A Raspberry Pi Sensor Network for Wildlife Conservation

Andrew Arnold
United States Military Academy
West Point, New York
andrew.arnold@westpoint.edu

Paul Corapi
United States Military Academy
West Point, New York
paul.corapi@westpoint.edu

Michael Nasta
United States Military Academy
West Point, New York
michael.nasta@westpoint.edu

Kevin Wolgast
United States Military Academy
West Point, New York
kevin.wolgast@westpoint.edu

Thomas A. Babbitt*
United States Military Academy
West Point, New York
thomas.babbitt@westpoint.edu

ABSTRACT

Scientists and the military require inconspicuous means to monitor wildlife. In this poster, we progress the ability for a Raspberry Pi sensor network to be used for wildlife detection and monitoring. Eliminating the need for expensive commercial camera traps, the sensor network will, with little to no human interaction, detect and collect vital information about the presence of endangered wildlife. Raspberry Pi sensor nodes collect and store data and transfer it over a mesh network to an android app interface. In order to reduce the node size and maintain battery efficiency, we are implementing parallel battery usage and standard lithium batteries. We will also increase the range, durability, and adaptability of the network by integrating a self-healing mesh network that does not require a master node for communication to and from individual sensors.

CCS CONCEPTS

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

KEYWORDS

Conservation, Raspberry Pi, Battery optimization, mesh network

ACM Reference Format:

Andrew Arnold, Paul Corapi, Michael Nasta, Kevin Wolgast, and Thomas A. Babbitt. 2020. A Raspberry Pi Sensor Network for Wildlife Conservation. In *Hot Topics in the Science of Security Symposium (HotSoS), April 07–08, 2020, Lawrence, KS.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3314058.3317293

1 INTRODUCTION

Military bases around the globe, and especially in the United States, contain significant biodiversity. This is due to the restrictions placed on access and use of the land outside of military training exercises [3, 4]. Rules and regulations exist to identity and isolate key habitats for endangered species and limit or restrict training in those areas [5]. By some estimates, the number of endangered species effected might top 200 [4]. Scientist attempting to research these species need a portable and robust system capable of using multiple sensors to capture audio, still pictures, and when possible, video.

To assist the military to monitor and make appropriate training decisions and scientist to conduct research with minimal environmental impact, we modified a wireless sensor network (WSN) to consist entirely of the Raspberry Pi Zero W [6] single board computer (SBC). This makes a number of improvements to the WSN proposed in [1, 2]. The Raspberry Pi Zero W is an improvement over using earlier models of Raspberry Pi's or the ZigBee XBee HAT and its use as a master node is novel.

The overarching goal is to create a lightweight redundant, self healing mesh network with extended battery capability. Our proposal allows every node to act as a sync or master. The system modifies the HSMM-Pi software [8] which was originally proposed for use in ham radio and creates a mesh network between the Raspberry Pi Zero W sensor nodes. The user with an Androids app can connect to any sensor node to transmit and receive data.

Minimal interactions is preferred when observing an environment for research. There a numerous studies on the effect of human activities on wildlife [7]. A more efficient battery at each node reduces the number of times a researcher must enter, and possibly effect, an environment. A modification to the battery connection and better power utilization allow for a more robust system.

2 SYSTEM DESIGN

Figure 1 provides an overview of our system. Each node consists of a Raspberry Pi Zero W which are equipped with a camera, an inferred motion detector, and a microphone. The camera and microphone capture audio-visual data which is stored on the sensor itself. The sensor sends a notification to the android phone through the mesh network telling the user there is new data. The user is then able to request the information through the app and can view the data.

The full mesh network implemented works to increase adaptability and resilience of the network. Previous designs of this system utilized a master node that was the only node able to interface with the app. The new design increases resilience because the entire network is not reliant on a single node interacting with the app. We are currently using HSMM-Pi which is a pre-built set of tools designed to create a mesh network on Raspberry Pi systems [8]. This system routes traffic through the mesh and manages routes through Optimized Link State Routing Protocol (OLSR).

*Corresponding Author

HotSOS, April 07–08, 2020, Lawrence, KS

ACM ISBN 978-1-4503-7147-6/19/04.
https://doi.org/10.1145/3314058.3317293

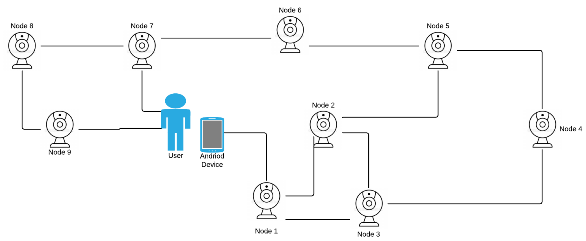

Figure 1: Overview of the mesh network.

A major goal of this design is to improve energy performance while reducing the overall size of the system. Previous versions of the project utilized a commercial battery pack, typically used for charging mobile devices, which connected with the Raspberry Pi via its micro USB power connector. This design implements standard lithium polymer (LiPo) batteries with direct connections in order to reduce size and improve cost efficiency.

In order to further reduce the size of the device, we are redesigning the previous version's PCB hat which implements an infrared sensor to detect motion and a microphone to record audio. We are removing the audio jack on the previous design and implementing direct processing of audio signals from the microphone, which enables us to reduce the size of the PCB hat. Additionally, the PCB hat serves as an interface to implement the new LiPo batteries and provides a method of quickly swapping dead batteries.

3 PRELIMINARY RESULTS & CONCLUSIONS

The current process of setting up the mesh network builds on previous models. Instead of using a Raspberry Pi 3 for the master node, we have transitioned to having any Raspberry Pi Zero W in the network serve as a master node. This allows the android app to connect to any node and eliminates the need for a different type of Raspberry Pi. This removal of a designated master node allows for a self healing properly where the loss of one node does not cause the network to fail and creates a full mesh network.

Since most LiPo batteries operate at 3.7V, our initial battery tests involved testing how the Raspberry Pi performed under direct power at this voltage. Tests were performed using a Keysight bench power supply while current and voltage data were captured on the device. A graph of the results is shown in Figure 2.

The small spikes in current draw in Figure 2 indicate times when the Raspberry Pi actively captured images. These amount to only small variations in current draw and an overall average current draw of approximately 206mA, resulting in about 14.5 hours of battery life with a 3000mAh battery. Choosing this battery capacity and its generic LiPo architecture allow us to design a more compact, but similarly efficient, enclosure.

Further, we are implementing two 3000mAh batteries in parallel to effectively double the device's lifetime to over 24 hours, based on our initial 14.5 hour estimate. In order to effectively implement two batteries, as well as the necessary microphone and infrared sensor, we have improved the previous version's PCB hat design. This requires Schottky diodes to be implemented in series with each battery to prevent mutual charging due to voltage differentials. This

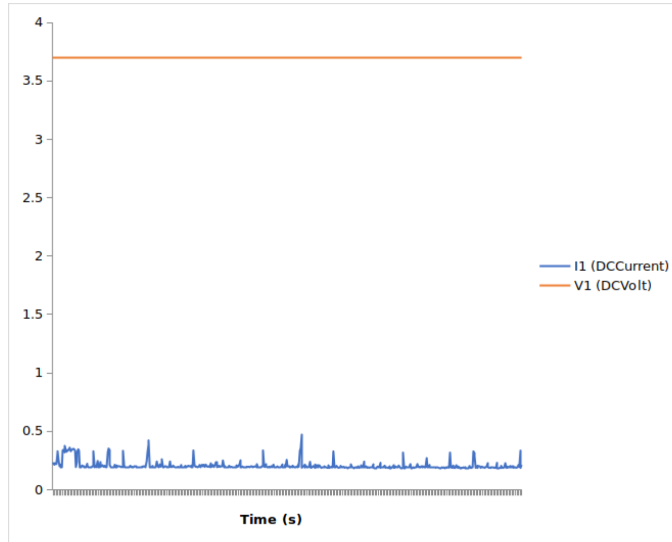

Figure 2: Current and voltage versus time for 3.7V direct power.

results in voltage drops of 0.3V across each diode, lower than the typical 0.7V diode voltage drop, which lowers overall source voltage to 3.4V, consequently resulting in a safer operating voltage for the Raspberry Pi as it is designed to operate at 3.3V. We predict that the network and battery modifications will make our wireless system more robust and assist in wildlife conservation.

ACKNOWLEDGMENTS

The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Army, Department of Defense or the U.S. Government.

REFERENCES

[1] Andrés Alejos, Matthew Ball, Connor Eckert, Michael Ma, Hayden Ward, Peter Hanlon, and Suzanne J. Matthews. 2018. Exploring the Raspberry Pi for Data Summarization in Wireless Sensor Networks: Poster. In *Proceedings of the 5th Annual Symposium and Bootcamp on Hot Topics in the Science of Security (HoTSoS '18)*. ACM, Article 18, 1 pages. https://doi.org/10.1145/3190619.3191679

[2] Brian H. Curtin, Rachelle H. David, Emmet D. Dunham, Cullen D. Johnson, Nikhil Shyamkumar, Thomas A. Babbitt, and Suzanne J. Matthews. 2019. Designing a Raspberry Pi Sensor Network for Remote Observation of Wildlife. In *Proceedings of the 6th Annual Symposium on Hot Topics in the Science of Security (HotSoS '19)*. Association for Computing Machinery, New York, NY, USA, Article Article 17, 2 pages. https://doi.org/10.1145/3314058.3317293

[3] David Doxford and Alan Judd. 2002. Army training: the environmental gains resulting from the adoption of alternatives to traditional training methods. *Journal of Environmental Planning and Management* 45, 2 (2002), 245–265.

[4] Michael J Lawrence, Holly LJ Stemberger, Aaron J Zolderdo, Daniel P Struthers, and Steven J Cooke. 2015. The effects of modern war and military activities on biodiversity and the environment. *Environmental Reviews* 23, 4 (2015), 443–460.

[5] Jay Price. 2016. Military Bases Serve As Safe Haven For Endangered Species. Retrieved January 22, 2020 from https://www.npr.org/2016/09/15/494127912/military-bases-serve-as-safe-haven-for-endangered-species

[6] Raspberry Pi Foundation. 2017. Raspberry Pi Zero W. https://www.raspberrypi.org/products/raspberry-pi-zero-w/

[7] Robert J. Steidl and Brian F. Powell. 2006. Assessing the Effects of Human Activities on Wildlife. *The George Wright Forum* 23, 2 (2006), 50–58. http://www.jstor.org/stable/43598938

[8] Urlgrey. 2017. urlgrey/hsmm-pi. https://github.com/urlgrey/hsmm-pi