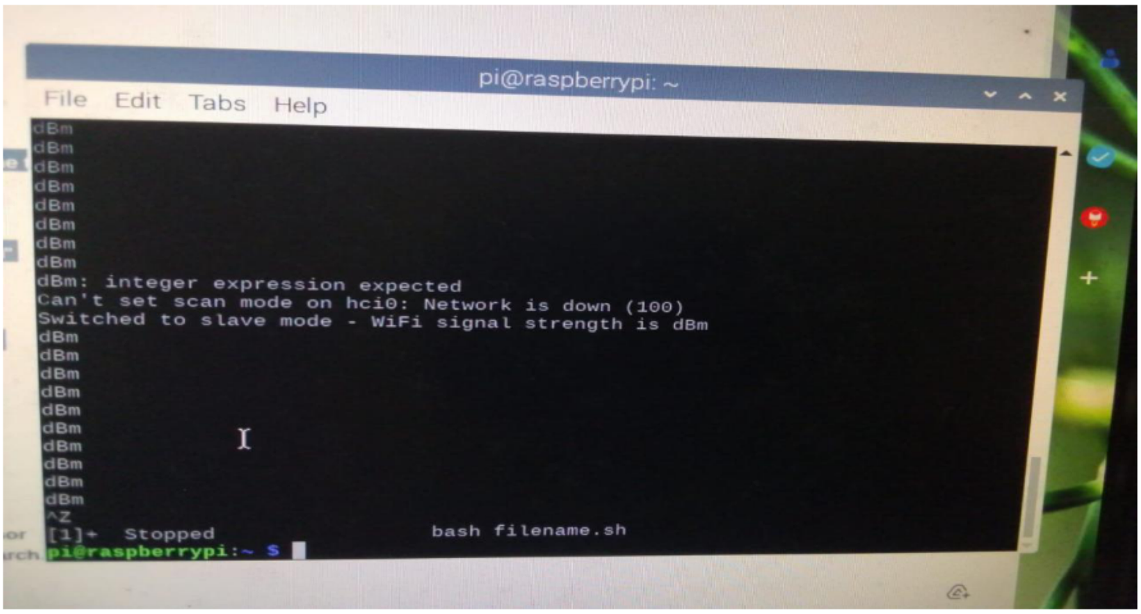

Fig 4: Second Raspberry pi switching to slave mode.

The first Raspberry pi is now acting as the master and sending data of the sensor nodes to the cloud as its Wifi signal is above the set threshold of 100dBm.Note that the signal level is only indicative and researchers can modify it as per their convenience depending on their Wifi setup.

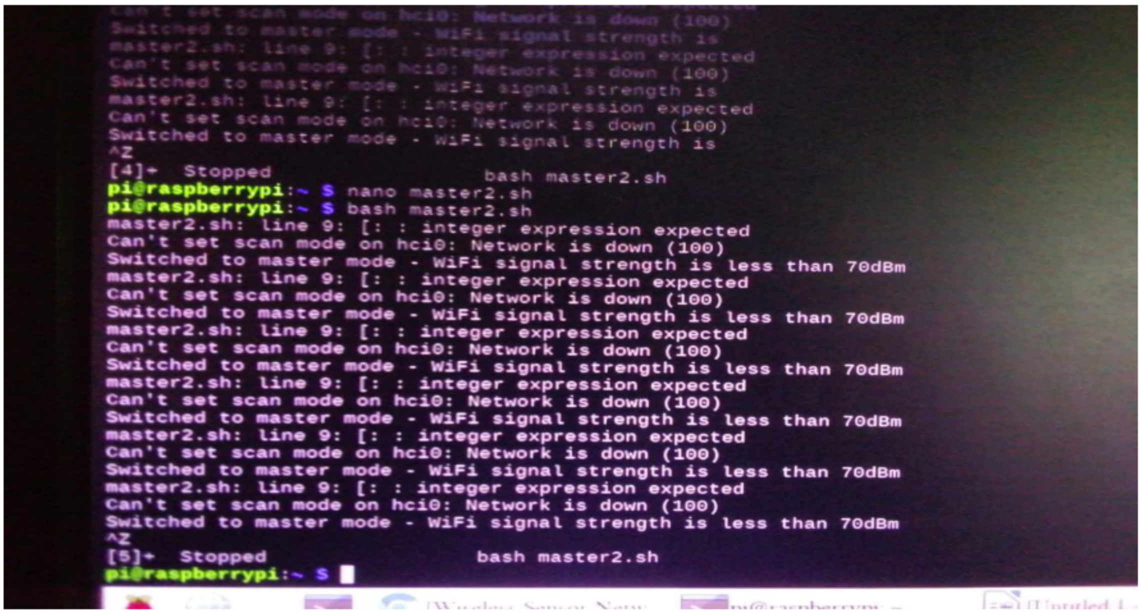

Fig5: First Raspberry pi switching to master mode.

6. Conclusion

The paper proposes a practical solution for optimizing the selection of the IoT gateway with a stronger WiFisignal in air pollution monitoring systems. The proposed approach uses a shell-based Linux command line program that monitors the signal strength of multiple WiFi access points and selects the access point with the strongest signal to ensure stable communication between the sensor nodes and the gateway. The experimental results show that the proposed method provides better stability and reliability in terms of data transmission than the conventional gateway selection methods.

However, the research has some limitations that could be addressed in future work. First, the proposed method does not consider other factors that may affect the selection of the gateway, such as power consumption, latency, and cost. Second, the proposed method is tested only in a laboratory environment, and further experiments in real-world scenarios are needed to validate its effectiveness. Lastly, the proposed method assumes that the sensor nodes are stationary, and it may not be applicable to systems with mobile sensor nodes. These limitations suggest that future work should focus on developing more comprehensive and flexible gateway selection methods that consider various factors and can adapt to different scenarios.

References

[1] A. Pandey, "Indian Government Launches Country's First 'Real-Time' Air Quality Index," India, 2015. [Online]. Available: http://www.ibtimes.com/indian-government-launches-countrysfirst-real-time-air-quality-index-1870328. [Accessed: May 08, 2023].

[2] S. Kumar, S. Jain, and R. Khanna, "A Novel Method for Air Pollution Detection Using IoT-Based Wireless Sensor Networks," in 2021 11th International Conference on Cloud Computing, Data Science & Engineering (Confluence), 2021, pp. 206-211.

[3] C. Toma, A. Alexandru, M. Popa, and A. Zamfiroiu, "IoT Solution for Smart Cities' Pollution Monitoring and the Security Challenges," Sensors, vol. 19, no. 15, pp. 3401, Aug. 2019. doi: 10.3390/s19153401.

[4] J. Kim, J. Choi, and S. Jang, "IoT Gateway Selection Method Based on Received Signal Strength Indication for Industrial Applications," IEEE Access, vol. 8, pp. 238524-238537, 2020. doi: 10.1109/ACCESS.2020.3040223.

[5] R. Gharieb, S. H. Ahmed, and A. Ali, "A Survey on Gateway Selection Techniques in the Internet of Things," Wireless Communications and Mobile Computing, vol. 2020, Article ID 8861834, 2020. doi: 10.1155/2020/8861834.

[6] M. B. Abid, K. Salah, and N. Ghani, "Gateway Selection in IoT Environments: A Comparative Study of Machine Learning and Traditional Approaches," in 2019 IEEE 8th International Conference on Advanced Computer Control (ICACC), 2019, pp. 441-447. doi: 10.1109/ICACC47704.2019.8971944.

[7] X. Wang and X. Sun, "A Lightweight Gateway Selection Algorithm for Resource-Constrained IoT Networks," Journal of Sensors, vol. 2019, Article ID 9567698, 2019. doi: 10.1155/2019/9567698.

[8] K. Z. Chonka, A. Agarwal, and P. Kumar, "Dynamic Gateway Selection for IoT-Enabled Smart Cities," in 2018 IEEE 16th Intl Conf on Dependable, Autonomic and Secure Computing, 16th Intl Conf on Pervasive Intelligence and Computing, 4th Intl Conf on Big Data Intelligence and Computing and Cyber Science and Technology,2018, pp. 727-732. doi: 10.1109/DASC/PiCom/DataCom/CyberSciTec.2018.00116.