IEEE 802.15.4 Based Water Quality Monitoring System

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ABSTRACT

Quality of water can be predicted using various parameters. Basically two kinds of impurities are present into water: Suspended impurities and Dissolved impurities. Water quality can be decided using different parameters like pH, Dissolved Oxygen[DO], Total Dissolved Solid and many more. pH and DO are the recommended parameter to be measured for deciding a quality of water at the fish farm. Here we present an application of wireless network: the sensing of DO for a fish farm. Application required sensor module for sensing a required data, wireless module for data transmission through radio channel and a gateway module as monitoring center. In this case, we have connected one master with two slaves using a transmission rate of 9600 b/s. The wireless transmission follow the standard IEEE 802.15.4 protocol and implement the routing protocol based on ZigBee standard. This is a qualitative and quantitative approach for a water quality monitoring. Main future of this application is that it is easy and effective way for doing real time water quality monitoring and it is extensible to any type of monitoring system just by interfacing an appropriate sensor.

Keyword: - *Water Quality, Dissolved Oxygen, wireless Sensor Network*

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1. INTRODUCTION

In recent time Wireless Sensor Network (WSN) have had a large increase in real applications. Its main advantage over other technologies is the actual economic development of its installation. The idea to implement an ad-hoc wireless network started at the beginning of the 70s (1 ref from paper). The typical scenario was to set up a communication network in a battlefield, where no infrastructure is available. Earlier high cost is an issue but nowadays it's not anymore. Old method used for deciding a water quality is taking sample of water to the laboratory and after testing, quality is decided but this is time consuming way of deciding the water quality, So Qualitative and quantitative measurements are needed from time to time, to constantly monitor the quality of water from the various sources of supply. In today's world different kind of sensors are available for measuring a parameter which can be used to decide quality of water. There is also availability of many boards which can be used as a portable computer which can be used to make data available on global platform. This paper described the implementation of wireless sensor node on water for water quality monitoring. It is characterized with mounting sensor in water which measure parameter for deciding water quality, turn over that data to transceiver unit which sends data continuously to a central node, here the central node is connected to board (portable computer) where one can observe the measured data and make it available on global platform.

2. SYSTEM ARCHITECTURE

This kind of system has simple architecture which basically include senor node, wireless module, gateway device as shown in below figure

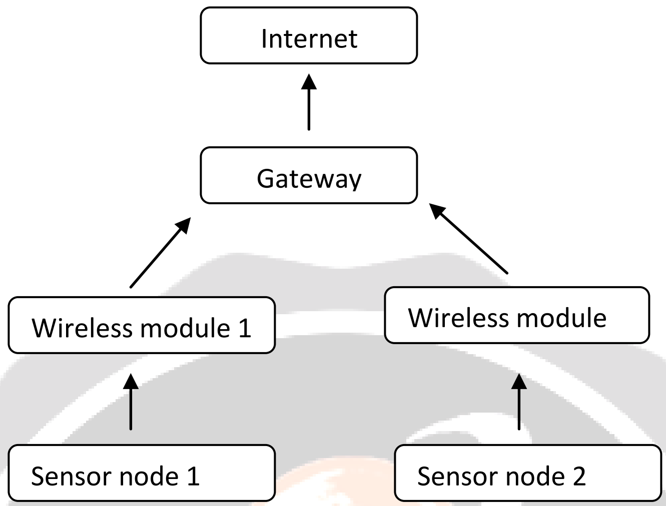

Fig -1: System Architecture

Ultimate purpose of wireless sensor network based water quality monitoring system is to automate the monitoring of water quality. The general work flow of the system to be designed consist of (1) taking water quality sample continuously (2) Sending and storing data at the gateway station (3) make that data available on internet to be used by a people from anywhere. This three steps can be easily mapped into a three-layer system architecture depicted by figure 1 which include (A) Gateway layer (B) A Wireless node layer and (C) Sensor layer. Following is a description of signal layers.

2.1 Gateway Layer

The gateway is one of the most important components upon which the efficiency of the sensing activity of a WSN depends. It collects all the information received from the motes in database and makes this information available usually via a wireless network. A Gateway must have enough computing power to be able to run a database, perform local calculations and communicate with existing network, but should be low power enough to run autonomously in the field.

If a gateway is to be used for WSNs in developing countries, it is clear that the scenario requires a device designed around the following constraints: low power consumption, high storage capabilities, flexible connectivity, low-cost and web-based design.

Fig -2: Raspberry PI [11]

To develop our gateway we selected Raspberry pi model B. It is based on ARM1176JZF-S 700 MHz processor with 512 MB of RAM, has two USB ports, generic USB keyboard and mica are compatible with raspberry pi.It is powerful enough to run a database and a web server. We decided to use a 4GB memory card, capable enough to store the OS and sampled data.it is compact. Lightweight, has high-performance and low power consumption.it can be used as a wireless access point, client or mesh node. The raspberry pi primarily uses Linux kernel-based operating system. Raspbian is recommended OS.

2.2 A wireless node layer

As wireless sensor node layer XBEE S2 module is used. It is based in 802.15.4 wireless protocol. IEEE 802.15.4 standard is a low cost, low data rate (<250 KBPS) and works in 2.4 GHz and 868/928 MHz wireless technology.

Fig -3: XBEE S-2[12]

It's used for personal area network and a peer-to-peer network.it is the base of ZigBee application layer and the network layer. ZigBee is a new kind of low complexity, low power consumption, low data rate and low cos wireless network technology. It's mainly used for close wireless connections. According to the standard IEEE 802.15.4, it can hold 64000 sensor nodes communicated with each other. The sensor node only needs tens of micro-ampere current to ensure network connection. Through radio waves data will be transferred from one node to another one.so their transmission efficiency is very high. The function of each sensor node is not completely identical. According to the function they are divided into three types: coordinator, Router and terminal node. Different network topologies supported are: star, ring, mesh.

2.3 Sensor Node

For this system implementation DS18B20 waterproof temperature sensor is used. DS18B20 has four main data components: 64-bit lasered ROM, temperature sensor, nonvolatile temperature alarm triggers TH and TL, a configuration register.

Fig -4: DS18B20 (waterproof) [18]

The device gain its power from the 1-Wire communication line by keeping energy on an internal capacitor during periods of time when the signal line is high and continues to operate off this power source during the low times of the 1-Wire line until it returns high to replenish the parasite (capacitor) supply. As an alternative, the DS18B20 may also be powered from an external 3 volt - 5.5 volt supply.

The DS18B20 Digital Thermometer delivers 9 to 12-bit (configurable) temperature readings which specify the temperature of the device. Data is sent to/from the DS18B20 over a 1-Wire interface, so that only one wire (and ground) needs to be connected from a microprocessor to a DS18B20. Power for reading, writing, and performing temperature translations can be derived from the data line itself with no need for an external power source. Because each DS18B20 contains a unique silicon serial number, multiple DS18B20s can exist on the same 1-Wire bus. This allows for placing temperature sensors in many different places. Applications where this feature is useful include HVAC environmental controls, sensing temperatures inside buildings, equipment or machinery, and process monitoring and control.

3. CONVERSATION OF TEMPERATURE INTO DO

Following equation is used for this conversation

$0°C < t < 30°C \quad DO = (P\text{-}p) \times 0.678 \backslash (35 + t)$

$30°C < t < 50°C \quad DO = (P\text{-}p) \times 0.827 \backslash (49 + t)$

Where: P=Barometric pressure (760.0375030 mmHg)

p= Water vapor pressure

p= exp (20.368-(5132/T(in Kelvin)))mmHg

Following table represents the comparison of standard data set with value given by the above equation.

Table -1: COMPARATION TABLE [14][15][16]

Temperature(C)	*DO(Standard)*	*DO(Practically)*
1	14.19	14.21
2	13.81	13.82
3	13.44	13.45
4	13.09	13.10
5	12.75	12.76
6	12.43	12.44
7	12.12	12.14
8	11.83	11.85
9	11.55	11.57
10	11.27	11.31
11	11.01	11.05
12	10.76	10.81
13	10.52	10.57
14	10.29	10.35
15	10.07	10.13
16	9.85	9.92

17	9.65	9.72
18	9.45	9.52
19	9.26	9.33
20	9.07	9.15
21	8.90	8.97
22	8.72	8.80
23	8.56	8.64
24	8.40	8.48
25	8.24	8.32
26	8.09	8.17
27	7.95	8.02
28	7.81	7.88
29	7.67	7.74
30	7.54	7.60
31	7.41	7.51
32	7.28	7.40
33	7.16	7.29
34	7.16	7.18
35	6.93	7.08
36	6.82	6.97
37	6.71	6.87
38	6.61	6.77
39	6.51	6.66
40	6.41	6.56

From above table one can easily conclude that value given from equation is approximately equal to the standard data set.

4. IMPLEMENTATION OF SYSTEM

In order to perform water quality monitoring on a wide area, measurement nodes were distributed over the monitored area. Measurement nodes are two temperature sensors (DS18B20). This sensor were implemented into monitoring area to which MCU is connected and it is interfaced with XBEE-S2 module which was configure as an End device using X-CTU software available from digi microcontroller was connected. Data available from the sensor were transferred on specific radio channel to the Coordinator module which was connected to the gateway board (raspberry pi model B) using USB adaptor board.

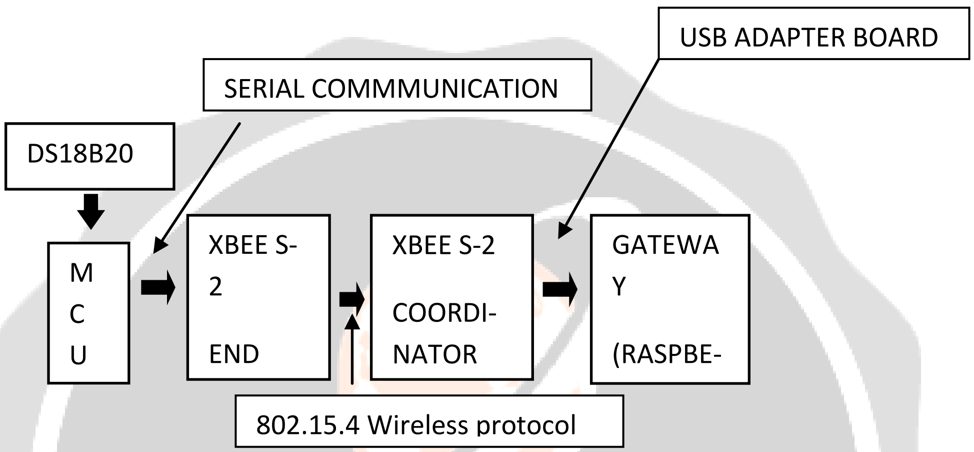

Fig -5: System Implementation

Those data were stored into the database (sqlite3) which was implemented on the gateway board and also made them available on the internet through application layer protocol (HTTP protocol) which can be accessed from anywhere worldwide whenever required. For server side implementation emoncms which is an open source implementation is used.
Following figure showing a webpage for monitoring a sensor data in real time which include a dial for current temperature, maximum temperature, minimum temperature, DO and recommended standard for DO as shown

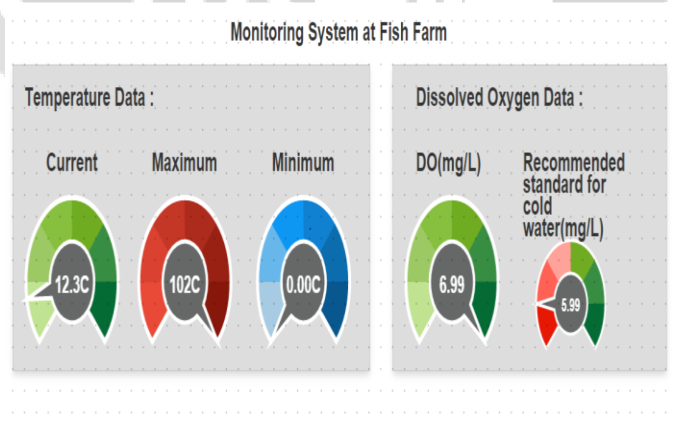

Fig -6: Monitoring Webpage

When ever DO value is below recommended standard value some action need to be taken and some of them are:avoid over use of fertilizers and organic manure to manage DO level,Recycling of water and use of aerators, artificially or manually beating of water, avoid over stocking of fishes,introduction of the hot water gradually with pipes to reduce DO if level is high.

5. CONCLUSIONS

Automatic measurement and reporting system of water quality based on ZigBee and raspberry pi makes use of water quality sensor with unique advantage and existing ZigBee network. The system can keep track of mineral water top quality continuously and it is affordable along with doesn't require people present on duty. So the water quality testing is likely to be easy.Main future of this system is that it can be used in any type of monitoring system implementation by interfacing a appropriate sensor.

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