

## Design and development of IOT Based Framework for Aquaculture

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**Abstract:** The farmers of the eastern Godavari region are shifting from agriculture to aquaculture so much so that there is a lot of stress on water-physically, chemically and biologically. This poses a threat to the lives of so many underwater species and affects the fish cultivation farmers. Therefore, it is important to measure the physio-chemical parameters of water of aqua-cultured sites in order to get an insight into the water conditions. In most of the places this testing is done manually by the farmers and through lab testing by researchers where there is no real time monitoring. This paper proposes a real time monitoring solution for measuring the physio-chemical parameters of water and a decision support system for data storage, monitoring, analyzing and sending the right information to the right persons involved at the right time.

**Keywords:** Aquaculture, IOT, Decision Support System

### I. INTRODUCTION

Farmers in the coastal Andhra Pradesh are turning away from traditional agriculture to aquaculture so much so that in the state that the land under fresh water and brackish water aquaculture has seen a fivefold increase to 82,000 hectares in the last three years. During this period, the industry grew from Rs 346 crore to Rs 561 crore. Further investments of over Rs 400 crore are expected to flow in from as many as 20 integrated units which are coming up in the state. The growth is so rapid that the aquaculture production in 1993 is expected to outstrip even the 1995 projection of 1.75 lakh tonnes made in a field survey conducted in Andhra Pradesh by the Cochin-based Central Marine Fisheries Research Institute [1]. The reason for such a drift are that the aquaculture domain is more profitable than agriculture domain and during natural calamities such as draughts and cyclones the agricultural crops may get completely destroyed but the fishes mostly survive.

However, the aquaculture industry in eastern coast of India is facing a lot of challenges due to this drastic shift which is affecting the environment-physically, chemically and biologically. Physically a lot of pressure is on water, chemically it is polluted and biologically it introduces pathogens and diseases. Some of the challenges posed are:

1. Conversion of agriculture land and mangrove areas for aquaculture leads to salinization of surface water and agriculture and, besides causing pollution and diseases.
2. Salinization of soil in nearby agricultural land and drinking water resources due to seepage and percolation from urban shrimp ponds are major environmental issues in aquaculture.
3. Water flowing out of aquaculture ponds carries excessive nutrients, bacteria, pathogens, and other nutrients which harm the surroundings.

4. Food and fecal matter from aquaculture facilities can deplete the dissolved oxygen levels and impact the surrounding.
5. Organic wastes lead to seabed deterioration and chemical changes in sea beds. The extreme condition of gasping of CO<sub>2</sub>, H<sub>2</sub>S and methane would occur which would endanger other species too.

Therefore, measuring and monitoring the physio-chemical characteristics of the pond water and soil is extremely important to keep the check on the aquaculture conditions.

At present the researchers are adopting field work and lab testing methodologies to test the physio-chemical parameters of water and soil. This method is cumbersome and there is no feature of real time monitoring. Thus it is not possible to send real time warning to the farmers to help them avoid any losses.

Keeping in view the above mentioned problem, this paper proposes a real time monitoring framework for design and development of an IOT based framework for aquaculture. The provision of Decision Support System is also introduced for real time storage, analysis and transmission of the readings with alerts to the farmers, researchers, fish cultivation agencies as per their needs and requirements.

## II. LITERATURE REVIEW

The United Nations Food and Agriculture organization (UNFAO) “2012 State of the World Fisheries and Aquaculture” report pointed out that the global amount of fishery products produced about 128 million tons per person animal protein intake of about 15% of which makes human dependence on fishery

resources higher. In the past five years the global aquaculture average total output accounted for 37.2% of the total global fish production [2]. Therefore farming techniques need to improve. With the introduction of IOT, this improvement has been made possible.

Water quality is an important parameter for dominates the quality of life of marine animals. Thus monitoring the quality of water is very important. Some of the important parameters of water to be monitored are water temperature, dissolved oxygen and PH [4,9,6,8]. Fishes are cold blooded creatures and any variation in temperature of water hamper the growth of fishes [6]. Due to abnormal growth of algae and phytoplankton the oxygen level decreases and as a result the fishes might not get enough oxygen which may decreases their chances of surviving which makes dissolved oxygen also an important water parameter. Too much acidity or alkalinity may impact the fish skins, water plants etc and thus keeping the check on the soil PH is equally important. Other sensor used were ultrasonic sensors [7,11] which would measure the depth of the water in the pond and turbidity sensor which measure water clarity. In some cases nitride and carbon dioxide content in water is also sensed [7]. The sensors along with the communication module and processing unit form the sensor node.

In order to transfer the data from the sensor node to the gateway node/ monitoring station the most popular communication module is zigbee[4,6,11]. Zigbee is widely preferred as it provides can support a large number of nodes and also the Zigbee API provides a

large number of power management potions. Apart from that zigbee has greater range than Bluetooth communication module. The Profibus DP was a new platform introduced in [9] which connected the slave module with the master module and also had the capability to support a large number of slaves. Another way of transmitting the data was through serial terminal.

In some cases the gateway node received the data wirelessly and transmitted the data to the central monitoring station via serial terminal where it was uploaded to the cloud [4]. In other cases the readings were directly stored on the central monitoring unit where the received readings were analyzed and plotted.

In some cases the control was bidirectional and if the reading violated the threshold then the control command was sent to the actuators where the heaters, aerators, lights would be turned on/off as per the requirement which would regulate the water parameters. Fish feeding is another important parameter which needs to be regulated in order to avoid wastages.

In some cases the readings could be viewed by the end user through mobile applications [11] which provide mobility and easy accessibility.

There was lack of GPS capability in this the sensor nodes in order to locate the nodes at the time of need. Also, only one/ two water

parameters were measured when more than that was required to fully understand the characteristics of water.

### III. EXISTING PRODUCTS AND COMPARISON

At present there are two products related to field of aquaculture. One of the products is Eruvaka Technologies in India and other is eFishery, Indonesia. Eruvaka measures only certain water temperature and dissolved oxygen and sends the reading to the monitoring unit and sends SMS to the farmers to provide alert notifications to them. Another product in the market is the efishery which is an Indonesian product to provide real time feeding to the fishes when the time is set so as to avoid wastages due to improper fish feeding.

The product proposed in this paper **differs** from the fact that there is introduction of decision support system and sending only relevant and informative data to the farmers, researchers and fish farming agency as per their requirements and needs. The Smartphone application would not only retrieve alerts but also be able to send feedback and have provision of controlling the system. Another important feature is that there will be floating nodes which will have algorithm to cover optimal path of the pond. This is the **novelty** of the proposed product.

Name of Product	Eruvaka Technologies, India, <a href="http://www.eruvaka.com/">http://www.eruvaka.com/</a>	eFishery, Indonesia <a href="http://www.efishery.com/">http://www.efishery.com/</a>
Sensors	Temperature, pH, Total dissolved oxygen,	Sensor to detect the fishes



Automatic/ Manual	Automatic control	Automatic feeder when set time
Mobile Application (Yes/No)	Yes, to view data	Yes
Cost	Rs.30k+extra	-
Real Time Monitoring	Yes and cloud platform	Yes, real time monitoring of feeds
Features	Send SMS/Alerts to farmers when readings violate threshold	-
Pictures		

Table 1: Detailed Comparison of Existing Products

#### IV. DETAILED ARCHITECTURE

The proposed architecture consists of a number of sensor nodes spread across different ponds. These sensor nodes will have sensors which would measure the physio-chemical parameters of the water and transmit the values to the nearby base station via a communication medium. The base station would collect the readings from sensors of nearby region and send these values to the central monitoring station which would be located at the main department. The monitoring station will have logic for data analysis and conclusion making and if the readings violate the threshold then control command would be sent to the base station and from these to the actuators in order to balance the physio-chemical parameters of water. The readings from the monitoring station could be accessed by the mobile devices, laptops or desktops wirelessly.

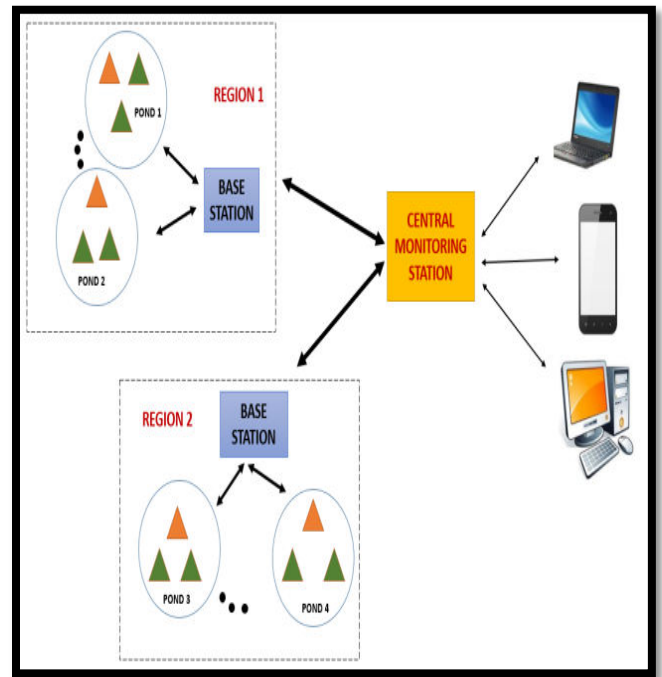


Fig 1: Proposed framework

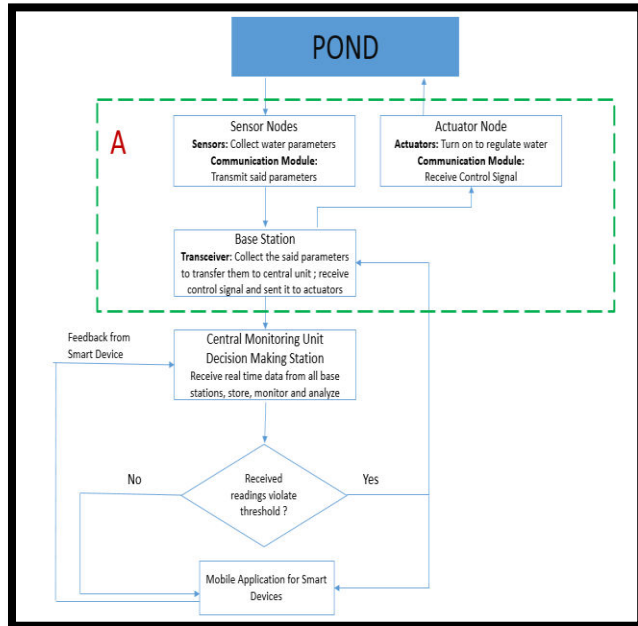


Fig 2: Flowchart of the system

Fig 2 depicts the flowchart of the system on how the system operates. 'A' denotes that the system is working as one unit for small lakes and ponds. The decision making system is the main unit which receives the parameters and decides which the course of action to be taken at the time of adversity.

After interacting with the farmers regarding how much they would spend on the product, their response was between 5000 INR and 25000 INR. The initial cost of the proposed product is said to be approximately 10,000 INR.

## V. SOCETAL BENEFITS

The product will benefit the fish cultivating farmers in a very large scale as at present there is lack of real time monitoring system. Also the famers expect to know any adversity in advance so as to prevent any monitory losses. This system provides this feature and hence helps farmers in better development.

## VI. IMPLEMENTATION

A farmer feedback was conducted by our collaborators at SRKR University, Andhra Pradesh to get a deep insight into their problems and their expectations from our product.

The compilation of their response is as under:

1. The farmers wanted a real time monitoring system for their pond as it would lessen their burden of manual testing of water parameters.
2. They wanted a system to alert them for any adverse condition well in advance to avoid heavy losses.
3. They were not getting any government support.
4. They would prefer floating nodes.

Keeping in view the above mentioned points, the first initial prototype sensor node was developed at using Intel Edison. Intel Edison is a dual core intel atom based SoC from Intel running yocto linux operating system and having built-in Wi-Fi and Bluetooth module. In order to measure the water quality, water temperature, pH, water turbidity and dissolved oxygen sensors were interfaced. In order to measure the atmospheric temperature LM35 was used. These combination of sensors when used together cover almost all the parameters of water quality measurement.

After interfacing the sensors, he nest step was to calibrate the sensors so as to give optimum values. The calibrations were performed using standard pH meters, thermometers so as to give accurate readings. These readings were displayed on 16X2 LCD screen so as to have a clear view of the readings.

A monitoring unit was developed using the Intel Analytics Cloud Platform where the sensor data gets stored for further analysis. The sensor data would get stored along with timestamp and the readings would appear with graphical plots.

In order to make the node energy efficient, solar panel is used the source of power. The

battery provides approximately 5 hours of battery backup and is also chargeable by lunar light.

At present, designing a proper casing for the project is under process so as to deploy is properly in pond and nearby areas. Project prototype which is in the making is displayed in Fig 3.



a) Solar powered sensor node floating in water

Physio-chemical parameters of water being depicted in LCD and transferred to cloud via built-in Wi-Fi of Intel Edison



Sensor values on LCD



Sensor values on Cloud

b) Readings on LCD and graphical plots on Cloud

Fig 3: Present Implementation

## VII. CONCLUSION & FUTURE WORK

An initial framework is developed by preparing a sensor node using Intel Edison. Water temperature, dissolved oxygen, water pH and water turbidity were measured and readings were displayed in the LCD screen. The sensor data were sent from the sensor node to the Intel IOT cloud platform through the built-in Wi-Fi module. Also in order to make the node energy efficient, they were solar powered with a battery backup of approximately 5 hours.

At present the stress is on developing a robust and aesthetic casing for the sensor node so as to deploy it in large ponds and lakes.

The work on server and mobile application will also take place in due course of time.

The aim of the project is to make a robust low cost and real time system and commercial product for the farmers.

## ACKNOWLEDGEMENT

This project is being carried out as a part of ITRA-Media Asia Labs, MHRD and Intel IOT



Projects. A provisional patent with Application Number 201611017103 has been filed.

We would like to thank SRKR University, Andhra Pradesh (Prof.Ramprasad Kalidindi, Mr.Chalapathi Raju, Mr. Gopala Raju PV) for their constant support regarding the feedback of the farmers and their requirements. Also special thanks to Prof MBK Prasad for sharing his expertise on marine animals and their lives. We would also like to extend our heartfelt thanks to Intel for their support whenever required.

## REFERENCES

- [1]. <http://indiatoday.intoday.in/story/farmers-turn-away-from-agriculture-to-fish-farming-in-andhra-pradesh/1/307343.html> Fishing for a Fortune, M.A. Mannan in Krishna, West Godavari and Nellore, January 3, 2013
- [2].A.R.K. Raju Penmetsa, S.R. Reddy Muppidi, Raghuram Popuri, Suri Babu Golla and Rambabu Tenneti, "Aquaculture and its impact on ground water in East Godavari District Andhra Pradesh, India – A Case Study", *International Research Journal of Environment Sciences*, ISSN 2319–1414 Vol. 2(10), 101-106, October (2013)
- [3].A.Rama Krishna Raju Penmetsa, Sitarama Reddy Muppidi, Raghuram Popuri, Suri Babu Golla & Rambabu Tenneti, " Impact of Aquaculture on Physico-Chemical Characteristics of Water and Soils in the Coastal Tracts of East and West Godavari Districts, Andhra Pradesh, India", *International Journal of Engineering Trends and Technology (IJETT)* – Volume 6 Number 6- Dec 2013.
- [4]. Bo Chang, Xinrong Zhang," Aquaculture Monitoring System Based on Fuzzy-PID Algorithm and Intelligent Sensor Networks", *IEEE*.
- [5]. Huiwen Cai, Sheng Zhao, Changwen Wu, Aiyi Zhu, Jing Yu, Xueqing Zhang," Environmental pollution and marine aquaculture ecosystem health assessment", *IEEE* 2010.
- [6]. Wen-Tsai Sung\*, Jui-Ho Chen, Hsi-Chun Wang, "Remote fish aquaculture monitoring system based on wireless transmission technology", *IEEE* 2014
- [7]. Satya Nagabhushana Rao Kamisetti, Shashikant Suresh Sadistap, Arvind Dattatreya Shaligram, "Smart Electronic System for Pond Management in Fresh Water Aquaculture:", *IEEE* 2011
- [8]. Minggong Hua, De-an Zhao, Wu Xia, Yi Zhu, Xingqiao Liu, "The Design of Intelligent Monitor and Control System of Aquaculture Based on Wireless Sensor Networks",*IEEE* 2010.
- [9]. Minghu WUI, Xiangmei Zhang, Tiezhou Wu, "Research on the Aquaculture Multi-parameterMonitoring System" 2010 2<sup>nd</sup> International Asia Conference on Informatics in Control, Automation and Robotic.
- [10]. Lin Wenmei,Liu Yuzhen, "Aquaculture Monitoring System", 2010 International Forum on Information Technology and Applications.
- [11].Jui-Ho Chen, Wen-Tsai Sung\* and Guo-Yan Lin, "Automated Monitoring System for the Fish Farm Aquaculture Environment", 2015 *IEEE International Conference on Systems, Man, and Cybernetics*.