Deploying a Raspberry pi Zero for Overhead Flight Detection with SDR And FlightAware

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Abstract.

This paper introduces an affordable system for detecting overhead flights using a Raspberry Pi Zero, Software-Defined Radio (SDR), and the FlightAware platform. The system captures ADS-B signals from aircraft to retrieve real-time flight data, including identification, altitude, and location. It effectively processes data on the resource-limited Raspberry Pi Zero and presents the information through FlightAware. The proposed solution is cost-efficient, dependable, and beneficial for aviation researchers and enthusiasts. This study underscores the potential of low-cost IoT devices for real-time flight tracking and monitoring.

Keywords. Aircraft Detection, Software-Defined Radio, ADS-B Signal Processing, Low- Cost Tracking Systems, Air Traffic Detection.

1. INTRODUCTION

The growing need for real-time aviation monitoring has driven the search for cost- effective methods of overhead flight detection. This paper explores the implementation of a Raspberry Pi Zero, combined with Software-Defined Radio (SDR) and the FlightAware platform, to develop an efficient, budget-friendly, and portable system for tracking aircraft. As a compact and energy-efficient computing device, the Raspberry Pi Zero serves as a suitable foundation for low-cost, DIY flight tracking solutions. By integrating it with an SDR receiver, the system captures and decodes ADS-B (Automatic Dependent Surveillance– Broadcast) signals transmitted by aircraft, extracting essential flight details such as position, speed, and altitude. The processed data is then visualized using FlightAware, a global flight tracking network that enables users to share and contribute real- time flight information. This system empowers aviation researchers, enthusiasts, and individuals in airspace-sensitive regions to monitor local air traffic, enhancing awareness of flight patterns. Additionally, it provides an open-source framework for tracking and analysing aircraft movements, fostering innovation and collaboration within the aviation

sector. The proposed solution presents an economical, scalable approach to aviation data collection, with potential applications in both educational and professional fields.

2. LITERATURE REVIEW

- Smith et al. (2007) explore strategies to enhance ADS-B system security through redundancy, encryption, and anomaly detection. These methods strengthen reliability by identifying spoofed signals and ensuring functionality during system failures. Although they improve security, they also introduce higher complexity and costs. Despite these challenges, such measures are crucial for maintaining secure air traffic management. [1]

- Ramirez et al. (2019) introduce Longshot, a technique for long-range time synchronization that leverages low-latency signal processing. This approach ensures accurate coordination across vast distances, benefiting applications such as GPS and IoT networks. While effective, environmental interference can affect its performance. Nevertheless, Longshot offers a scalable and efficient solution for precise synchronization. [2]

- Moser et al. (2019) propose a passive radar system utilizing IoT hardware to detect objects by processing existing broadcast signals. This technology provides an economical alternative to conventional radar, making it useful for surveillance applications. However, limitations in range and signal interference can impact performance. Even so, it presents a viable and cost-effective option for practical use. [3]

- Eichstaedt and Budroweit (2022) develop a multi-channel ADS-B receiver designed for space applications, utilizing GNU Radio and SDR technology. The system efficiently decodes aircraft signals in space, offering real-time monitoring, compact size, and low power consumption. However, its coverage is more restricted in space than in terrestrial environments. Still, it holds potential for satellite-based air traffic management. [4]

- Varga et al. (2015) introduce a real-time air traffic monitoring system utilizing ADS-B technology to track aircraft positions and movements. While effective, its functionality relies on the availability of ADS-B signals. Despite this limitation, the system significantly enhances situational awareness in air traffic control. [5]

3. PROBLEM IDENTIFICATION

3.1. *Problem Statement*

Aviation monitoring requires a cost-effective, portable, and efficient solution for real-time flight detection and tracking. Many existing systems depend on expensive, complex infrastructure, making them less accessible to hobbyists, researchers, and small-scale applications. This limitation restricts the ability to monitor aircraft movements and collect essential data such as position and altitude. Developing an affordable alternative would expand access to real-time flight information, fostering greater engagement in aviation awareness, research, and hobbyist activities.

3.2. *Risk dentification*

- Obtaining real-time flight data is often expensive and technically demanding, restricting access for hobbyists, researchers, and small-scale users. A budget- friendly alternative involves integrating a Raspberry Pi Zero with an SDR and FlightAware to receive and decode ADS-B signals. This compact and easy-to- deploy system offers real-time flight tracking, making aviation monitoring and analysis more accessible to a wider audience.

- ADS-B signal reception may be affected by interference, hardware constraints, or suboptimal antenna placement, resulting in incomplete or inaccurate flight data. To mitigate these issues, the system utilizes an optimized antenna and fine-tuned SDR settings. These enhancements improve signal reception, ensuring consistent and reliable data capture even in challenging environments.

4. METHODOLOGY

This methodology describes the implementation of a Raspberry Pi Zero-based system for detecting and tracking overhead aircraft using a Software-Defined Radio (SDR) and integrating the collected data with FlightAware for real-time visualization. The system leverages Automatic Dependent Surveillance-Broadcast (ADS-B) technology, which enables aircraft to transmit critical flight information such as position, altitude, speed, and identification. A structured block diagram illustrates the interactions between the system's hardware and software components, ensuring smooth operation. The hardware setup consists of a Raspberry Pi Zero, which functions as the central processing unit, handling data acquisition, decoding, and transmission. An SDR module captures ADS-B signals broadcasted at a frequency of 1090 MHz, while a high-gain antenna improves signal reception, allowing detection of aircraft at considerable distances.

On the software side, an ADS-B signal processing module decodes raw radio frequency signals into meaningful flight data using open-source tools like dump1090. The processed data is then formatted and transmitted to FlightAware servers via an API or a direct integration pipeline, where it is combined with global sources to provide accurate and comprehensive flight tracking. The system workflow begins with the antenna receiving ADS-B signals, which are digitized by the SDR and processed by the Raspberry Pi Zero to extract relevant flight details. This data is subsequently uploaded to FlightAware, enabling users to view live updates and detailed flight paths through its online platform.

4.1. Implementation

- This lightweight operating system is well-suited for optimizing performance on the Raspberry Pi Zero. After downloading, the OS image is written onto a microSD card using software such as Balena Etcher. Once the image is successfully written, initial configurations are applied. To enable SSH for remote access, a file named ssh is created in the boot partition of the SD card. Additionally, for Wi-Fi connectivity, a wpa_supplicant.confige file is added, containing the required network credentials. These steps ensure seamless remote management and network access for the Raspberry Pi Zero.
- After inserting the microSD card into the Raspberry Pi, the device is powered on. To ensure the system is up to date, the following command is executed Sudo apt update && Sudo apt upgrade -y. This updates the package lists and installs the latest software versions. Next, Pi Aware, a FlightAware software package for ADS-B data reception, is installed. This involves downloading the required repository using the w get command, adding it to the system, and installing Pi Aware with Sudo apt-get install pi Aware. Additionally, the SDR software dump1090 fa, which decodes ADS-B signals, is installed using Sudo apt-get install dump1090-fa This setup enables the Raspberry Pi Zero to receive and process ADS-B transmissions effectively.
- Once the software setup is complete, the hardware components are connected. The SDR is linked to the Raspberry Pi using a USB OTG cable, and an antenna is attached to the SDR for signal reception. After these connections are made, the Raspberry Pi is powered on. If each node in this system is connected to the internet and assigned a unique IP address, the network can be scaled indefinitely. This would create a distributed sensor network with the ability to cover large areas and gather extensive data.

5. CONCLUSION

The integration of the Raspberry Pi Zero with Software-Defined Radio (SDR) and FlightAware presents an efficient and cost-effective approach to real-time flight detection. By decoding ADS-B signals, this system enables continuous monitoring of aircraft position, velocity, and other crucial data. Its affordability and portability make it accessible to a wide range of users, from aviation enthusiasts to researchers. Additionally, its scalability allows for seamless integration into global flight tracking networks, enhancing overall airspace awareness. This technology democratizes access to aviation data, fostering collaboration and innovation in flight monitoring. As more individuals and organizations contribute to these networks, the accuracy and coverage of global flight tracking will continue to improve, leading to advancements in both commercial and research applications.

6. REFERENCES

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