



Demo: The integration of mu-Net and BlueBuzz Acoustic Modem

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ABSTRACT

In this demo, we showcase the recent progress of μ -Net, a community shared, open-source, open-architecture infrastructure that supports acoustic communication, underwater networking, and marine robotics. Specifically, We will demonstrate the integration of u-Net and a newly developed acoustic modem. In the demo, multiple ROS running systems are able to form an underwater wireless network and communicate using acoustic modems.

CCS CONCEPTS

- Networks $\rightarrow$ Ad hoc networks; Physical links; Network experimentation;
- Computer systems organization $\rightarrow$ Robotics.

KEYWORDS

Acoustic modem, μ -Net, ROS, Aqua-Net

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1 INTRODUCTION

The μ -Net system is an open-access, open-architecture infrastructure designed to support the integration of underwater communication, networking, and robotics [2, 4]. The core of the infrastructure is a flexible and re-configurable software architecture to interface with the open-access robotics suites, such as ROS. This way, μ Net can provide networking capability to underwater robots and vehicles with a comprehensive set of networking capabilities for collaborative robots.

In this demo, we would like to show the outcome of such integration by adapting a ROS application, turtlesim, to the μ -Net system.

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Figure 1: Photo of BlueBuzz with paired transducer. View is of computer board. The analog board and amplifier board are stacked behind.

We will show that multiple ROS-running systems can form a network and send data packets using a newly developed open-source acoustic modem.

2 BLUEBUZZ ACOUSTIC MODEM

The BlueBuzz [1] (Fig. 1) consists of an onboard computer for encoding/decoding, an onboard microcontroller (MCU) for modulation/demodulation, an analog section containing transmission and receiving hardware, and a paired transducer as a transceiver.

For transmission, a 12-bit digital-to-analog converter (DAC) controlled by the MCU is used to generate modulated sine waves

for transmission using either Frequency Shift Keying (FSK) or Frequency Hopping Frequency Shift Keying (FHFSK). The DAC output is fed into a custom amplifier with a 36db gain and an impedancematching circuit and is then transmitted by the transducer.

For the reception, the preamplifier boosts the received signal heard by the transducer to a readable voltage range with three stages: a band pass filter with 100V/V gain (stage A), a band pass filter with 30V/V gain (stage B), and a selectable 1-7V/V programmable gain amplifier (stage C). The combined gain of all stages gives a selectable range between 3-21kV/V (69-86db). The gain range of the modem was determined through experimentation.

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system with a ros-aquanet-adapter installed as a plugin. Every Raspberry Pi is equipped with a BlueBuzz modem. As for the application layer, a revised turtlesim_teleop_key is running on each sender to generate ros-twist messages to control the turtle displayed on the receiver side.

The receiver part consisted of a single Raspberry Pi with ROS and ros-aquanet-adapter installed. It is equipped with a BlueBuzz modem as well. The receiver is running a revised turtlesim_node application to visualize the movement of the turtles. Each turtle is receiving the corresponding movement commands (*i.e.* ROS twistmessages) from an individual sender device.

Thus, the demo setup represents a multi-stream

Scott Mayberry, Dmitrii Dugaev, Jinzhi Cai, Zheng Peng, and Fumin Zhang

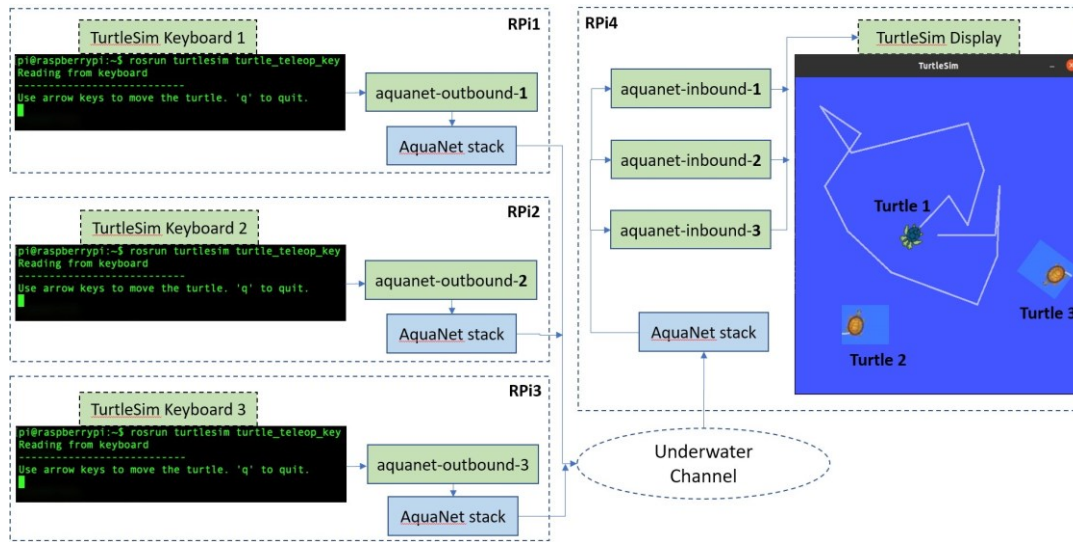


Figure 2: Demo software architecture

3 THE DEMO

The objective of this demo is to show that the ROS applications can perform network communications using the μ -Net system. In this demo, multiple users from different network nodes can run a ROS program to control the movement of animated turtles on another network node. The acoustic communication at the physical layer is enabled by the BlueBuzz modems. We employ AquaNet [3], an important component of the μ -Net infrastructure, for routing and multi-user support. The remote control and display are achieved by modifying a ROS software called turtlesim. The original turtlesim allows a user to control the movement of an on-screen turtle by reading the user's local keyboard input. The software runs on a single node and does not involve any network operations. Our revised turtlesim software is different. The control and the display of the turtle are on different nodes. The user inputs are transmitted using the μ -Net system, by interfacing with the Aqua-Net protocol stack.

The demo setup has three main components: the senders, the receiver, and the underwater network. As illustrated in Fig. 2, three Raspberry Pis serve as the senders. Each of them is running the ROS

communication network between 3 senders and 1 receiver. The senders generate network traffic containing the turtle movement commands, while the receiver visualizes the movements of individual turtles on a screen. This is supported by the ros-aquanet-adapter we developed as a component of the μ -Net system. It provides a convenient way for ROS applications to perform inter-vehicle communication with ROS topics and ROS messages over an underwater acoustic channel.

In summary, the demo shows that μ -Net has achieved its objective of supporting communication, networking, and robotics. A short video of the demo can be found at https://youtu.be/oWhh_1zWX2o.

4 SPACE AND EQUIPMENT REQUIREMENTS

To demonstrate the software and hardware systems, we would like to request a demo table and a location that has access to water. In addition, it will be appreciated if the conference can provide us a LCD monitor with an HDMI cable to show the demo, a USB keyboard and a USB mouse to control the Raspberry Pi. Moreover, We would also like to ask for a poster stand next to our demo booth.

ACKNOWLEDGMENTS

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REFERENCES

- [1] Scott Mayberry, Jinzhi Cai, and Fumin Zhang. 2022. BlueBuzz, a Low-Cost OpenSource Acoustic Modem. In *OCEANS'22 IEEE HAMPTON ROADS*.
- [2] Scott Mayberry, Junkai Wang, Qiuyang Tao, Fumin Zhang, Shuai Dong, Connor Webb, Aijun Song, Xiaoyan Hong, Dmitrii Dugaev, and Zheng Peng. 2021. First Step Towards UNet: Open-Access Aquatic Testbeds and Robotic Ecosystem. In *Proceedings of The Fifteenth International Conference on Underwater Networks and Systems (WUWNet)*. Shenzhen, China.
- [3] Zheng Peng, Zhong Zhou, Jun-Hong Cui, and Zhijie Shi. 2009. Aqua-Net: An Underwater Sensor Network Architecture: Design, Implementation, and Initial Testing. In *Proceedings of IEEE/MTS OCEANS*. Biloxi, MS, USA.
- [4] University of Alabama, Georgia Institute of Technology, City College of New York and Michigan Technological University. 2021. The μ -Net Project Website. <https://aquatictech.org/>. Accessed: 2022-07-15.