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Practical Implementation of WSN based Data Acquisition System with External Connectivity

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***Abstract*—WSN technology holds lot of promise in developing sensing and monitoring applications for both terrestrial as well as underground environment. The data thus acquired could be transmitted wirelessly even to remote locations for processing and further analysis thereby helping the decision makers to take appropriate measures. This paper discusses the experimentations done to develop a WSN based Data Acquisition System to monitor water quality parameters like pH, Conductivity, ORP/Redox etc. in real time. The System has VPN based connectivity to external network through appropriate gateways, so that enterprise applications can interact with WSN Mesh Networks. A generic prototype model has been developed which could be deployed for monitoring the water quality of any water body. A custom application in Matlab has been developed for online and offline sensor data visualization and analysis.**

Keywords- WSN, Data Acquisition System, Water Quality Monitoring, VPN

I. INTRODUCTION

A Wireless Sensor Network offers the scope of developing systems with wide range of applications in the areas of habitat sensing, environmental monitoring, military and health surveillances etc. Wireless Sensor Network's ease of deployment and un-attended operation makes it an ideal choice for collection of data even from remote and hostile terrains under adverse conditions.

The growth of WSN has been fuelled by the advancements made in micro electro-mechanical systems (MEMS) [1]. WSN are characterized by resource constraints in terms of memory computational power, battery longevity, bandwidth etc. e.g. a typical wireless sensor node MicaZ is built around a RISC 8 bit Microcontroller Atmel Atmega128 with 128KB of programmable flash memory, 4KB of SRAM for data storage and 4KB of EEPROM and bandwidth of 250kbps [2].

This paper presents the various design aspects related to implementation of Data Acquisition System using Wireless Sensor Networks [9]. A practical implementation has been carried out for real time monitoring of water quality of a water body using under-water sensors and their interfacing with the Data Acquisition and Communication System.

II. MOTIVATION

The water quality of world famous Dal Lake in Srinagar, J&K, has deteriorated considerably in the last two decades. With the increase in the number of house boats, residential buildings, restaurants and hotels coming up along the lake front, the authorities are finding it difficult to monitor and keep a check on the raw sewage discharge entering Dal Lake from different directions. The polluted water has resulted in unwarranted weed growth, decrease in water clarity, enrichment of waters and high microbial activity [3].

The existing system is based on manual collection of water samples by field assistants from the site and processing it in a consolidated way. The major shortcoming in this system is that it requires large manpower and there is a long delay in processing and generating the results. The information collected may not reflect the variations in the parameters being monitored thus leading to inaccurate diagnosis of environmental incidences.

This project has been undertaken to develop a solution for monitoring the water quality of the Dal Lake in real time using Wireless Sensor Networks.

III. DESIGN APPROACH

A. Design

The design is based upon under-water sensors of Global Water for measuring pH, Conductivity, ORP/Redox, Temperature, Turbidity, Oxidation levels. These sensors, which give current output, were interfaced to Data Acquisition Card MDA320 of Crossbow supporting both analog and digital channels. The software components are organized in 3 tiers, namely, Data Acquisition Tier, Server Tier, and a Client tier [4][8].

The main contribution of this paper is to demonstrate building a customized Data Acquisition System and its connectivity to the external network for remote monitoring purposes.

B. Hardware Devices

- Sensors (pH, Conductivity, Temperature, Turbidity, Dissolved Oxygen, ORP/Redox).
- Data Acquisition Board (MDA320)
- Gateway (MIB600)

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- Motes (Micaz)

C. Software Tools

- Mote works environment (TinyOS, Xserve, Xcommand, Moteview)

D. Sensor Network Architecture

WSN is comprised of hundreds or even thousands of self-organizing, low power, low cost multifunctional nodes spatially distributed for various applications via a region of interest. These sensor nodes are equipped with Data Sensing, Processing and Communicating capabilities.

Sensors are programmable to sense an event at regular intervals of time or report an event as and when it occurs. The nodes are generally equipped with embedded sensors to measure light, temperature, humidity, moisture etc.

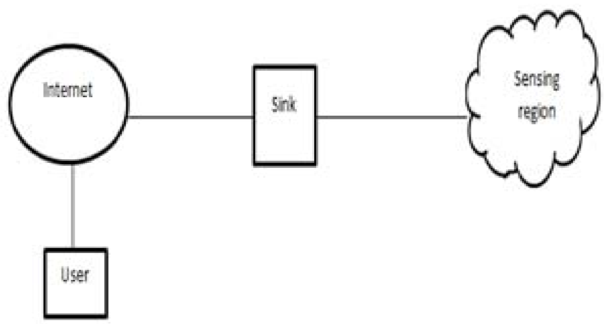

Figure 1. Design Approach

In addition to a variety of nodes available from different OEMs, one can use sensors specific to one's application to build a data acquisition system for real time monitoring using wireless sensor networks. [4]

IV. ARCHITECTURE OF DATA ACQUISITION SYSTEM

Data Acquisition System has been built on three-tier architecture comprising of Data Acquisition Tier, Server Tier, and Client Tier as shown in Fig. 2.

The Data Acquisition Tier consists of cloud of sensor nodes formed by interfacing sensors (under water sensors) to data acquisition boards (MDA 300/320) attached with MicaZ motes. The server tier is an always-on facility that handles sensor data calibration and database logging. Client tier connects to the server tier for user visualization of sensed data.

The software representation of the system is shown in Fig. 3. The nodes are programmed with data sensing and transmitting application. The Base Station Node is programmed with gateway application which is capable of sending and receiving data from sensor nodes. These applications are designed around component based event driven Operating System – TinyOS written in NesC [5]. The gateway program transfers the raw packets from the network to Xserve over LAN. The Xserve serves as a primary interface between WSN and the client-tier. Xserve is capable of calibrating data as well as logging data to postgreSQL based on XML configuration files. The client-tier applications (Moteview / Matlab) can connect to the server tier over VPN/TCP-IP for offline and online sensor data analysis

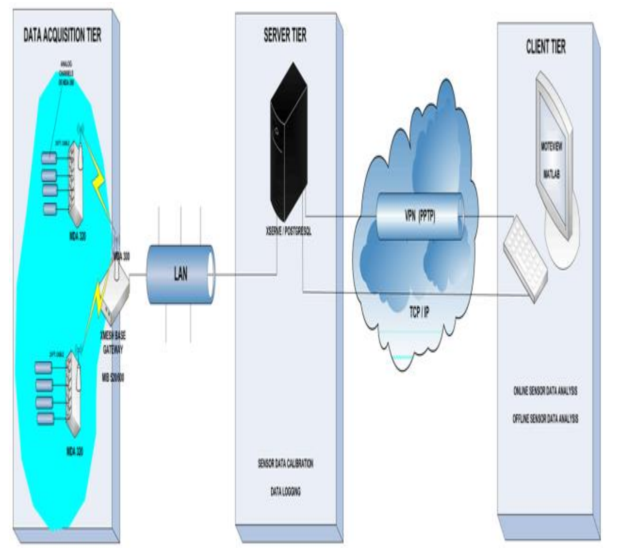

Figure 2. Layered architecture of Data Acquisition System

A. Hardware Implementation

Data Acquisition Tier was built around host of underwater sensors sensing physical parameters like temperature, pH value, conductivity, dissolved oxygen to determine the water quality of a water body.

The platform has been developed around MDA320 data acquisition card with 8 single ended analog channels, 8 digital channels, counter channel, external sensor excitations, LEDs and power supply (VCC). Signals with dynamic range of 0 V to 2.5 V can be plugged to these channels. The analog to digital converter has 12-bit resolution. The LSB value is 0.6mV. The result of ADC can be converted to voltage knowing that voltage = 2.5 *ADC_reading /4096. The sensor generates the current output of 4 to 19 mA corresponding to the value of physical quantity being measured. Resistors need to be added to the MDA320 board to properly scale the voltage levels of external analog sensors so that maximum voltage is 2.5 V DC. A resistor value of 125 Ohms was chosen while calibrating the signal conditioning circuit [6][7].

The sensors used are either two-wire or three-wire Global Water Sensors. The interfacing of these sensors with MDA320 is shown in Fig. 4 and Fig. 5.

B. Software Implementation

The motes were programmed by two types of applications:

- Data Sensing and Transmitting application.

- Gateway application.

Data Sensing and Transmitting Application is an Xmesh based nesC program used for sampling the data and transmitting it. The program samples the channels when the timer event occurs, the timer duration can be programmed as desired. The flow chart of the data sensing program is shown in Fig. 6.

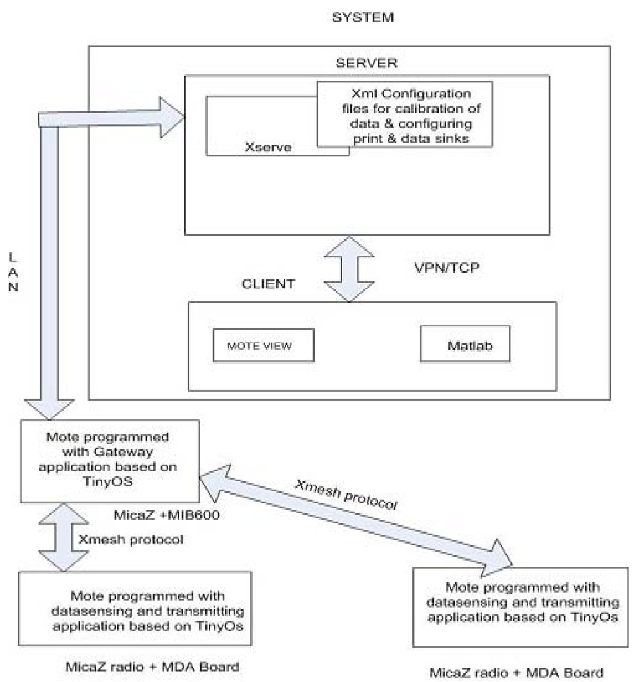

Figure 3. Software Representation of WSN

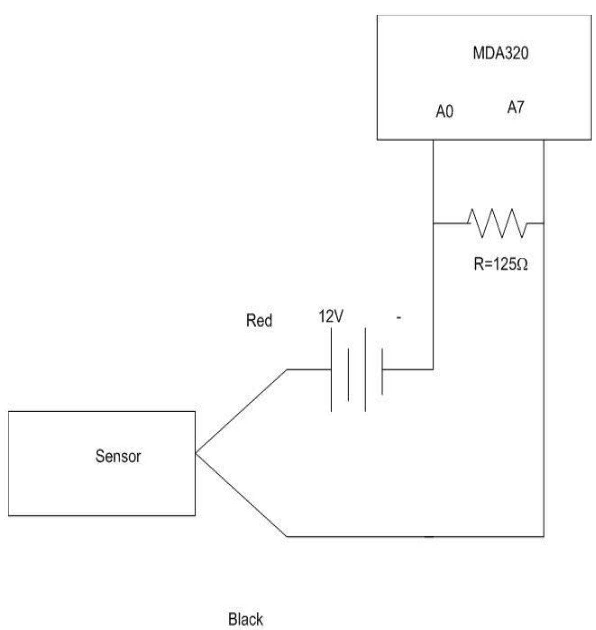

Figure 4. Two wire sensors interfacing with MDA320

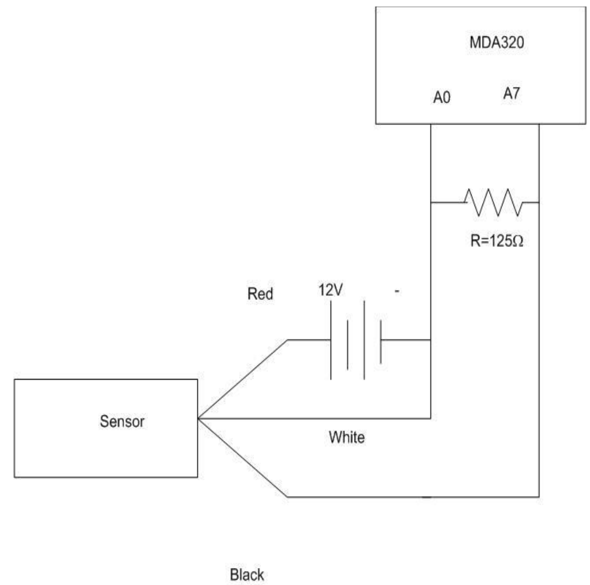

Figure 5. Three wire sensors interfacing with MDA320

The program is capable of sensing, analog, digital and voltage reference values. These sampled values are stored accordingly. The component graph of data sensing and transmitting application originally available in Moteworks platform generated using nesdoc is shown in Fig. 8. The gateway program is a nesC application to serve as a base station within the Xmesh network. The program also has capability to inject command and queries in the network through Xcommand a propriety application of crossbow. The Mote programmed with gateway application is interfaced with MIB600.The MIB600 provides Ethernet connectivity to the MicaZ motes for communication and in-system programming.

The MIB600 allows remote access to sensor network data by means of TCP/IP. The MIB600 serial server connects directly to a 10 Base-T LAN like any other network device. The MIB600 can bridge “wired” and “wireless” segments of a network. It is also an effective conduit for sensor data. The MIB-600 offers two separate ports; one dedicated to in-system mode programming (lower port number) and second for routine data communication (higher port number) over LAN.

Xserve is the core of Server tier and acts as a Serial Forwarder allowing applications to communicate directly with wireless sensor networks through it [8]. It also acts as an application server providing high level services such as sensor data calibrations and data base logging. XML config files can be configured as desired for calibration and logging. Fig. 7 shows an excerpt of XML config file used for sensor data calibration.

The Sensor data was visualized at client tier on Virtual Private Network. The Fig. 9 shows the proof of concept of VPN established between the Server Tier and the Client Tier. Point to Point Tunneling Protocol (PPTP) was used to mimic a direct link between the two locations, allowing for a secure connection. A custom application has been developed for visualization and analysis of sensor data at Client Tier in matlab. The application is capable of performing offline and online sensor data analysis.Fig.10 shows live data reading being collected from 2 sensor nodes.

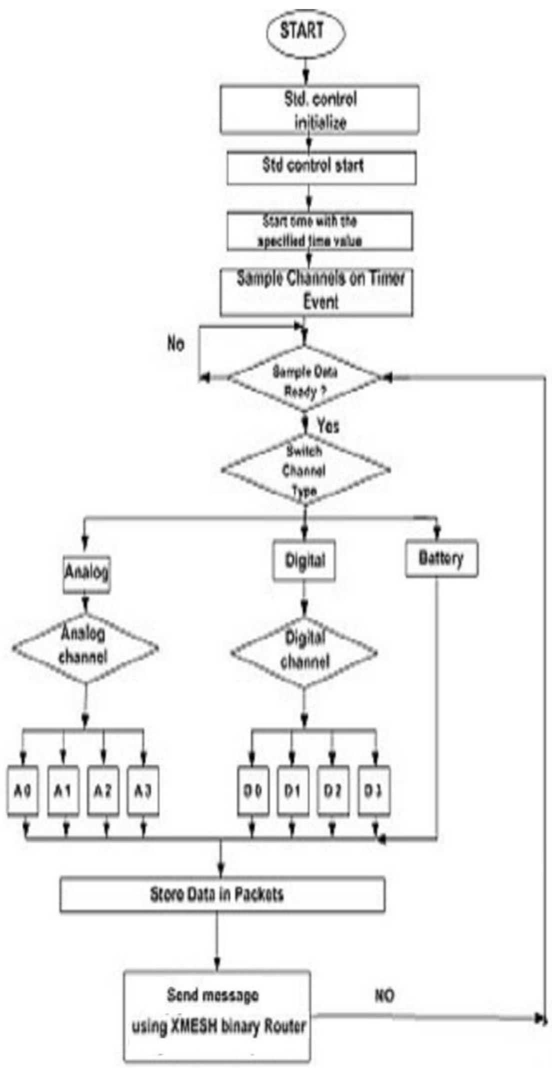

Figure 6. Flowchart of data sensing and transmitting application

```
<XField name="adc0" type="uint16" length="2" byteoffset="18">
 - <XConversion returntype="uint16" function="(2*625*x/16384)">
      <XConvParam type="uint16" fieldname="adc0" variablename="x"/>
   </XConversion>
</XField>
```

Figure 7. Excerpt of XML config file

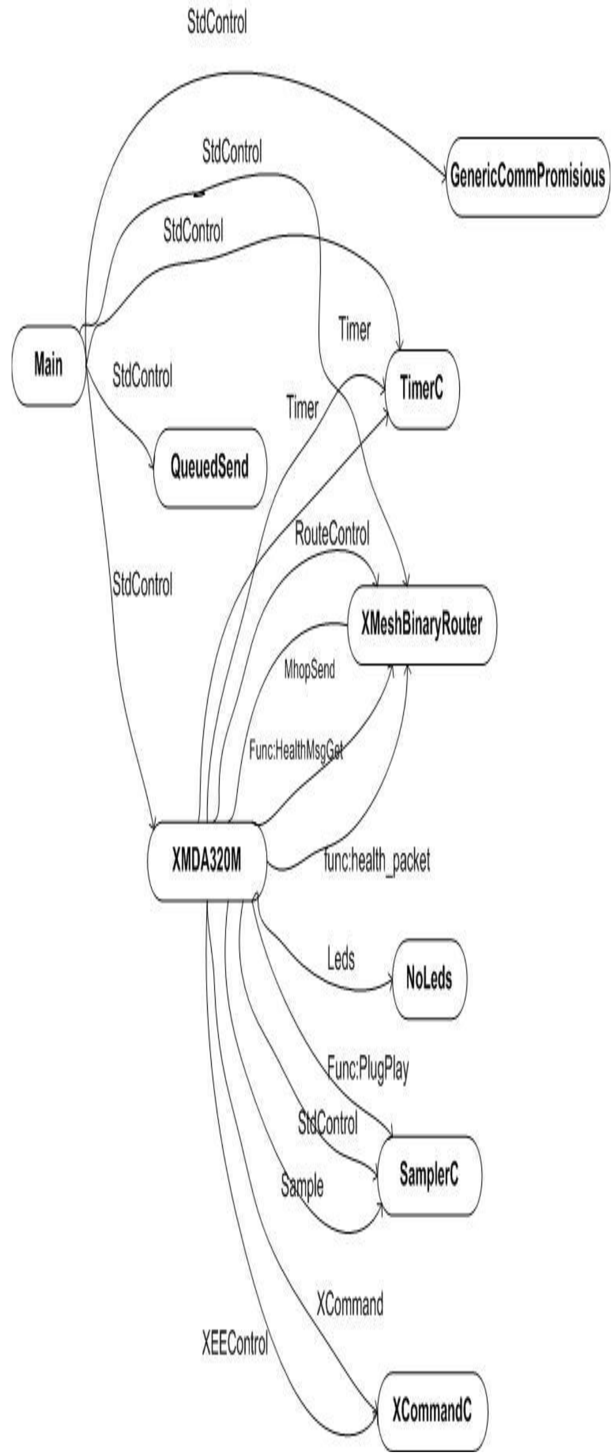

Figure 8. Component graph of Moteworks data sensing and transmitting application based on Xmesh protocol

V. CONCLUSION

In this paper we have presented a complete design of a Data Acquisition System used for real time monitoring of water quality. The design is based upon Wireless Sensor Networks and underwater sensors. The hardware and the software aspects of the system have been thoroughly discussed. A test bed has been developed for real time monitoring of water quality of Dal Lake based on the said architecture. A custom made application for client tier has also been successfully developed for remote access of data. A VPN connection was established between the Data Acquisition Site and the client location using the scheme as per the Fig. 9.

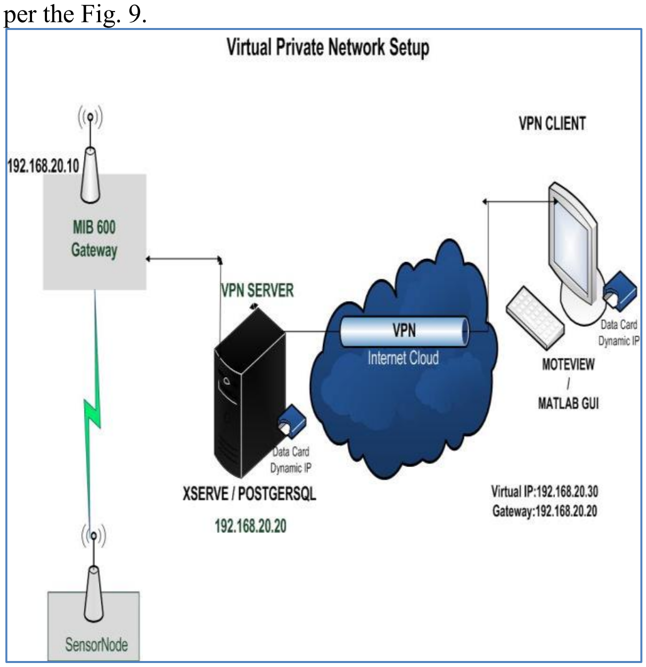

Figure 9. VPN Connectivity between Server and Client Tier

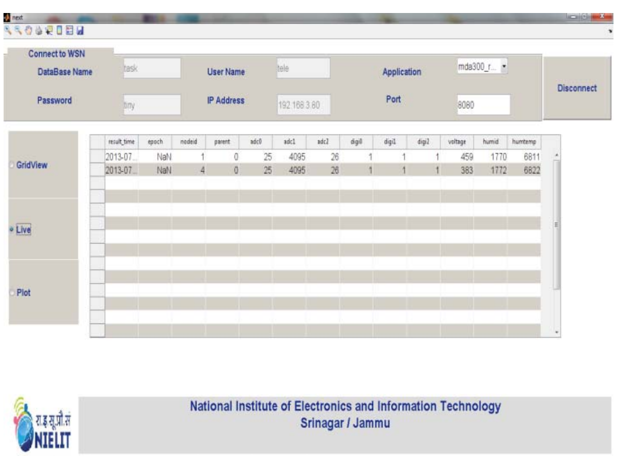

Figure 10. Snapshot of custom made Matlab application displaying live Sensor data

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REFERENCES

[1] Abdulrahman Alkandari, Meshal alnasheet, Yousef Alabduljader, Samer M. Moein, "Water Monitoring System using Wireless Sensor Network (WSN): Case Study of Kuwait Beaches", IEEE 2012

[2] Memsic, Moteworks Manuals.

[3] Baziga Badar and Shakeel Ahmad Romshoo, "Assessing the pollution load of Dal Lake using Geospatial tolls " , Proceedings of Fall 2007: the 12th world lake Conference:668-679.

[4] Jun Zheng & Abbas Jamalipour. "Wireless Sensor networks, A networking perspective", Wiley , 2009

[5] Philip Levis "TinyOS Programming" 2006

[6] Zulhani Rasin and Mohd Rizal Abdullah, "Water Quality Monitoring System Using Zigbee Based Wireless Sensor Network": International Journal of Engineering & technology vol:9 No.10

[7] Global Water User Manuals

[8] Memsic, CrossBow Xserve User Manual

[9] WANG Ji, XU Guo-bao, SHEN Yu-li, " A sea water monitor system based on wirless sensor network," Telecommunication Engineering, 2008, Vol. 48, No.9,pp23-28

[10] Frank Reichenbach, M.H. Dirk Timmermann (2005). Monitoring the Ocean Environment with Large-Area Wireless Sensor Networks . Paper presented at the 8th EUROMICRO Conference on Digital System Design.