Development of Embedded Wireless Network and Water Quality Measurement Systems for Aquaculture

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***Abstract*—** In this paper development and deployment of wireless network for water quality measurement units in multiple fish ponds is presented. The developed portable water quality measurement units are installed on a floating platform to measure water quality parameters such as dissolved oxygen, pH, temperature, environment pressure and conductivity. All these units possess wireless communication interface to communicate with central unit for remote monitoring, control and data transfer. These systems are weather proof and can sustain harsh environmental conditions like rain, moisture, dust & humidity. Suitable software protocol is developed to maintain harmonious communication between the monitoring devices and remote user. The LabView based application software is developed to extract the various pond water quality data and other information of user interest for appropriate management of aquaculture. The result obtained are also discussed to determine stress factor on aquatic fish

Keywords— Water Quality Measurement, Wireless Network, Sensors, Aquaulture & Fisheries, Monitoring

I. INTRODUCTION

Indian fisheries and aquaculture industry is an important sector, providing occupation, revenue generation and nutritional values to the public. Presently India is second largest in the area of aquaculture and have third position in global scenario in terms of production of fishes (4.4%) of global fish production [1]. The future development of aquaculture in India depends on adoption of new and innovative production technologies, management and utilization of less utilized water resources and proper market tie-ups etc. [1]. Finding new areas and producing high quality and reliable products will improve the value of Indian fisheries in global scenario. For reliable and quality product in fisheries industries, one needs to take care of the harvesting stage, quality of water, post harvest handling, hygienic processing etc. In the developed countries aquaculture is far advanced in the field with use of sophisticated technology, while in the developing countries like India still have traditional forms of aquaculture [2]. So Indian aquaculture and fisheries industry needs use of new scientific methods and engineering practices to maintain efficient aquaculture life cycle. Thus, the quality of water plays an important role in maintaining the aquaculture life cycle. Ponds/lakes/Rivers are usually spread in large areas from few square meters to hundreds of square meters so economically it may not feasible and reliable to have wired/wireless sensors for measuring the individual water quality parameter at each pond under the harsh environmental conditions.

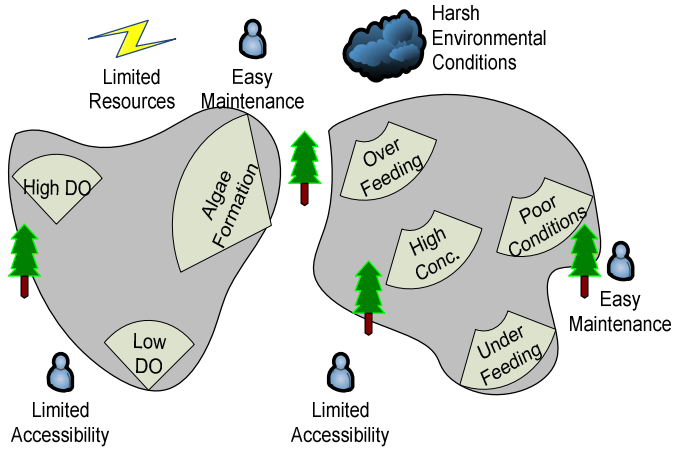

Figure 1: General Issues in Fish Farms/Ponds

In this paper we are discussing about embedded wireless network and water quality measurement systems to monitor the water quality such as dissolved oxygen (DO), pH, temperature and conductivity of ponds/lakes/rivers. Using this embedded network protocol we can install as many as 255 such systems with 8 sensors for each individual system. These developed systems are all run with a 12VDC rechargeable battery. These systems are installed on a floating structure; if the floating structure is anchored at the center of pond we can get quality information about the water quality. The developed systems can sustain environmental conditions like high humidity & high temperature. Four such systems are developed and installed in four different ponds at CIFA Bhubaneswar.

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II. PROPOSED SYSTEM

Water bodies are generally not easily accessible and are more prone to pollution. Also they are far from the institutions/bodies from where the quality measurement tests takes place. We have developed a system which will on line monitor the water parameters of multiple ponds continuously and provides the feedback to farmers/scientist's in order to maintain proper fish pond management. The block diagram of the developed system is shown in Figure 2:

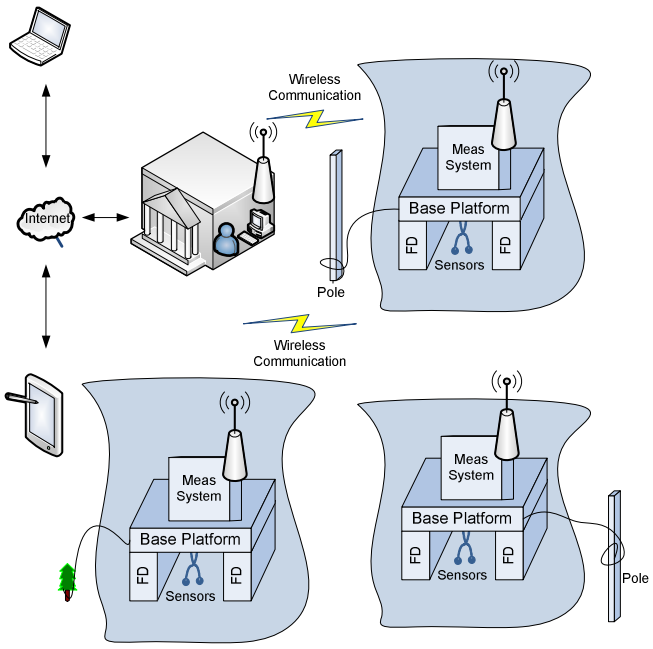


Figure 2: Deployment of Water Quality Measurement Systems

Multiple water quality measurement systems are developed and deployed using readily available latest sensors and embedded technology to work under the demanding environmental conditions, which exist near water bodies. They are installed on a floating structure and anchored properly to a pole or to a tree to cover large surface area of the pond. These systems are run with a rechargeable DC battery and solar panel system can also be incorporated for maintenance free operation. Wireless communication is necessary for remote gathering of information regularly. Each system is equipped with wireless communication interface to communicate with the remote station located around 1 km area of the ponds. The remote station then publish the data on the internet, to cover large area for proper fish pond management.

III. SYSTEM DESIGN

Different types of the state of art wireless sensors are available for monitoring of different water parameters [3] [4]. To provide a wireless communication for each sensor is complex and not economically feasible. Four water quality measurement systems are developed using different sensors/scientific instruments (from onwards called as measurement unit), embedded controller and wireless communication device (XBee-Pro) [5]. General scheme of the developed system is shown in the below Figure3:

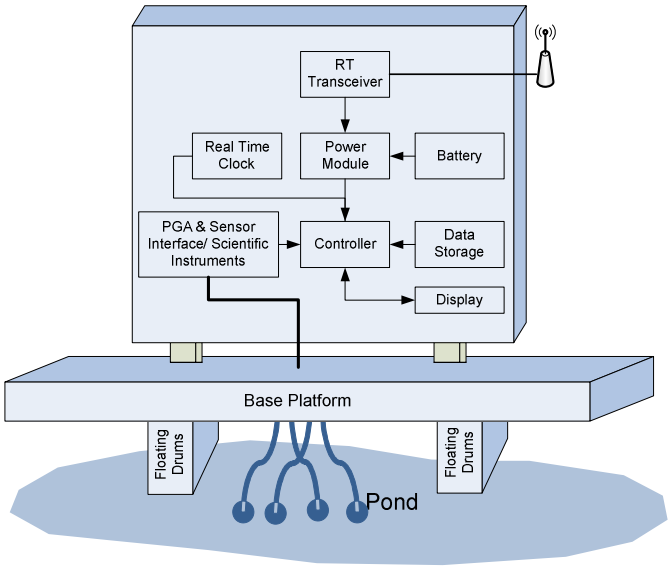


Figure 3: General Scheme of the Water quality Measurement System

Four water parameters dissolved oxygen, pH, conductivity and temperature are measured using the proposed system. The measurement unit consists of either sensor system which measures above mentioned parameters with analog output or scientific instrument like Orion 5-Star [6] with digital output (RS232-communication). The measurement unit is interfaced with the PIC 18F4520 microcontroller [7] which reads and validates the measurement and stores the data in the memory. External peripherals like real time clock, display, wireless communication and memory are connected to the microcontroller. Power module is used to convert the high level DC supply to low level DC supply outputs to provide power to the measurement units.

Deploying of the wireless communication is necessary to receive remote online data of water quality. The developed systems are installed rigidly on a floating platform and tied to a pole/tree near the pond or at the center of the pond to cover large surface area of the pond. Based on the wind direction the floating platform with move across the pond and gather the data. The sensors are immersed into the pond water at the desired length. All the systems are installed in an area of few hundred square meters and each system will communicate with the remote station located at about 1 km. The remote station have high performance PC with ZigBee wireless communication and internet facility. Wireless network protocol is developed to maintain harmonious communication between the measurement devices and remote station. Each

measurement unit will communicate with the remote station in a predefined network protocol. This mechanism is necessary to prevent loss of data.

Application software is developed to gather the on line data of each individual measurement system. The data acquired from the systems may not be as per the user desired, so different algorithms are developed to extract and covert the acquired data in the suitable format. The algorithms are also used extract the information for shorter and longer durations. Based on this information, one can correlate the water quality with the different fish activities like feeding practices, breeding, harvesting etc. Gathered information is transmitted to remote users through internet.

This acquired knowledge will be helpful in understanding the condition of the lake during the harvesting season. Based on this knowledge preventive actions or mechanisms can be implemented to minimize the losses and increase the productivity for subsequent seasons. Alarms or different control mechanisms like operation of aerator etc., can be implemented if water quality become poor. By taking action at the initial state massive losses can be avoided. This knowledge will also be helpful for scientists to establish different models for good fish growth. Using the advantage of the present communication mechanism the information can be transmitted to the mobile devices or to the other gadgets.

IV. Firmware & Application Software

The system is built around the controller which monitors and controls the measurement unit, wireless communication and display.

A. Data Monitoring and Storage:

The controller scans the measurement unit at one sample (all parameters) per second. Then the data is validated, accumulated and stored in memory in a predefined format with a date and time stamping. The format is shown in Figure 4. The data is stored in two different methods, one is short term memory and the other one is long term memory. In short term memory only recent information is available and in long term last 27 days of information is available.

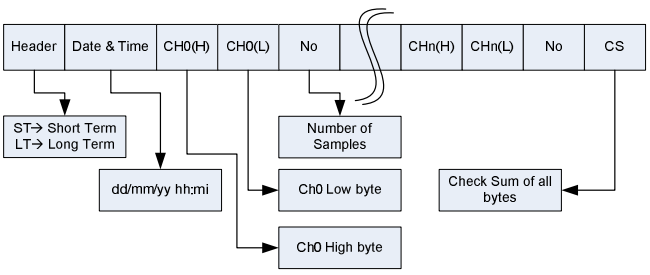


Figure 4: Data Packet Format

In short term the data of each individual channel is accumulated for a user defined duration along with number of samples accumulated. Data packet is build and is stored in the short term memory location. Similar mechanism is used for long term, where the time duration is longer than short term and stored in long term memory location.

The data packet consists of header, date and time, data and check sum. The header is separate, for short term (ST) and long term (LT). The header is used to separate the data packet from one another. The date and time is simple date and time information, here the second's information is neglected to increase the storage capacity. The data consists of accumulated sum of each individual channel along with the number of samples that are accumulated. Based on the number of sensors connected, the data can vary from one channel to maximum of eight channels. Checksum is an error detection mechanism to validate the data that is stored is correct or not. Here XOR checksum mechanism is implemented.

B. Network Protocol:

Each water quality measurement system used in the network possesses a wireless device for communication with the remote station. A predefined network protocol is necessary to maintain a harmonious communication between the measurement system and remote station. Measurement system acts as a slave in the network where as the remote station acts a master. Communication between remote station and measurement system is shown below Figure 5 (a) and Figure 5 (b):

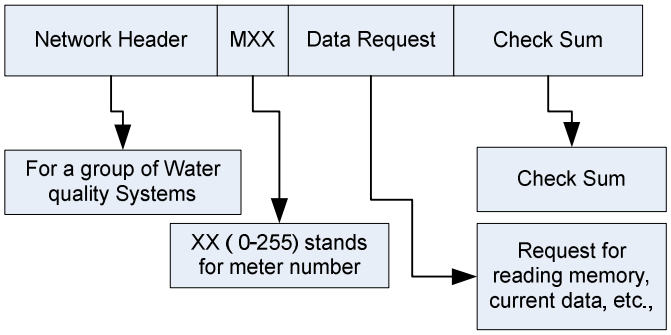


Figure 5(a): Command to Measurement System

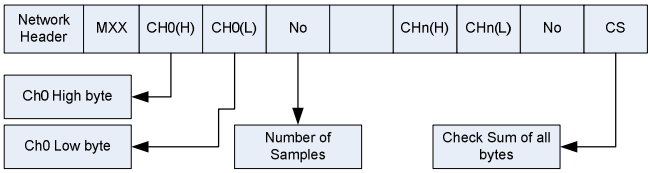


Figure 5(b): Response of Measurement System

The network protocol consists of network header, meter number, data request and check sum. The network header is used to group devices of similar measurement criteria or measuring similar ponds with same breeding capacity or same

fish etc., Meter number is unique for each measurement device and it is an 8-bit number, so only 255 such devices can be connected in such a network. Checksum is an error detection mechanism to validate the network protocol.

C. Application Software:

Application software is developed to monitor the measurement systems from the remote station. The application software is developed using Lab VIEW. The GUI of the main screen is shown in figure 6:

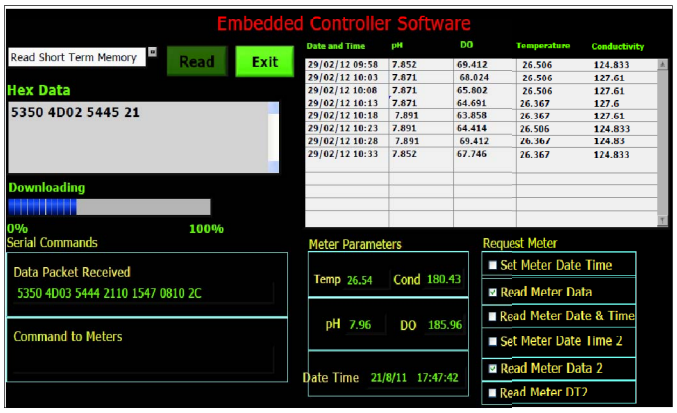


Figure 6: Water Quality Measurement Systems

The application software has features like read/write/erase memory, set/read date time, read current data etc., Only one device can be interacted at a time. Individual actions like feeding, aerator operation etc., can also be controlled using from the remote location.

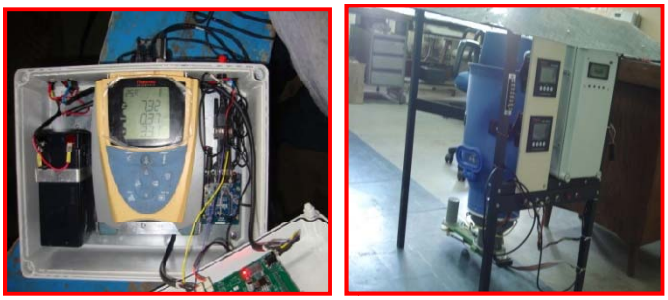
V. RESULTS AND DISSCUSSIONS

The developed and deployed water quality measurement systems are shown in Figure 7 and Figure 8:

(a) (b)

Figure 7: Water Quality Measurement Systems

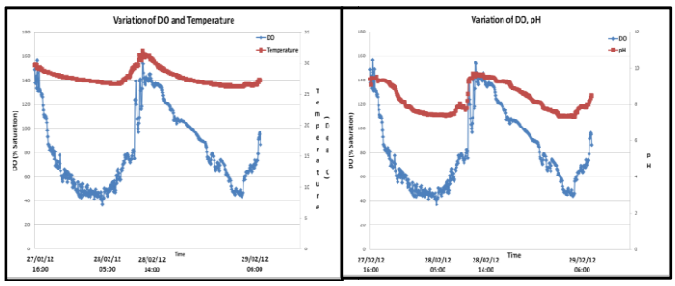
Four such devices are developed and each device is having their own functional requirement. Only water quality measurement is common among all those devices. All these devices are properly protected from harsh and demanding environmental conditions.



(c) (d)

Figure 8: Water Quality Measurement Systems

These devices are tested and installed in different ponds, at ICAR-CIFA[8] Bhubhaneswar, India. The systems are extensively tested at CIFA, and initially found errors in the wireless communications. It is found that few data packets are lost during communication. During the initial stages, it is observed the developed electronics (PCB's) started corroding due to high humidity levels. Precaution measures are taken care subsequently. The variation of dissolved oxygen, pH, Temperature is shown in Figure 9.



(a) (b)

Figure 9: Variation of DO, pH and Temperature (2 Days)

The above results show the correlation between different pond parameters. The variation of dissolved oxygen is closing following with the variation of temperature and pH.

Recent developments in the area of energy harvesting systems, telecommunications more such smart systems can be deployed in water bodies. So that we can preserve, conserve our water bodies and necessary actions can be taken if necessary.

VI. ACKNOWLEDGEMENTS

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VII. REFERENCES

[1] The State of Fisheries and Aquaculture 2010 by The State of World Fisheries and Aquaculture (SOFIA)

[2] Prospects for coastal aquaculture in India by k. alagarswami, Central Marine Fisheries Research Institute, Cochin, in CMFRI Bulletin 20

[3] C. Albaladejo, P. Sanchez, A. Iborra, F. Soto, J. Lopez, R. Torres. (2010, July 19). Wireless Sensor Networks for Oceanographic Monitoring: A Systematic Review [online]. Article available on: http://www.mdpi.com/journal/sensors

[4] P. Jiang, H. Xia, Z. He, Z. Wang. (2009, August 19). Design of a Water Environment Monitoring System Based on Wireless Sensor Networks [online]. Article available on: http://www.mdpi.com/journal/sensors

[5] XBee-Pro-PKG User's Guide by Digi http://www.digi.com/products/wireless-wired-embedded-solutions/zigbee-rf-modules/point-multipoint-rfmodules/xbee-series1-module#overview

[6] Thermo Scientific Orion 5-Star Plus pH/ORP/IS/Cond/DO Benchtop Meter http://www.thermoscientific.com/

[7] PIC 18F4520 Data Sheet Microcontrollers with 10-Bit A/D and nanoWatt Technology

[8] The Central Institute of Freshwater Aquaculture http://www.cifa.in/