Designing a Raspberry Pi Sensor Network for Remote Observation of Wildlife

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ABSTRACT

Scientists and the military need unobtrusive methods of observing wildlife. In this poster, we assess the feasibility of a Raspberry Pi sensor network for wildlife detection and monitoring. While technology for wildlife observation such as camera traps exist, they are expensive and/or require human intervention to collect the data. An inexpensive sensor network that can take pictures of wildlife with negligible human intervention will enable scientists and military personnel to discretely detect the presence of endangered wildlife. Each raspberry pi sensor node collects data for transmission to a remote user via an android app interface. In order to improve battery efficiency, the system features an adaptable network with four distinct sleep modes. We also explore increasing the range and durability of the network by integrating a mesh network.

CCS CONCEPTS

• **Computer systems organization** → **Sensor networks**; • **Applied computing** → *Computers in other domains.*

KEYWORDS

Conservation, Raspberry Pi, Battery optimization, mesh network

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1 INTRODUCTION

Despite the extensive destruction caused by open warfare, military bases paradoxically assist in habitat preservation by creating vast, empty tracts of land that are necessarily free of human contact, which increases the rate of biodiversity [2, 6]. For example, over 200 endangered species live in proximity of military installations in the United States [6]. Scientists and military personnel attempting to detect and monitor wildlife presence in proximity to military installations need robust, discreet, yet inexpensive methods for observation. While devices like camera traps offer a way to monitor wildlife, they tend to cost several hundreds of dollars and employ a flash device that can startle animals and discourage their presence.

To help scientists and the military inexpensively monitor areas for wildlife activity, we developed a sensor network based on the Raspberry Pi Zero W [8] single board computer (SBC). The higher processing and networking capabilities of SBCs make them viable as inexpensive sensor network nodes [1, 7]. Most prior sensor network research involving Raspberry Pis uses early model Raspberry Pis or other SBCs [1, 7] and/or relies on the ZigBee XBee HAT to set up a full OSI layered network with nodes relying on a master node to push collected data into a network [1, 3].

In contrast, our goal is to create a versatile mesh network not reliant on specific nodes for packet routing. The most developed software for Raspberry Pi mesh networking is OpenMesh [5]. OpenMesh's Better Approach To Mobile Ad-hoc Networking (BATMAN) [9] software provides a full layer 2 network that flows packets through a Raspberry Pi mesh without the use of router nodes. The hsmm-pi software [4] also creates a full layer 2 network that flows data through a DHCP run mesh for longer range data transfer with Raspberry Pis for a ham radio application.

All of these software developments are geared towards implementation of a full-size Raspberry Pi platform. To the best of our knowledge, our work is the first to explore implementing a versatile mesh network on resource constrained Raspberry Pi models like the Raspberry Pi Zero W.

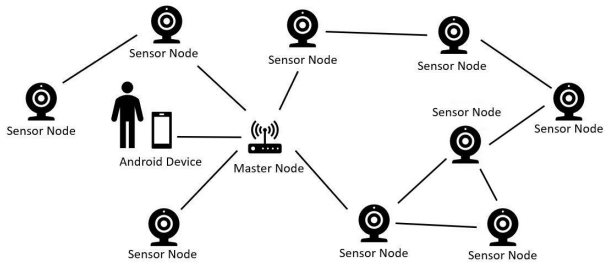


Figure 1: Overview of our Raspberry Pi sensor network.

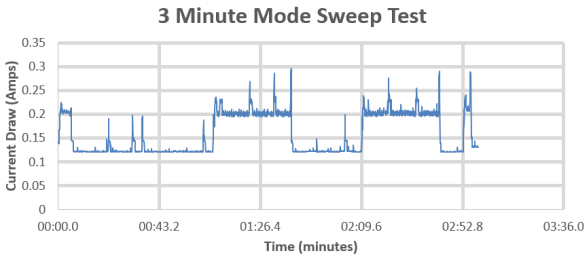


Figure 2: Close up of battery test and state switching.

2 SYSTEM DESIGN

Figure 1 gives an overview of our system. The sensor nodes consist of Raspberry Pi Zero W SBCs [8]. Each sensor node uses three primary sensors: a camera, microphone, and infrared motion detector. The camera and microphone capture audio-visual data, which is relayed to the master node that communicates with the user's Android device. The nodes are connected together through a mesh network that allows for dynamic deployment. Users can deploy multiple sensor nodes per master node. Each node has a transmission range of approximately 30 meters. The master node communicates with the user through an Android device. This enables the user to operate the camera and take pictures, audio, and video. In addition, each sensor node has a motion sensing option that notifies the user upon detection of movement and can automatically capture audio-visual data.

In order to improve efficiency and extend battery life, we implemented four distinct sleep modes. The first mode is a "test" mode, in which all board and sensor functionality is activated. This mode is intended only for testing and will only be entered upon user prompting. The second mode is an active "field" mode. In this sleep level, only the ports pertinent to wildlife detection will be activated, to include the camera and microphone. This is the default mode when operating the system and will shift between the higher and lower power consumption levels. The third is the "passive sleep" mode where the clock speed is decreased and all sensors are disabled except the passive motion sensor. This state is entered upon user prompting or if no motion is detected for 20 minutes. If motion is detected, it will leave this state for the active "field" mode. Lastly, the "deep sleep" mode includes a timer that periodically checks whether the user inputted any data. This mode is only available through user settings in the Android app.

3 PRELIMINARY RESULTS & CONCLUSIONS

In order to test the power-saving capabilities of the system design, we implemented a test suite of four distinct tests to alternate between the various modes. Rather than relying on an input from the motion sensor, the test suite automatically toggles modes at set intervals to produce a more reliable testing pattern to fully deplete the battery and test for node longevity. The test suite was loaded onto the Raspberry Pi and the current was measured over time via an oscilloscope. We used a battery with a 22,000 mAh capacity and 5.8A current output.

Figure 2 illustrates our battery test results. The Raspberry Pi is in "passive sleep" mode approximately 82% of the time, and in active "field" mode the other 18%. This resulted in a system life of 80 hours, which is a 5.3 times improvement over a sensor node without our power saving modes implemented [1]. At lower intervals of activity, we project that our system could remain active longer. Additionally, we notice that the Raspberry Pi Zero's power draw is characterized by frequent current spikes, likely due to some of its essential subsystems. Our preliminary results suggest that our Raspberry Pi Zero W's motion sensing function coupled with power mode implementation is effective in helping conserve battery power. Future tests on the network will help fully ascertain range, effectiveness, and system life. While the observed current spikes can accelerate battery discharge and deterioration, we anticipate that our Raspberry PI sensor system will offer an inexpensive yet reliable method to facilitate wildlife conservation.

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