# Low Power WSN and Cloud Infrastructure for Remote Lake Water Quality Monitoring

**S. Singh[1], P. Ranjan[2], R. Jha[1], and M. R. Tripathy[2]**

[1]Yuktix Technologies Pvt. Ltd., India
[2]Amity School of Engineering and Technology, Amity University, Uttar Pradesh, Noida, India

**Abstract**— Bangalore is state capital of Karnataka, India and also knows as IT capital of India. In 1975, total number of lakes in Bangalore was 51 which had reduced down to 17 now because of population growth, land encroachment and water pollution. Earlier they were a good source of daily use water but now due to extensive pollution, it cannot be used. A new system is proposed based on Low power WSN clubbed with cloud infrastructure to monitor water quality in the lakes in real time during different seasons in a year and see the variation of water quality in different region i.e., close to human infra, in middle of lake, during rainy season etc.. Basic plan is to conduct this experiment simultaneously across the 17 lakes in Bangalore. With the data collected, suitable measures can be suggested to government to take effective actions in order to save the exiting bio-diversity across the lakes. Cloud infrastructure can be useful to see and analyze real time data from anywhere and even archive data which can be further downloaded to see variation in last few years. Similar approach can be implemented to measure real time air quality in Bangalore and some of other major polluted cities like Delhi.

## 1. INTRODUCTION

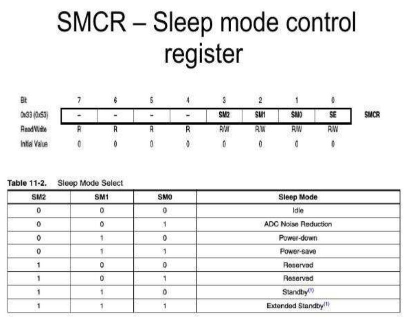
Bangalore being the IT capital and hub of India attract people from all over the nation. Population of Bangalore [1, 2] had increased drastically. With increased population, these lakes have been abused by government and public at large. This kind of systematic encroachment has caused either extreme pollution in the lakes or even total extinction. As population comes close to the water bodies, without any proper passage of sewage and waste water from homes, waste water is piped in the lakes which further exacerbate the problem. As per the current study by Bangalore authority, Lakes in Bangalore have been a major place for birds like Weaver birds that migrate to Bangalore in the months of August and spend their autumn here. With lake water being polluted and lakes disappearing, these birds have stopped coming to Bangalore altogether. This again affects the bio-diversity and natural settings which Bangalore once used to take pride in. These degradations in environmental entities motivate the measurement of water quality of lakes at different places during different time of year using solar powered wireless sensor network (WSN) and cloud infrastructure pushing government to take effective measures to halt these degradations and rejuvenate local water bodies.

This paper is organized in five sections. Section 2 discusses basic experimental set up. Section 3 outlines connections with Internet of Things (IoT) and related technologies. Section 4 provides a table of attributes and detailed description and in Section 5 we conclude and outline further research agenda.

## 2. PROJECT SET-UP

This project of remote water quality monitoring include some of the major parts which are (A) End Sensor Node (B) Central Data acquisition unit and (C) Cloud infrastructure. End sensor nodes are the first most important part of any wireless sensor network which play the role of gathering information from the environment and in which sensors are directly interfaced. For placing end sensor nodes in a remote area where there will be no availability of electricity. End sensor nodes need to posses certain specific properties like 1. Low power consumption 2. Non-conventional source of energy for elongated life time. While discussing about low power consumption of the end sensor nodes, those controllers have to be considered which consume minimum amount of power operating at 3.3 volts. From this perspective best possible option is Atmega2560 which has 4 serial ports and a lot of other sensor ports which other controllers cannot provide. Tiny-AVR micro-controllers are also one of the best among other choices. Along with low power consumption, controllers have to operate in low power mode while sleeping. Assume that we have to send data to central data acquisition unit every 20 seconds which includes t1(sensing time) and t2(sending time). Sensing time is the time taken by the controller to measure the sensor value and sending time is the time taken to send data to central data acquisition unit. As per AVR2560, it samples ADV values at 76.9kSPS, means one sample at 0.000013 seconds. Also if our transmitter use 9600 bits/second, assuming in one transmission it is sending maximum of 128 bits, then at 9600 baud rate it take 0.0131 seconds. So total time taken will be $t = t1 + t2 = 0.000013 + 0.0131 = 0.013113\,\mathrm{s}$.

So after sampling and sending data in 0.013113 seconds, if controller goes to deep sleep mode, it consumes less power. Sleep mode will transition to wake up mode by using sleep mode control register in AVR2560 V3. Below is the small description of SMCR registers which provides key to time triggered architecture towards environment monitoring.




| Bit | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | |
|---|---|---|---|---|---|---|---|---|---|
| 0x33 (0x53) | – | – | – | – | SM2 | SM1 | SM0 | SE | SMCR |
| Read/Write | R | R | R | R | R/W | R/W | R/W | R/W | |
| Initial Value | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |

Table 11-2. Sleep Mode Select

| SM2 | SM1 | SM0 | Sleep Mode |
|---|---|---|---|
| 0 | 0 | 0 | Idle |
| 0 | 0 | 1 | ADC Noise Reduction |
| 0 | 1 | 0 | Power-down |
| 0 | 1 | 1 | Power-save |
| 1 | 0 | 0 | Reserved |
| 1 | 0 | 1 | Reserved |
| 1 | 1 | 0 | Standby(1) |
| 1 | 1 | 1 | Extended Standby(1) |

Figure 1: SMCR register.

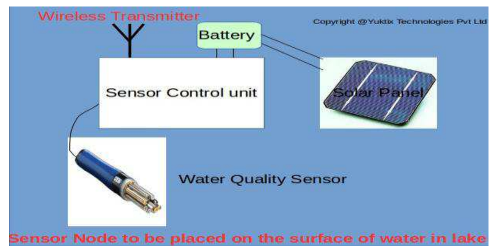



Figure 2: Solar powered WSN water sensor node.

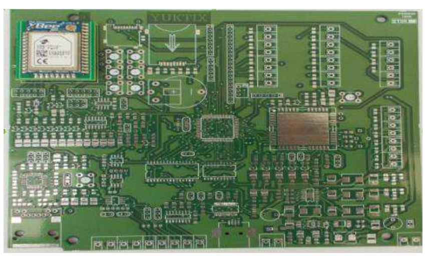


Figure 3: New PCB for end sensor node.

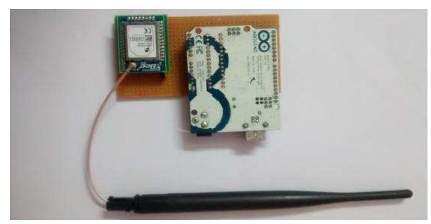


Figure 4: Present water quality sensor node.

(A) Solar WSN: WSN proves to be very useful in the case scenario when you need to put up a lot of sensors in a specific area and also want to push data to some remote location from where it can be monitored easily. A WSN can be described as a group of spatially distributed autonomous sensor to monitor different environmental variables [3, 4] and send the data to a main location. Solar powered WSN proves to be very useful when these sensor nodes are deployed to remote location difficult to access frequently and don't have a stable electric power supply. Using solar powered WSN let users to let end sensor nodes run on solar as primary source and battery as secondary source. Below is diagram representing solar power WSN end sensor node. Proposed WSN end sensor node consist of 3 major parts, 1. Control unit 2. Wireless unit 3. Sensor suite.

1. Control Unit: Proposed WSN control unit use AVR 2560 V3 [5] micro-controller which uses 3.3 volt supply and is a 100 pin chip with multiple GPIO's, ADC, UART, SPI and I2C peripherals in which multiple sensor can be added. Below is PCB for our WSN end sensor node control unit which is in active phase of development and testing.
2. Wireless unit: Wireless unit in WSN plays the most important role of transferring data from end sensor node to coordinator. In this set up Digi Sub-Ghz 865LP xbee module [6] which work in the spectrum of 860 to 873 MHz is used. Working Non-LOS range of 865LP while testing it in field with 2.1 dB antenna was found to be 100 meter while with 14 dBi patch antenna it was found to be 400 meter. End sensor nodes to be used in our project will be placed in open lakes, so they will fulfill given requirements. Proprietary build of AVR-UART library for communicating with Xbee module is deployed. Yuktix AVR-UART library is ISR based, so consumes less processing power and does not hog unnecessary controller time. For testing the range and data transfer, we used simple transparent mode available with Digi 865LP module but for more effective and efficient data transfer, so that not even single data

packet is lost, we will used API mode [8] available with Xbee. While performing testing, we used our laptop running MySQL. Below is the snapshot of received data.

3. Sensor suite: We are considering various available analog as well as digital sensors to be interfaced with our sensor nodes. As of now we have decided to go with rshydro sensor with multiple variables in one sensor.

(B) CDAU — Central Data Acquisition unit In our present work, we are using RPI as a CDAU. RPI is an ultra-low-cost (20–35) credit-card sized Linux computer which was conceived with the primary goal of teaching computer programming to children but now days is used for different other purpose due to its low power consumption as compare to conventional computers which run LINUX, its small size and its processing power which is sufficient enough to run multiple parallel processing computations and MySql storage to store data received from different end sensor nodes. Below is the pic of our present CDAU which we are running with AC converted to DC power and plan to run it with solar power accompanied by battery as a back-up in night and cloud conditions in future.

A USB GPRS dongle would be plugged to the CDAU which will keep on sending the data received from end sensor nodes to Yuktix cloud just to make sure that GPRS data is used efficiently and at the same time, data can be viewed in real time with least latency. Cloud Infrastructure Cloud infrastructure is one of the most important part of this project, as that give us the power to see sensor data in real time in a visual manner i.e., both using graphs and tables. We are using Yuktix cloud which is already in use in one of the project in Bangalore for measuring real time weather data in the manner similar to [7]. Yuktix runs the provisioning services and time series database on top of Azure Table service (a NOSQL data service) and traditional RDBMS. A device is provisioned with a unique serial number. The stored data is then distributed via a set of REST services. Our web interface is built on top of our REST services. Yuktix cloud infrastructure can be used to manage multiple devices deployed over a region using groups, sites and single devices. Below is the picture of Yuktix cloud application running in real time and displaying real time weather data received from different weather stations.

Figure 5: System running MYSQL database, simulating SDAU.


Figure 6: Water quality sensor node

Figure 7: CDAU — Central Data Acquisition unit prototype and set-up.

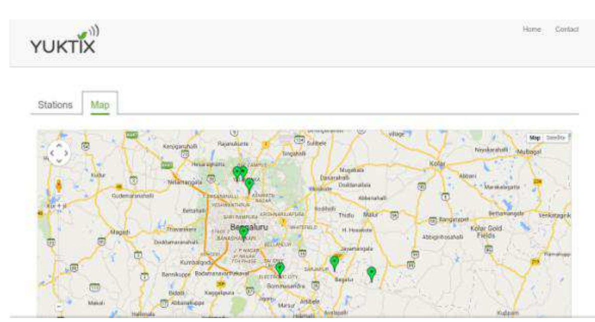



Figure 8: Yuktix web-application.

Yuktix cloud application is capable of sending data to any server using web-hook script. With Yuktix cloud you can run multiple models to analyze and predict water quality data. Yuktix also provide data archiving option with which you can store water quality data with a frequency of 3 minutes for year which can be used further in future for in-depth analysis and research. Yuktix cloud infrastructure also consist of smart-phone application (at present only for Android, future app will be on tizen) with which you can see real time data on the go.

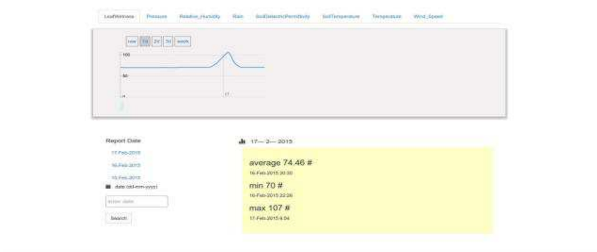



Figure 9: Yuktix web-app, data display in real time.


Figure 10: Yuktix Android app with different devices data in real time.

## 3. CONNECTION WITH LARGER TECHNICAL SCENARIO

Future prospects of this project include getting more high resolution water quality data from end sensor nodes and do further analysis of water quality data based on which suggestions and preventive measures can be given to government and local decision making bodies to save the ecological habitat existing around lakes and make lakes water potable. Same IOT (Internet of Things) infrastructure can be used for different case scenario's like 1. Air quality monitoring, 2. Sound pollution monitoring 3. Weather prediction 4. Correlating environmental data with disease propagation 5. Agriculture related information system design etc..

## 4. SYSTEM EVALUATION TABLE

A basic summary table of different attributes of this system is provided below.

Table 1: A basic summary table of different attributes of this system is provided below.

| S. No | Propoerty | Valuation |
|---|---|---|
| 1 | ifetime | 5 years |
| 2 | Cost and Ease of Deployment | Plug and power end sensor node and CDAU and start getting |
| 3 | Coverage | Wherever cell-phone Network is available |
| 4 | Sensor Polling | Every 10 second, can be reduced further to 5 seconds |
| 5 | Wireless range | Non-LOS — 100 meter, LOS — 400 meter can be extended to 1500 |
| 6 | Security | 128 bit Advanced Encryption Standard |
| 7 | End sensor Node | Low power, multiple sensor, solar powered |

## 5. CONCLUSION AND FUTURE DIRECTION

A low cost solar powered solution can be deployed all across Bangalore in order to measure water quality of lakes in different locations during different time of the year and preventive measures can be taken in order to maintain the water quality apart from saving bio-diversity of ecological system living nearby. Same data can be used by various other organization and NGO's along with Bangalore Citizen Weather network data in order to form their plan for the incoming year. Also sleep mode feature of the WSN nodes elongates their operational lifetime for longer duration without any need of any external power supply.

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