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RESEARCH STUDY ON UNDERWATER WIRELESS SENSOR NETWORKS (WSN)

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ABSTRACT

In this research work an application of Wireless Sensor Network (WSN) in underground water. In today developing environment the wireless system plays an important role in communication process. Though there are many equipment's to carry out the communication successfully Sensors plays a vital role. In this research work we found many interesting aspects of underwater acoustic communication. In this work we have described on critical analysis on requirements of system and system design and development methods.

The Underwater Sensor Network (UWSN) is a powerful technique which is used for aquatic application and it's different from other ground based networks. There is a long propagation delay and the bandwidth is low with high error rate.

Keywords: WSN, UAV, TINYOS, NESC etc.

I. INTRODUCTION

The Wireless Sensor Network application I have chosen is an Underwater Sensor Network developed by the Massachusetts Institute of Technology Computer Science and Artificial Intelligence Laboratory in conjunction with the CSIRO Centre Laboratory in Australia. More than 70% of our planet is covered by water. The Underwater Sensor Network can be used for scientific exploration, commercial exploitation, coastline protection. They are envisioned to enable applications for oceanographic data collection, pollution monitoring, offshore exploration, disaster prevention, assisted navigation and tactical surveillance applications. The Underwater sensor network consists of static and mobile underwater sensor nodes. The features of the UWSN are:

- A point-to-point communication between nodes.
- Broadcasting using an acoustic protocol.
- A variety of nodes sensing capabilities, including cameras, water temperature, and pressure.
- Data muling using the capability of the mobile nodes to locate and hover above the static nodes.
- Network maintenance functions such as deployment, relocation, and recovery.

The application is a novel platform for Underwater Sensor Networks and the point to point communication uses a novel high-speed optical communication system integrated in the TinyOS stack. Simple underwater monitoring systems exist, but due to the complexity of the environment and the sophistication of the user scenarios, the application demands a more scalable networked solution, and this requires new research at every layer of the protocol stack (from the physical layer to the application layer) as well as new underwater experimental infrastructure to implement, test and compare the solutions [2].

Table 1: shows each bit position where the sensor is used.

BIT POSITION	SENSOR
0	ON-BOARD TEMPERATURE SENSOR
1	WATER TEMPERATURE SENSOR
2	WATER PRESSURE SENSOR
3	CMU CAMERA SENSOR
4	ACOUSTIC COMMUNICATION MODULE

II. CRITICAL ANALYSIS ON UWSN

a) **System requirements analysis**: The network can localize and track the mobile nodes, essentially providing navigation beacons. The network can also be used to monitor and relay special events, to aggregate global perception maps, and to track and predict the change of events, for example the movement of fish or the spread of pollutants. We plan to build on this work and pursue these types of application with larger networks deployed in coral reefs

b) **System design and development methods:** The different methods in system design are as follows:

Mobility Control for Data Muling: In this method Data transfer is achieved with a protocol to establish a data link between the mobile and static node, and a protocol for data transfer. The mobile node begins with a query about the available data. The data is then transmitted in239 byte check summed packets. This is a master-slave process with the mobile node taking the role of the master and requesting the data either in a packet by packet mode, or the communication link. If any packet is lost (for example, when the request does not arrive or data does not arrive) the mobile node times out and sends another request. At the end of the data transmission, the mobile node asks the static node to reset and erase the data that was collected. This simple data transfer protocol relies on state only for the mobile node; the static node is stateless.

Integration with AUV systems: In this an AquaFleck, mounted between the two cylindrical hulls, for optical communications with its sea or counterpart. We refer to this node as the gateway node. An RS232 serial cable from the box connected to the onboard Linux computer via a waterproof connector on the left rear bulkhead. The gateway node was loaded with the TinyOS Generic Base application. This application accepts messages from the UART that are sent over the optical communication link. It also receives messages from the optical communication link and relays them over the serial link to the Starbug Linux computer.

III. MESH NETWORKS

Mesh network consists of gateways, mesh clients and mesh routers. A mesh network is a communication radio which has radio nodes as mesh topology. These radio nodes works as a single network in a specified area sometimes called as Mesh cloud. Mesh Network is reliable and offers redundancy if when one node is not working the other nodes will communicate with each other. The principle is similar to the way packets travel around the wired internet data will hop from one device to another until it reaches its destination. Dynamic routing algorithms implemented in each device allow this to happen. To implement such dynamic routing protocols, each device needs to communicate routing information to other devices in the network. Each device then determines what to do with the data it receives — either pass it on to the next device or keep it, depending on the protocol. The routing algorithm used should attempt to always ensure that the data takes the most appropriate (fastest) route to its destination. A mesh network is a self-organizing network, having high radio range, flexible.

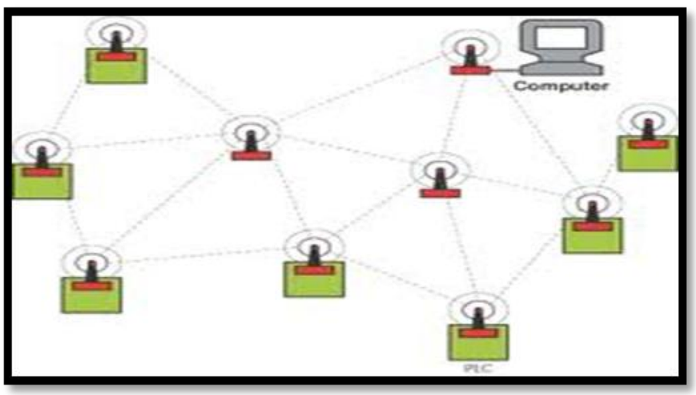

Figure 1: Wireless Mesh Network with multiple nodes

IV. EVALUATION RESULTS ON UWSN

The evaluation of this Underwater Sensor Network has been carried on, the important aspects of its development which are the optical communication, the acoustic communication, the data collection, and then, on the general system. Both optical system and acoustic communication were tested in an indoor pool (clear water) and in the Charles River by placing a transmitting sensor node and a receiving sensor node in the water such that the top side of the sensor node enclosures was facing one another. Both boxes were at a depth of 30-40cm. A 60mm F1.0 compound lens was added to the optical transmitter in order to demonstrate longer range communication. For a transmission rate of 1Hz, it was possible to still obtain 96% reception at up to 7m, if the transmitter was pointed directly at the receiver node which illuminates an LED when received correctly. The energy expenditure of optical communication has been measured at 1094nJ/bit which compares favorably with Berkeley Mica moties which uses 760nJ/bit transmitted. For the acoustic transmission, a transmitter would continuously send a square wave signal and the reconstructed data stream output of the receiver was viewed on an oscilloscope or indicated by a flashing LED on the receiver. The pool tests were performed with a 1Hz square wave data signal and the flashing LED output of the receiver at 10m was visually consistent with the input signal, although it is possible some glitches may have occurred.

Distance	Received Packets	Missed Packets	Packet Success Rate
2.1m	199	0	100.0%
4.3m	199	0	100.0%
5.3m	199	2	99.0%
6.4m	199	0	100.0%
7.0m	199	8	96.0%

Figure 2: Data received during the process from the sensor nodes and the base station.

At the river, the data rate was 50Hz and at 5.8m a square wave output was observed on the oscilloscope with no glitches. At 8.6m glitches were apparent in the output, although communication would still be possible at a reduced data rate. Acoustic packet communication was also tested using a pulse position modulation (PPM) encoding to avoid problems with reflections. The packet size was 20 bytes and was check summed to verify correct reception. The data shows that acoustic communication is usable up to a distance of 15m at a data rate of 41bit/s. Ranging experiments between two Aquaflecks have been conducted using time or light. There is a consistent overestimation of the actual distance, possibly due to an inaccurate estimation of the speed of sound in the tow tank water. However, the error is under 4% which is suitable for use in the localization algorithm. A localized underwater network with bimodal communication (optical for directional communication and acoustic for broadcast and ranging) was implemented and has many interesting and useful applications. Two types of data collection experiments have been done: long term collection of temperature and pressure data in a creek affected by ocean tide, and large-scale data collection and storage with cameras. Three sensor nodes were deployed in Tingalpa Creek, Brisbane and tasked with logging water temperature and water pressure. The sensor nodes were deployed approximately one kilometer apart along the creek for a period of three days. A file system recently developed at CSIRO was used to save data to the on-board ash memory. The nodes were programmed to log water pressure and temperature every 150 seconds. The file system was initialized such that it could hold seven days' worth of data. Approximately 110kbyte of the 512kbyte on-board ash memory was used. After the sensor nodes were retrieved, the logged data was uploaded via the optical-based communications link, which took around 388s to complete. The data acquired from the pressure sensor along with the high and low tide times, which are marked with broken lines. We can see an approximately one hour lag between the expected and observed low tide times. We understand that this is due to the dynamics of the water owing in and out of a creek from the ocean. We have also collected, stored, and retrieved images taken with the camera in a suite of experiments. The Underwater Sensor Networks consisting of up to 8 Aquaflecks, Starbug, and Amour have been deployed at two sites in Brisbane: an 8 x 5 x 1.5m pool at the CSIRO laboratory, and at an Olympic dive pool at 5m depth. The work was conducted during two periods of intense joint experiments: February and August 2005. The Aquaflecks were deployed with an approximate grid topology. Starbug and Amour traversed the network for data muling and to pick up and transport the static sensors, given an

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initial starting location, the AUV moves toward the first node using visual navigation and compass heading. The down cameras process the color imagery at 5 Hz to locate the distinctive yellow colored boxes. The front cameras could potentially be used for navigation, to head toward a yellow target in front of the vehicle. However when travelling at 1m above the bottom, the field of view of the front cameras restricts visibility to boxes at least 4m ahead. When the AUV arrives in the vicinity of a node, that node's identity can be used to reset any accumulated localization error. Once a candidate node has been detected the AUV commences a hover operation and maintains its position with respect to the target. The node is queried (HELLO message) and it responds (ACK message) with its identity, capability, software revision and internal clock value. The identity is compared to the expectation from the navigation process and if a mismatch is found the vehicle will head toward the desired node based on the location it knows it is now at. If no response is detected after a set number of retries then there are two possibilities: looking at some other yellowish object or the node has failed, and these two conditions are difficult to distinguish. If the query message confirms the identity of the node we were seeking then the AUV initiates a data transfer dialog. The capability byte has one bit set for each type of sensor present in the node. In two experimental campaigns conducted in February 2005 and August 2005 in the CSIRO laboratory pool and an Olympic dive pool, we have reliably located hundreds of Aquafleck nodes and navigated between them. The Starbug AUV is routinely able to tour all the Aquaflecks in its map. Hundreds of data transfers comprising thousands of packets have been uploaded from our Aquafleck nodes to storage onboard the Starbug AUV.

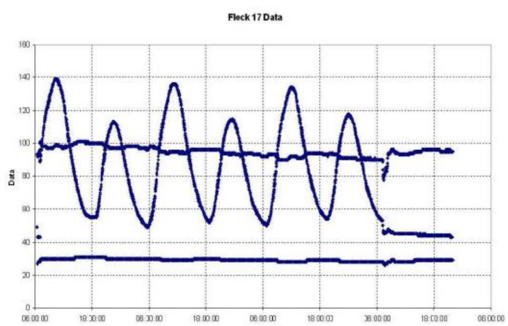

Figure 3: shows the data received when the sensors are activated by using Aquaflecks.

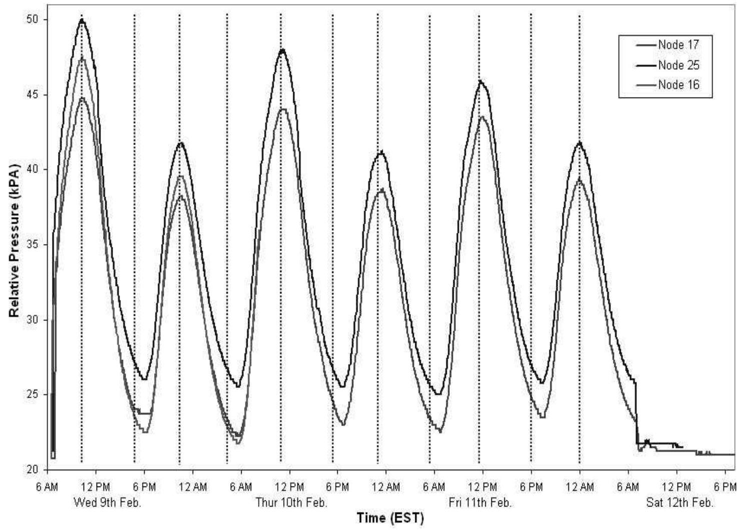

Figure 4: shows the relationship between pressure and time in seconds.

V. COMPARISON

This research study is compared with other wireless sensor networks such as Zigbee, optical communication systems and Star bugs sensor networks. Here the main advantage is the packets retrieval from the sensor nodes when undergoes synchronization between the base station and the main station. There is complexity in the design of acoustics optical communication which is overcome by this Aquaflecks, which provides better resolution and optimization for the wireless sensor network when undergone in water and hence gives better efficiency.

VI. CONCLUSIONS

In this research study I conclude that, it is possible to build an Underwater Wireless Sensor Network using alternatives to radio communications which are optical communication and acoustic communication. It is challenging to achieve high reliability and performance due to the complexity of the environment, but some particular techniques are developed on the research ground to improve this system which is of a high interest. Thereby, data muling is an approach which consists to use an underwater vehicle to navigate towards the nodes, locate static nodes, hover over the nodes and collect the data stored. It is a solution to the low range communication provided by the optical communication and the acoustic communication, and it is a mean to achieve a time-efficient, energy-efficient data transfer. Acoustic communication is capable of transmission over higher distance, but on the expense of power and cost. The protocols developed for this application within the TinyOS stack are specially conceived to enable low power operations on the nodes and the system itself uses sleep mode for power management and energy saving. The system wakes up periodically to collect or transfer the data. This approach considerably increases the autonomy of the system for long-term monitoring.

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