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Real Time Remote Wireless Sensor Network for Water Quality Monitoring

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***Abstract*—** Water contamination is one of the significant apprehensions for the green globalization. Potable water is really a scarce resource to today's generation. Urbanization, overpopulation, industrialization, has lead to tremendous increase in untreated sewage disposal and industrial effluents. This has lead to spread of life threatening diseases. Water surveillance is an important tool to control the level of contamination in the polluted water. In India, water quality is analyzed by manual water quality surveillance methods which exacerbate water quality deterioration. Therefore, the need of a continuous, real-time, in-situ monitoring system for water quality management has risen. Wireless Sensor Network (WSN) which is real-time, continuous and dynamic system has fascinated us for pro-active water quality management. Though there are a number of research papers available on the working of WSN in different areas, the studies on application of WSN in environmental monitoring remains limited. In this paper, we discuss requirement and suitability of WSN for water quality surveillance. This research work deals with clustering approach which will be energy efficient to increase the lifespan of the network. Then the optimization approach is implemented to optimize the performance of the network.

Keywords-*Water; WSN; Water Quality Monitoring*

I. INTRODUCTION

Wireless sensor networks (WSN) are spatially distributed autonomous sensors dedicated for sensing and computing physical parameters. These nodes sense and monitor the parameters and transmit the collected data to a remote location using wireless communication technologies. The characteristics of WSN are ease of use, ability to withstand uncontrollable environments, ability to cope with node failure, scalability of deployment and heterogeneity of nodes.

In the past decade, WSN have been extensively deployed in a number of applications such as marine environment monitoring[1,2], forest area monitoring[3,4], health care[5,6], disaster prevention[7,8], military surveillance[9,10], ocean sensing and evaluation of health of vegetation[11]. Coral reef monitoring is normally done using WSN due to their ability to provide real time information. WSN's can also be deployed in forests to detect when a fire has broken out by measuring temperature, humidity and gases. In health care field, WSN's are used for monitoring cardiac patients, post surgery rehabilitation, stroke rehabilitation and brain trauma rehabilitation. Disasters such as tsunami, flood etc can be predicted by wireless systems. Borders and other critical areas can be closely monitored using sensor networks. Oil spills in oceans can be easily detected and new species of flora and fauna can be discovered by deploying sensor nodes in oceans.

Water quality refers to the physical, chemical and biological characteristics of water. It is the measure of condition of water relative to the requirements of humans or other species. Most common standards to access the quality of water are potability, environmental water quality and industrial and domestic use.[12]

Water quality monitoring is commonly defined as the sampling and analysis of water and conditions of the water body. These water bodies may be lakes, streams, rivers, estuaries or oceans. Monitoring the quality of water can help us evaluate the physical, chemical and biological characteristics of a water body in relation to human health, ecological conditions and designated water uses. Water quality can be monitored either by the conventional method which includes sampling, transporting, measuring data in laboratory or by the recent technology of remote sensing using wireless networks.[13]

A water quality monitoring system is usually developed to monitor physical parameters like temperature, pH, turbidity and conductivity and chemical parameters like heavy metals and dissolved oxygen (DO) for ocean bays, lakes, rivers and other water bodies. Proliferation of toxic substances can lead to dramatic effects on human health, biological life and local economies. Consequently, water quality has become a critical issue of concern.

This paper is organized as follows: Section II presents the literature survey and water quality monitoring using WSN is presented in Section III. Comparative study of water quality monitoring between traditional methods and WSN is described in Section IV. Section V concludes the research paper.

II. LITERATURE SURVEY

O'Flynn,et.al [14] present a Smart Coast Multi Sensor System for water quality monitoring. The aim of this system is to provide a platform that should be capable of meeting the monitoring requirements of the Water Framework Instruction. The physical parameters such as temperature, conductivity, pH, turbidity and water level and chemical parameters like phosphate and dissolved oxygen are investigated. The Plug & Play capabilities enabled by the Wireless Sensor Network platform established at Tyndall National Institute, Cork, Ireland allow for integration of sensors as required. Moreover some custom sensors are also developed within the project.

An ISO/IEC/IEEE21451 based network of smart sensors is suggested by Adamo, et.al [15] for in situ and continuous space-time monitoring of superficial water bodies, in particular for seawater. The system is aimed at being an important tool for the evaluation of water quality. In addition, it proves to be a valid support in making strategic decisions concerning critical atmosphere issues. The motive behind this system is to capture possible extreme events and to collect data for long period of time.

The sensing of DO for a fish farm is described in Parmar, et.al [16]. In this paper, the author has linked one master with 2 slaves using a transmission rate of 9600 b/s. The wireless broadcast follows the standard IEEE 802.15.4 protocol & implements the routing protocol based on ZigBee. Main feature of this request is that it is extensible to any type of monitoring structure just by interfacing an appropriate sensor.

A low cost system design for real time water quality monitoring in internet of thing proposed by Vijayakumar et.al [17] utilizes sensors to check many important physical & chemical parameters of water. The parameters such as turbidity, temperature, pH, dissolved oxygen conductivity of water can be measured. The measured standards from the sensors can be treated by the core controller. The raspberry PI B+ model may be used as a core regulator. Finally, the sensor data can be observed on internet using cloud computing.

An automated warning SMS alert system as presented by Boyne,et.al [18] uses GSM module having knowledge of AT commands.. After examination of the conception & the trademarks of PLC in combination embedded systems, the build out of the entrenched Programmable Logic Controller for water quality & index measurement is proposed by the seamless mixture of the Keil, Flash magic software & the Microcontroller with analog signal training for sensors input data.

A Water Sensor Network (WSN) system prototype developed for water quality monitoring in Lake Victoria Basin is propound by Faustine et.al [19].The development was followed by evaluation of prevailing environment including availability of cellular network coverage at the site of operation. The system contains of an Adriano microcontroller, water quality sensors, & a wireless communication module. Parameters like temperature, dissolved oxygen, pH, and electrical conductivity are detected in real-time and the information in graphical & tabular formats is disseminated to relevant stakeholders through a web-based portal and mobile phone platforms. The investigational results have shown that the system has great operational prospects in real world atmosphere for optimum control and protection of water resources by providing key actors with relevant and timely information to facilitate quick action taking.

A configuration model that improves the reuse & facility of the monitoring project is described by Zhang et.al [20]. The developed software signifies the monitoring hardware and analysis the data with expert knowledge to implement the auto control. The monitoring system has been an outcome of the digital, intelligent, & effectively ensures the quality of aquaculture water. Practical deployment results indicate the system reliability and real-time characteristics. Also, it displays good effect on environmental monitoring of water quality.

Karuppasamy et.al [21] have built up a model for water quality checking in lakes. The framework comprises of a PIC microcontroller, water quality sensors, and remote system communication module. It identifies water temperature, ph (Potential of Hydrogen), and electrical conductivity progressively and circulates the data which is sent to pertinent partners through an online gateway and can be picked up by means of cell phone stages. This information is indicated with the area of the lakes where it has been deployed.

A framework design comprising of data collecting nodes, a base station and a remote station is suggested by Barabde et.al [22]. Each of these stations is connected by means of remote connection module. The information from nodes is transmitted to the base station comprising of ARM controller intended for extraordinary reduced space application. Information gathered by the base station, for example, pH, turbidity, conductivity, and so on is sent to the remote checking station. Information gathered at the remote site can be shown in visual organization on a server PC with the help of MATLAB. This approach brings a few points of interest over current observing frameworks as far as cost, portability and applicability are concerned.

Valerio et.al [23] proposed the concept of a wireless sensor network (WSN) designed for real time remote sea water quality monitoring. Each network node is equipped by sensors measuring temperature, ambient light, conductivity, dissolved oxygen, pH, dissolved ions and turbidity for an automated diagnosis that enables the early identification of critical situations in the water quality, allowing an immediate intervention favoring pollution control.

Vasilescu et.al [24] introduce a novel platform for underwater sensor systems to be utilized for surveillance of coral reefs and fisheries over long periods of time. The sensor arrangement comprises of statics well as portable sensor nodes. The nodes have a point to point communication utilizing a novel rapid optical correspondence framework coordinated into the TinyOS stack, and they communicate utilizing an acoustic convention incorporated in the TinyOS stack. The hubs have an assortment of detecting capacities, including cameras, water temperature, and weight. The versatile hubs can find and drift over the static hubs for information muling, and they can carry out maintenance capacities, for example, topology, migration, and recuperation. In this paper they depict the equipment and programming design of this submerged sensor arrange. They then depict the optical and acoustic systems administration conventions and present exploratory systems administration and information gathered in a pool, in rivers, and in the sea. In the end, they depict their trials with versatility for information muling in this system.

III. WATER QUALITY MONITORING USING WSN

Latest technologies in Micro-Electro-Mechanical Systems motivated development of small yet low cost sensors. Sensors with WSN process all kinds of data at a minimal cost with high precision. The application of wireless sensor network (WSN) for a water quality monitoring is composed of a number of sensor nodes with networking capability. Such monitoring system can be setup emphasizing on the aspects of low cost, easy ad hoc installation, easy handling and maintenance. They empower us for continuous monitoring of surface and underground water. Water quality Monitoring WSNs, also known as aqueous sensor network (ASN) is also useful for real-time monitoring of streams, lakes, ocean bays, [25]. Depending upon the required applications, different kinds of physical, biological or chemical sensors can be incorporated. This allows long-term, wide area, in situ multi-parameter monitoring. Each node of the sensor network is capable of measuring environmental parameters of interest like the turbidity and temperature is measured in real time by the sensors that send the data to the base station or control/monitoring room. They can be deployed in both long-term (pollution detection etc) or short-term aquatic exploration (natural resource discovery) via regular water quality monitoring, identifying gaps with standards [25]. Based on the gaps, suitable action is taken for treatment. To determine drinking suitability, water quality indices like pH are checked thoroughly. The whole water environment monitoring system presents useful characteristics as large network capacity, flexible disposition, low power consumption, low cost, and minor influence on the natural environment [26].

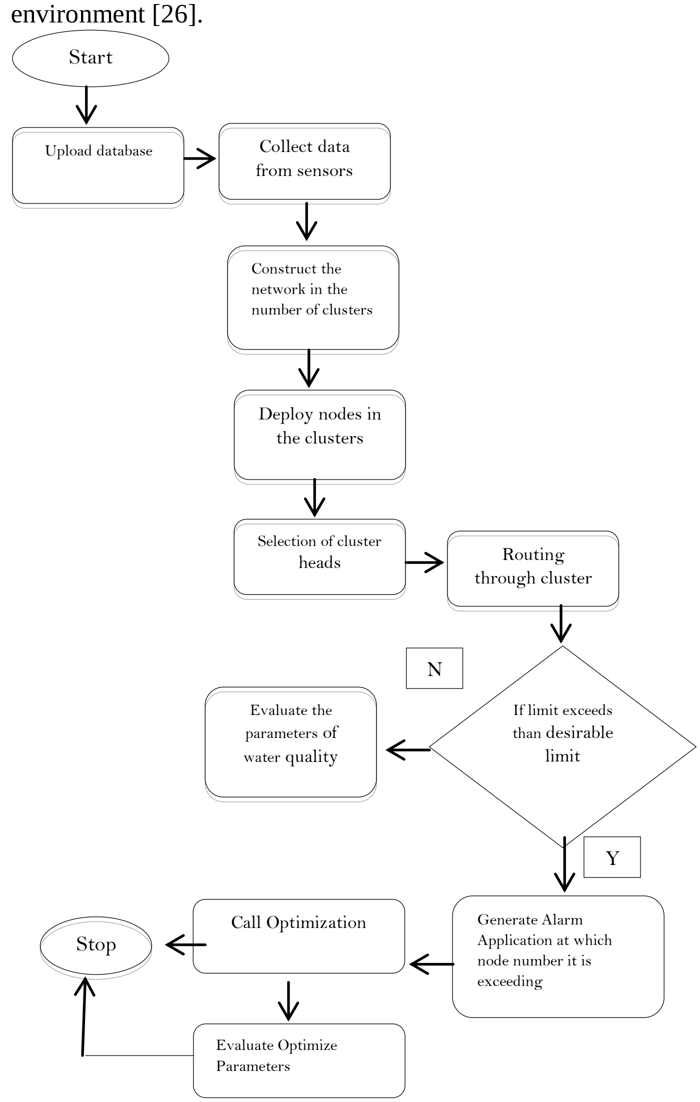

Figure 1: Methodology adopted in the project

In this system, a wireless sensor network is laid underwater. Whole network is divided into a number of clusters, with each cluster having a cluster head and sensor nodes. The sensor nodes collect the data from the environment and send it to the cluster head. The cluster head then sends this information to the base station through the radio block. This information, which is in the analog form, is then converted into digital form and uploaded into the database. At the base station, various parameters of water quality are monitored and evaluated. This information is disseminated through relevant stakeholders through mobile phone platforms.

IV. COMPARATIVE ANALYSIS

At present water quality monitoring is done by either of the three methods, each of which has its advantages and disadvantages:

1. Conventional methods where samples of water are collected from the cross sections of rivers and lakes. These samples may be collected from daily to monthly basis, depending upon the requirement of monitoring [27]. Collected samples are then analyzed in the laboratory. This method is manual, which makes it tedious and time consuming. Moreover, chances of contamination are also there.
2. Automatic monitoring system for continuous monitoring of water quality. The system consists of a network of sensor, sub-stations and a control centre. Data is collected periodically by recovering the devices [27]. The sub stations provide real time information about the various parameters in question but the system can be quite costly.
3. Wireless sensing technology which provides real time in-situ information about the quality of water with the potability perspective. After the data is collected and processed, further evaluation can be done in terms of physical and chemical characteristics. The resultant analyses can be intimated to relevant stakeholders with the help of mobile applications and internet.

V. RESULTS

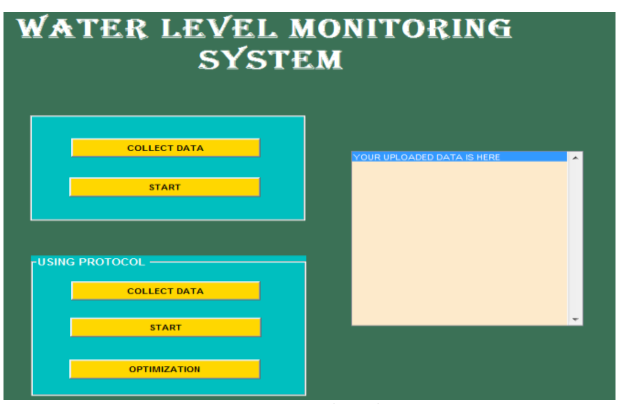

Figure 2: Layout of the front end

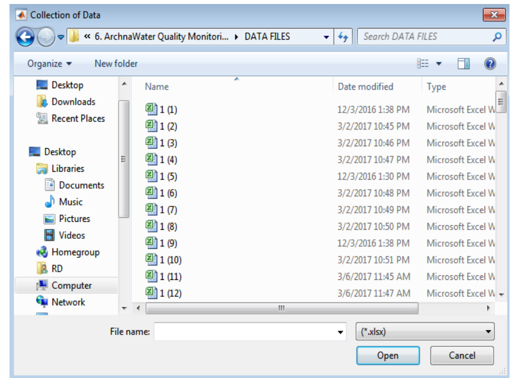

Figure 3: Database files

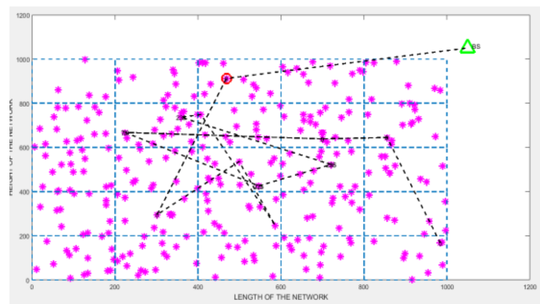

Figure 4: Deployment of nodes

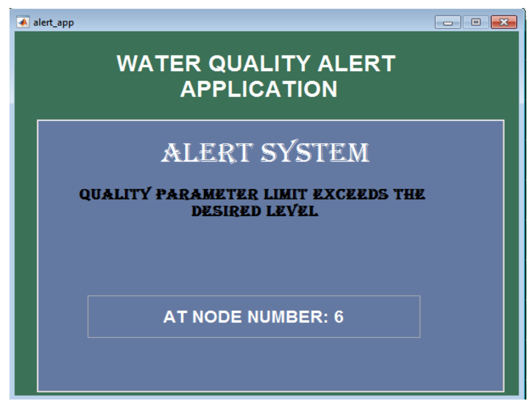

Figure 5: Alert System

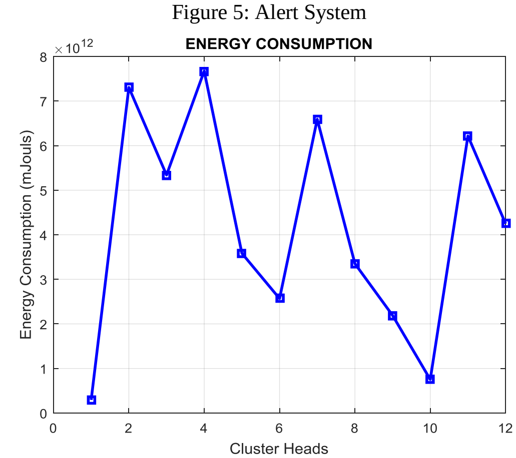

Figure 6: Energy consumption using Stable Election Protocol

The above figure shows the energy consumption of the network and shows that cluster heads are consuming $8*10^{12}$ mJouls . The energy consumption is plotted with respect to the number of cluster heads

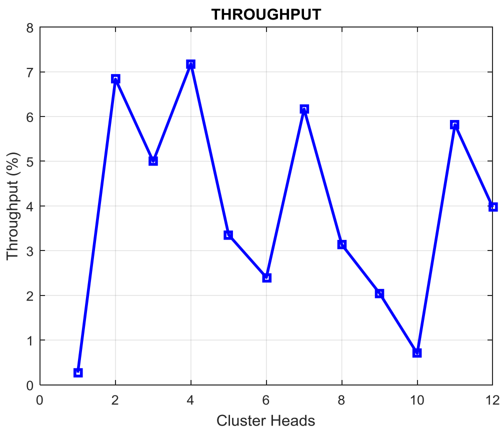

Figure 7: Throughput using Stable Election Protocol

The above figure shows the throughput of the network and shows the overall performance in the network. Throughput shows that the efficient delivery of the packets and showing less percentage which is further improved using optimization.

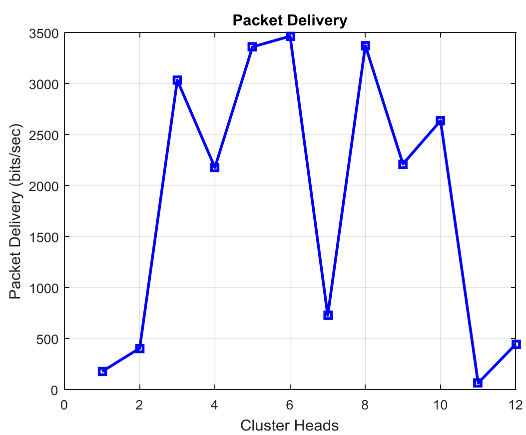

Figure 8: Packet delivery using Stable Election Protocol

The above figure shows the packet delivery of the network in terms of bits per second and shows successful delivery bits. The packet deliveries must be high for the high network lifetime.

After Optimization

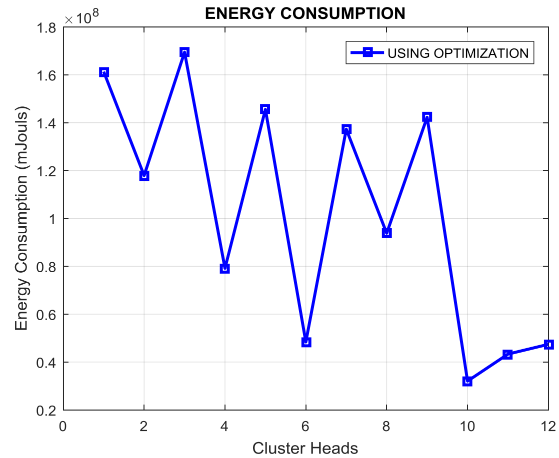

Figure 9: Energy with optimised Stable Election Protocol

The above figure shows the energy consumption of the network after optimization which shows the consumption of energy in low manner with respect to without optimization which shows that the optimization is showing better energy consumption of the network in which operations are performed using cluster heads.

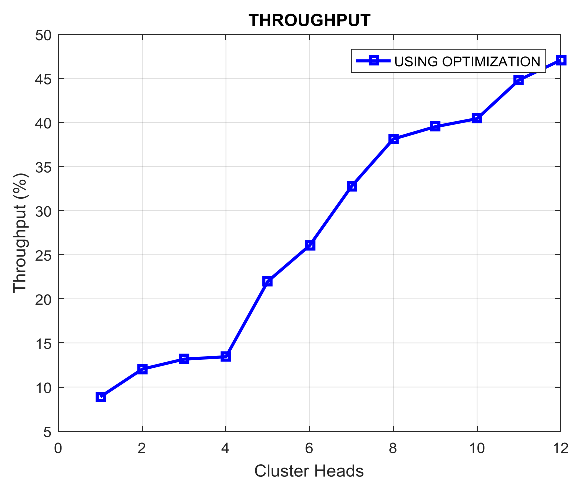

Figure 10: Throughput using optimised Stable Election Protocol

The above figure shows the throughput of the network after optimization and shows 45 percent high optimize throughput than without optimization. The throughput must be high for efficient packets delivery to the base station through inter cluster communication

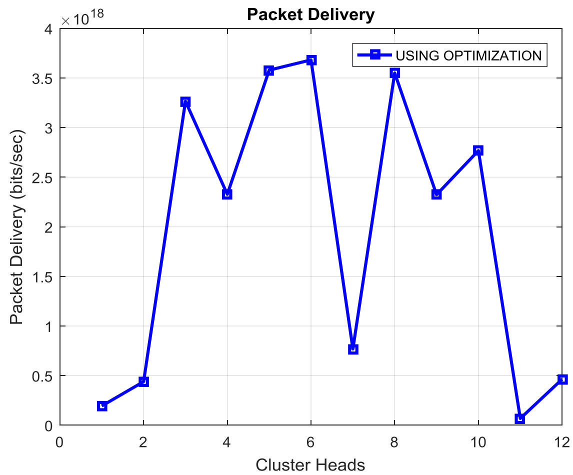

Figure 11: Packet delivery using optimised Stable Election Protocol

The above figure shows the packet delivery of the network using optimization and we can compare it without optimization and shows that after optimization more bit rate are delivering in efficient manner with any loss of packets to the base station. The proposed optimize approach is performing better to increase the lifespan of the network.

VI. CONCLUSION

Water is a very fundamental need of all living beings but not all the water present on earth is fit for use. Checking the potability of water is a very important task and becomes difficult terms of regularity, if done manually. Hence our project is based on checking the quality of water through an online system. The project collects the information regarding the quality using wireless sensors and the collected information is disseminated through on online portal. Various methods of water quality monitoring are studied and wireless sensor networks are found to be most suitable for the potable water perspective.

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