Underwater Acoustic Network Testbed

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Extended Abstract for ACM WUWNet 2011:

Testbeds provide valuable infrastructure for evaluating and developing network protocols. This demonstration presents nodes for an underwater acoustic network (UAN) testbed. The testbed can be made available for collaborative experiments with the UAN research community. For most experimental configurations, the nodes can be remotely controlled via the Internet.

Testbed Node Hardware

We have designed and constructed three different sets of testbed nodes, for different deployment scenarios (a total of 26 nodes).

We have built 10 nodes which are very small and easy to deploy by hand, for example by suspending them from a dock or other existing infrastructure. These nodes are shown in Figure 1. Each node includes a WHOI Micromodem [1] with its floating-point coprocessor board to allow PSK packet reception, as well as an optional multi-channel receive array to improve PSK receive performance. The transducer center frequency is nominally 25 kHz with 5 kHz bandwidth. Burst data rates range from 80bps to 5300bps. The power amplifier is a low-power (150 dB re:1µPa@1m) linear power amplifier (maximum link ranges on the order of 500-1000m) to allow multi-hop networks to be deployed in a relatively small physical area and to increase deployment duration with the limited batteries in a small pressure housing. The pressure housings are rated to 100m. The deployment duration is on the order of 100-200 hours, depending on the network's offered load and node settings.

In each testbed node, the Micromodem is controlled by a Gumstix (http://gumstix.com) embedded computer running Linux, consuming 1.4-2.5 Watts, depending on configuration. Network protocols can be implemented on the Gumstix. The Gumstix can run autonomously if the node is submerged, or the Gumstix can be controlled remotely with a serial console or 802.11 WiFi if the deployment infrastructure supports it. Alternately, the Gumstix can interface to sensor instruments using the serial port.

In addition, we have built and fielded 8 shallow-water buoy testbed nodes, for use in up to 30m water depth, deployed by a small boat. They are shown in Figure 2. Internally, their electronics are similar to the nodes described above, with the following differences: the buoys can be configured to operate at either 25 kHz or 10 kHz, with optional multi-channel receive arrays; the power amplifiers have a fixed transmit power of 185 dB re:1µPa@1m (maximum link ranges on the order of 2-4 km for 25 kHz, or 5-10 km for 10 kHz, highly dependent upon propagation conditions); the buoys each have a GPS; deployment duration is on the order of 100 hours; remote control capability is provided by a Freewave radio (http://freewave.com) providing serial ports which can be controlled over the Internet with a serial port server.

Finally, we have built and fielded a set of deeper water testbed nodes, consisting of four 25 kHz subsurface nodes and two 10 kHz subsurface nodes, rated to 600m, as well as two buoy nodes. The buoy nodes operate at *both* 25 kHz and 10 kHz, and are also equipped with GPS receivers and Freewave radios, providing gateway routing capability. These nodes require a large boat or small ship with a crane or A-frame for deployment. The node electronics are similar to the shallow-water buoys described above, with the following exceptions: they currently do not have multi-channel capability, but can receive single-channel PSK; deployment duration is on the order of 300 hours for subsea nodes and 400 hours for buoy nodes. These nodes are shown in Figures 3 and 4.

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References

[1] L.Freitag et al., *The WHOI Micro-Modem: An Acoustic Communications and Navigation System for Multiple Platforms*, IEEE OCEANS 2005; http://acomms.whoi.edu/

Figures: Left to right: (1) small, shallow-water nodes; (2) shallow-water buoys; (3) deeper-water subsea nodes; (4) deeper-water buoys.