

Poster: Building a test-bed for wireless sensor networking for under-water oil and gas installations

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1 Introduction and background

When the oil and gas industry moves its production facilities into even more challenging environments, like the off-shore fields in the arctic areas, advanced use of information and communication technology (ICT) is imperative. Sensor network research lacks results from experiments with real communications between real sensors. At the University of Oslo, Norway, we are in the initial phase of building an underwater sensor networking lab, in order to be able to get such research results.

The long term goal of our research is to enable the building of robust, wireless, sub-sea sensor and actuator infrastructures. Oil and gas sensor networks will be heterogeneous. Heterogeneity will be exploited along three dimensions: by admitting components with different data formats and semantics, by allowing different communication media (both wireless and wired), and by addressing different loads of data.

Initially we are building a laboratory in a large water tank. Later we will cooperate with an oil and gas company and deploy our sensor and actuators on an off-shore oil and gas rig. The use of such real environments will hopefully give us a lot of realistic research results.

In this poster we report on our initial efforts to build such a robust sensor networked infrastructure. Initially we develop two motes for underwater use that facilitate different types of communication channels.

2 Overview

High reliability is a central issue for oil installations, this fact being exaggerated by the difficulty and cost of replacing and adding sub-sea units. The wireless communication should therefore have alternative, parallel transmission channels with the possibility of easy reconfiguration. Then critical data can be re-routed if some parts fail. An extra security feature is introduced utilizing different technologies for redundancy.

Hydro acoustic communication is very reliable and feasible and has been used in a range of applications, in spite of the rather low bit-rate typically achieved, e.g. 100 – 1000 bit/s [2].

In optical communication the light is spread considerably from the transmitter and therefore the energy is widely distributed. This means that the transmission ranges from simple light sources will be restricted (unless focused), demanding a reduced range between the motes. To implement a full 3-D communication possibility, each mote must have multiple light emitters and sensors to cover several directions.

The actual motes chosen for this project, Moteiv Tmote Sky [1], are battery operated and programmable in the TinyOS environment [3]. We have developed special extension cards

for the ultrasound and IR light transducers and plugged them into the motes. We plan to embed these motes in water-tight plastic containers. The external components are controlled by appropriate drivers which cooperate with the operating system.

3 The ultrasonic transceiver

The mote extended with ultrasound transmission capabilities consists of an extension card having a sender of type Murata MA40S4S and a receiver of type Murata MA40S4R. Frequency shift keying has been chosen for the coding strategy, and frequencies of 39.8 kHz and 41.8 kHz are used for 0, 1. The sending stages are controlled by two parallel relaxation oscillators made from a Schmitt-trigger, a resistor and a capacitor. Figure 1 shows the printed circuit board adjacent to the mote.

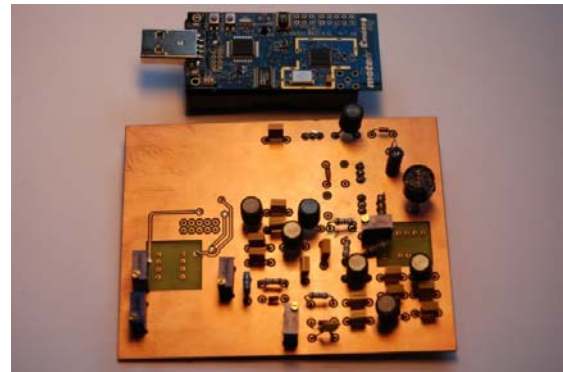


Figure 1 Ultrasound transceiver and Tmote Sky

4 The optical transceiver

Another technology for sub sea transmission is to use infrared (IR) transceivers. An extension PCB for the Tmote has been developed. The transceiver of type Agilent HSDL-3208 is a low power 115.2 Kbit/s infrared transceiver, operating at $850 \leq \lambda \leq 900$ nm (see figure 2).

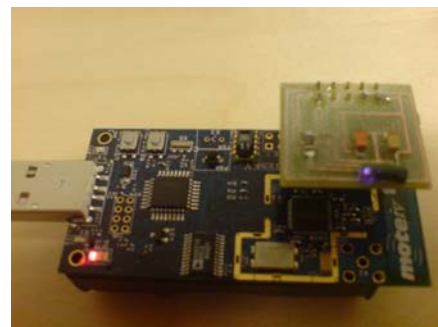


Figure 2 Tmote Sky with IR extension PCB with one HSDL-3208 IR transceiver

As for the ultrasound case the IR extension cards is interfaced to the mote through the TinyOS drivers and adhere to the same protocol hierarchy. We are using the microcontroller of the Tmote Sky to handle the information transfer directly through the IR extension cards. This is not ideal, as the task handling of TinyOS is too slow to cope with high bitrates. To utilize maximum performance of the HSDL-3208 it is necessary to store data on the extension card, and provide the card with means to handle the bit transfer.

5 The ultrasonic transceiver performance

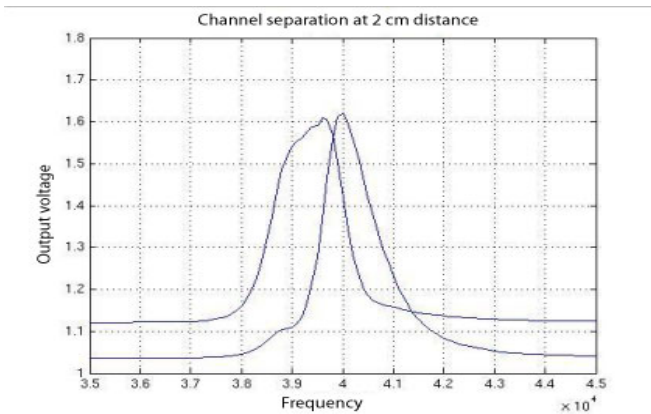


Figure 3 Measured channel separation at 2cm distance

Initial testing of the ultrasonic transceiver was focused on the ability to separate the communication of 0,1 FSK-signaling. Initially the sending stage was placed only 2 cm from the ultrasonic transducer and performed a frequency sweep from 30KHz to 50KHz. Figure 3 shows the frequency response of the transceiver's two filter stages, where a logical 0 is detected at 39.8 kHz and a logical 1 at 40.3 kHz. A channel separation of 0.5 KHz is sufficient for most applications.

Regarding power consumption, calculations indicates 7.5 mA through the branch to signal ground at any time when powered. In addition, our amplifier uses approximately 200 μ A for each stage, giving a total of around 8 mA at idle before adding the sending stage. In other words, ultrasound is a quite power consuming option.

6 The optical transceiver performance

Initially we limit our testing to a 2D plane in air and water, and the transmitting Tmote is directed directly towards the receiving TAOS TSL 251R photo sensors. We are also transmitting from one mote at a time, eliminating interference.

To test the performance in water, we placed the system in a glass container and lowered it into a water tank, while the TSL 251R sensor was placed outside the tank.

The results in Figure 4 show, as expected, that the range is reduced in water and that the relative attenuation increases with increased range. We can also see that the attenuation caused by the glass tank and container clearly affects the measurements.

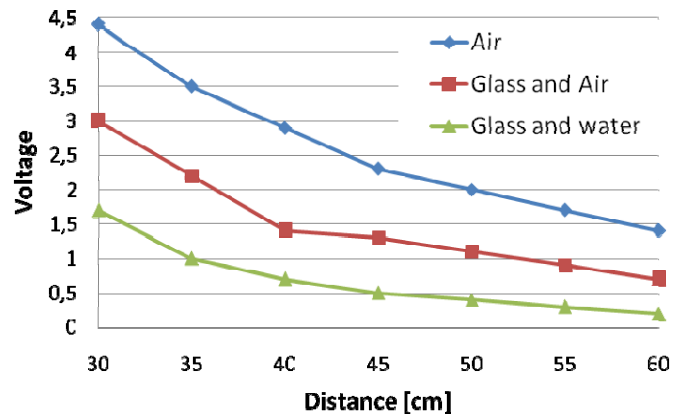


Figure 4 Voltage and distance between 2 motes in air and water. Higher voltage means less damping

7 Conclusions and future work

In this paper we have presented our initial efforts to construct an underwater lab for sensor and actuator communication. We build on previous work on underwater communications [4,5], and the goal of our project is to get results from real experiments that can later be used by the oil and gas industry when they deploy such networks in their installations offshore. The combination of ultrasonic, optical and RF networks, even as supplements to wires, is ensuring redundancy for robust and uninterrupted communication for critical industrial application like subsea oil and gas installations.

In future work we will test our components under water, improve our designs, and build components that we will use to build and test a heterogeneous, fault tolerant and robust sensor network. Later we will also test out the equipment on a real gas and oil installation.

8 Acknowledgements

Thanks to Ifi-drift, StatoilHydro and our colleague professor Sverre Holm.

9 References

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