Wireless Sensor Network for Long Range UAV Swarm Communication

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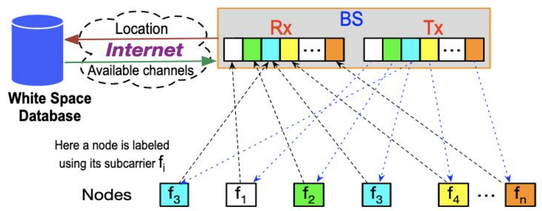
Introduction

- Unmanned Aerial Vehicle (UAV) swarms can be deployed to survey large areas such as for agriculture, environmental monitoring, and search-and-rescue missions.
- Current long range communication technologies are costly to deploy such as meshed Wi-Fi, LTE-M, or 5G.
- Sensor Network Over Whitespace (SNOW) is Low-Power Wide-Area Network (LPWAN) technology that freely operates on unallocated TV white space (470 - 698 MHz).
  - SNOW enables distributed and asynchronous long range communication from sensor nodes to the base station (BS).
  - SNOW can be implemented with inexpensive COTS devices lowering deployment costs.



SNOW Architecture [1]

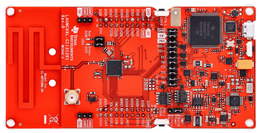
- Current implementations of SNOW are costly to adopt.

KEY RESEARCH CHALLENGES

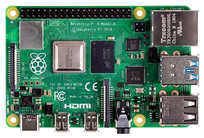
- How can we **adopt** SNOW in current UAV systems with minimum cost?
- How can we **deploy** a fully end-to-end communication pipeline using SNOW?

Hardware

SDR capable of operating on TV white space RF band
(**Nuand BladeRF 2.0 Micro**)



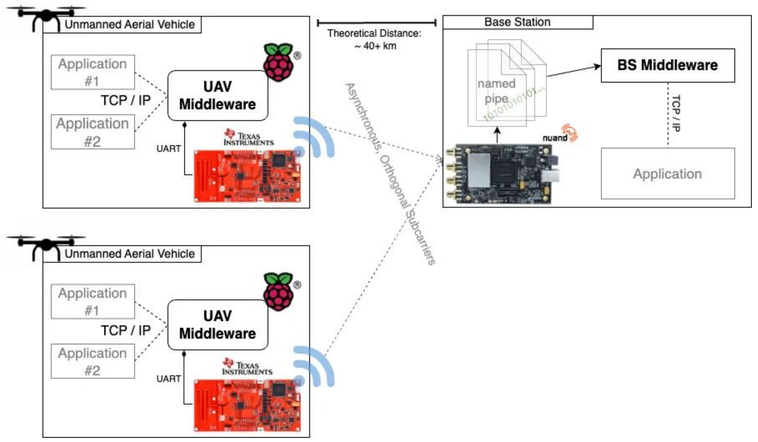
MCU with programmable RF PHY layer with support of UART communication
(**TI CC 1312R1 LaunchPad**)



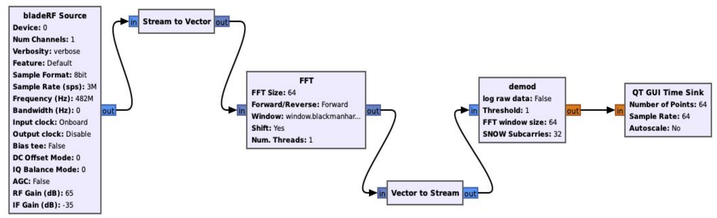
SBC for the UAV mission computer
(**Raspberry PI 4 Model B**)

Design

System Architecture



- Designed for external applications to send packets via SNOW by connecting to a TCP/IP connection hosted on the UAV SBC or BS middleware applications.
  - TCP/IP is a wide-known communication protocol and easy to adopt in existing applications.
- The BS middleware application leverages parallelized packet parsing for each subcarrier in the SNOW network.

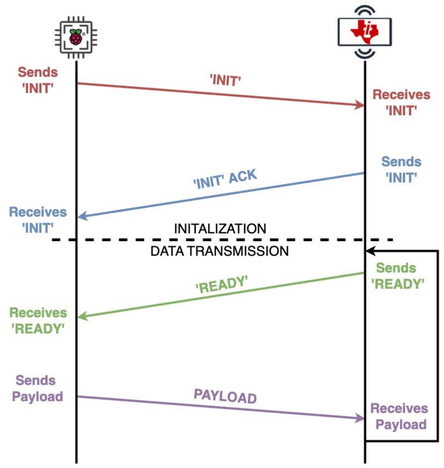


- We leverage the base GNU Radio implementation of SNOW (gr-snow) to handle DSP with the addition of writing to named pipes for IPC to the BS middleware.

Design

UAV Hardware Synchronization / Transmission

- Raspberry Pi supplies power to TI CC 1312
- TI CC 1312 is ready on boot up but Raspberry Pi requires initialization
- Raspberry Pi and TI CC 1312 handshake for initialization and packet transmission



Future Work

- Most of the work has been simulated within a lab environment. We plan on flight tests to simulate real-world deployments.
- To stick with the idea of low-cost deployments, we want to leverage Docker to simplify the deployment process of the BS middleware application.
- We plan on setting up test deployments to measure range and bandwidth of SNOW on our selected hardware.
- SNOW and the middleware applications are designed as a one-to-many network topology. Subsequent test deployments should increment the number of SNOW nodes to verify the network topology and validate acceptable network performance and reliability.

References:

[1] M.Rahman, D.Ismail, V.P.Modekurthy, A.Saifullah. Implementation of Ipwan over white spaces for practical deployment. In Proceedings of the International Conference on Internet of Things Design and Implementation (IoTDI '19), pages 178–189, 2019.

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