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A Water Quality Monitoring system based on Wireless Sensor Network

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Abstract -Wireless Sensor Networks (WSNs) have been achievedwidespread applicability in water quality monitoring. However, existing WSN-based monitoring systems are not adequate for monitoring pond and lake water, city water distribution and water reservoir. Moreover, these frameworks cannot be reused in other monitoring applications since they use static and application specific sensor nodes and are not dynamic to the changing requirements. Thus, we introduce a reusable, self-configurable, and energy efficient WSN-based water quality monitoring system that integrates a Web-based information portal and a sleep scheduling mechanism of sensor nodes. The testbed and simulation results show that the framework can monitor the water quality in real-time and the sleep scheduling mechanism increases the network lifetime, respectively.

Keywords –Wireless Sensor Network; Water Quality MonitoringSystem; Zigbee; Sleep Scheduling.

1. INTRODUCTION

Recently, Wireless Sensor Networks (WSNs) have received widespread applicability not only in monitoring applications, but also in the field of data collection, surveillance, and medical telemetry [4]. However, the impact of using WSNs in industry is still not effective due to their inefficient implementations. For instance, industries are still using the traditional way to monitor the quality of water in water distribution systems [6]. Even though they use sensors, they do not have an efficient approach to detect the pathogen or viruses in drinking water since it is neither a wireless network nor unattended. Thus, WSNs have great potential in real-time monitoring the water quality in different locations because (i) sensors are cheap and easy to deploy, (ii) can monitor the whole water distribution system, and (iii) sensors nodes can collect water data automatically and send to the data center through multi-hop communications.

Sensor node (source node)

Multi-hops

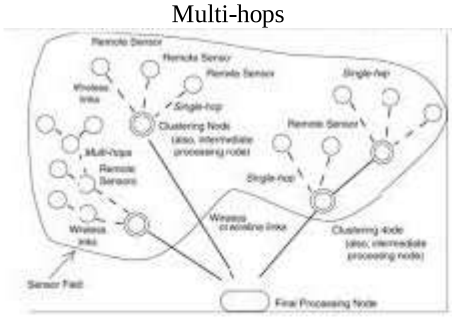

Figure 1: A Typical Wireless Sensor Network

However, sensors are battery powered and have limited energy (i.e., lifetime). Thus, designing energy efficient management approaches (i.e., routing protocols such as LEACH [13, 14], Directed Diffusion [13] data aggregation and scheduling) are significantly important for WSNs. Figure 1 illustrates a typical ad hoc WSN that supports multi-hop routing protocol [2, 10, 14] by allowing sensors to forward sensed data to the gateway through other sensor nodes.

However, existing WSN-based monitoring systems are designed for specific applications due to the available sensors that are application specific. Hence, weather and water sensor networks are designed and operated individually though the integration of water and weather networks is highly required due to the correlation of water quality and temperature. This scenario also lets researchers to design various stacks of protocols so that sensor nodes can communicate each other easily. Furthermore, no global data center exists for various sensor applications. In early 2008, NASA proposed a water distribution Sensor Web solution [8] to monitor the quality of drinking water, which requires a specific hardware and thus, cannot be reused in others monitoring applications.

Thus, we design and implement a WSN-based water quality monitoring system. The contributions of the paper are follows.

- The monitoring framework uses Squidbee sensor motes [13] and pH sensors and can monitor water quality in real-time.
- This is an integrated framework from the network deployment to the application layer and can also be used in other monitoring applications.
- The framework integrates a simple but energy efficient sleep scheduling mechanism of sensor nodes which increases the network lifetime.

The remainder of the paper is organized as follow. Section III presents the background of designing a WSN-based water quality monitoring system with some related works. Section III presents the architecture and working principle of the proposed WSN-based water quality monitoring system. Section IV presents the experimental setup and results for the online water quality monitoring and also the simulation results of alternative sleep scheduling mechanism. Finally,

II. BACKGROUND

Section V summarizes the proposed work with some future since they have been used for many years. Thousands of people die world-wide every year especially in Africa due to the drinking of contaminated water. Even in Walkerton, Canada (2000) [6], seven people died and over 2,300 people were affected for drinking contaminated water by Escherichia coli. Similar incident occurred in North Battleford, Canada in 2004 [6] where, 7,000 people were affected. Thus, developing a real-time online monitoring system in water distribution is highly important to prevent the future Water-related diseases. A water supply system consists of the water source, water treatment, and water distribution system [6]. Existing water source and water treatment systems suffice to get purified water.

They cannot detect the dissolved contaminants such as

a WSN framework to determine the water quality and security in the water Industry [1]. They introduce a new communication protocol for in-situ WSN, which combines new methods for data mining and modeling. Like most of other monitoring projects, they neither consider the mechanism of reuse nor fully optimize the WSN. In [5], the authors present a similar WSN architecture for monitoring the leakage of water pipe. In the part of designing and deploying the WSN, both projects should have shared the same method to design the WSN or they could have shared the same WSN.

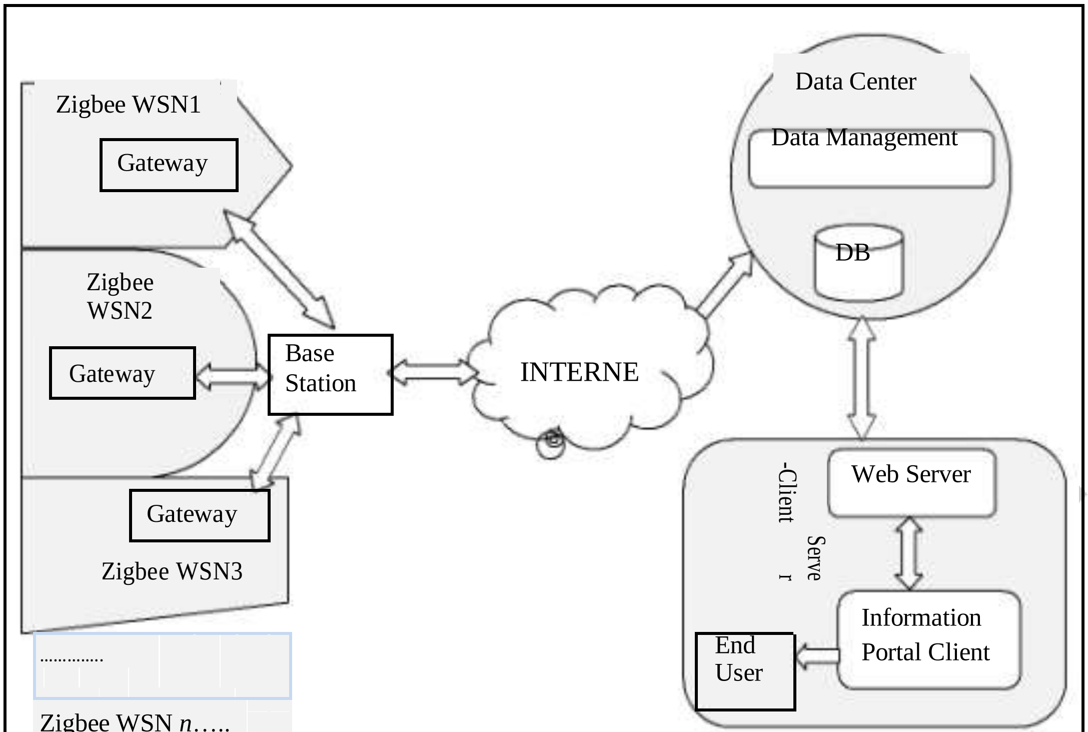

Figure 2: High Level Architecture

However, monitoring water quality in distribution system is the most important because the purified water flows to the distribution system that is directly connected to the human drinking water taps. Using traditional approaches of monitoring water quality in the water distribution system are not safe. Chlorinating in distribution system is usually used to protect microorganisms. However, drinking too much chlorinated water leads to Cancer and other diseases. Thus, chlorine is considered as another contaminant as well as pathogen and viruses. Moreover, there is no single instrument that can detect all the possible water parameters such as pH, turbidity, chlorine.

Laser technology is used to monitor water quality [6]. However, laser technologies only can monitor particles.

However, they did not share each other. From the sensor mote itself to the communication protocol, each part has to be redesigned from the scratch, even though both projects have the same monitoring environment. Therefore, the requirement to make the WSN solution reusable is necessary and important. Thus, we propose a reusable Wireless Sensor Network (WSN) architecture to achieve online monitoring in water distribution system, which can monitor the water quality easily, quickly and safely.

III. ARCHITECTURE

The proposed Wireless Sensor Network (WSN)-based water quality monitoring system, as shown in Figure 2, can be re-used in different monitoring systems while increasing the lifetime of WSN. The components of this framework are presented as follows.

Zigbee-based WSN

Each WSN consists a large number of Zigbee-based sensor motes to monitors a specific environmental area. Zigbee is a set of communication protocols using low power radio based on IEEE802.15 [10]. All sensor nodes in the WSN are open hardware based on ZigBee. That is, any parameter, such as temperature, humidity, light can be detected and sensed by the open sensor mote. Additionally, the alternate sleep mechanism is designed in the ZigBee protocol stack that alternately chooses only one sensor node instead of all sensor nodes working in a WSN to monitor a specified area. Thus, this sleep mechanism reduces the overall network energy consumptions.

Data Center

This component is the public data management center that archives and manages all sensors data for monitoring projects. The gateway collects the sensed data, processes and sends data to a base station that is connected to the Internet. Finally, all data is stored in a shared database where, they are classified by a global rule such as ontology so that data operations become easier. Gateway also registers and locks its own information on the data management component to prevent unauthorized users access because different types of users have different data access privilege.

Client-Server Component

Client-Server is a fixed reusable component, which includes Information Portal and Web Server. Information Portal is the Web Interface for end users that can be customized for different monitoring applications. An alarming function is integrated into the Web Server since it is highly required for most monitoring applications. The alarming function could be reused in different WSN-based monitoring applications. The Web Server works as the bridge between Client and Data Center. Its functionality includes retrieving information from the database, authorizing users to the database, alert notifications, and communicating with client.

IV. EXPERIMENTAL DESIGN

The water quality monitoring prototype is set up based on the proposed architecture presented in Section III. Experiments (both testbed and simulation) are performed to evaluate the performance of water WSN in terms of real-time (online) monitoring and network lifetime.

A. Experimental Setup

To implement the water quality monitoring prototype, the required hardware has to be setup and configured at the test place.

Sensor mote

Before deploying the WSN, the sensor mote has to be configured with proper sensors. Since the Squidbee sensor mote [13] does not have the pH sensors, the additional pH sensor has to be added. Once the new pH sensor is added to the Squidbee sensor mote, the mother board of the sensor mote has to be configured using the functions that are presented in Figure 3.

Sensor gateway

Squidbee sensor gateway is a plug-play hardware that also works as a base station when is connected to a computer. Communication parameter of sensor motes and gateway are set to the same value (e.g., speed is 9600 baud rate) to enable sensor nodes to communicate with the gateway. Besides the basic communication configurations, network parameters such as network identifier, node address, and destination node address are also configured.

B. Implementations of Water Monitoring Prototype

After configured, the WSN can automatically collect data when the sensor motes are powered on. All functions are implemented using C++ of Microsoft visual studio.

Collect and Process data

In the water WSN, the sensor gateway receives data automatically. However, the received data has to be processed to a proper format. Figure 3 illustrates the order of functions to implement the gateway.

```
CreateSerialPort
Set the parameter of serial port
whilethe event occurs do
   clearBuffer
   readSerialPort //receiving data processData //
   process the received data writeToDatabase //store
   the data locally sendDatatoServer //send data
   stream to Web server
end while
```

Figure 3: Implementation of the Gateway

Web Server

The most significant feature of the Web server is to automatically send alert messages. Since the WSN is connected to the Internet directly, the Web server could receive the data stream from the gateway. Therefore, once the alert component detects un-normal data, it sends emails to registered users. Figure 4 shows functions used to implement the alarming component.

```
Function isWrong //send alerts by
    email Read incoming data stream
    ifthe value is out of range then
        record this value
        send Email
    end if
```

Figure 5: Web Interface to all the users

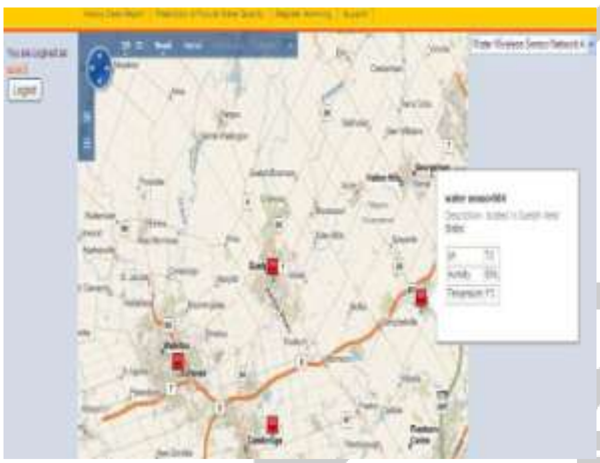

Figure 6: Online Monitoring based on the Microsoft Map

Information Portal

Information portal represents client in client-server architecture. There are three types of users in the client side: public people, registered users, and the administrator. For each type of users, the Information Portal is different. However, all users can access all public information of the online monitoring solution. Figure 5 illustrates the interface for all the users. Figure 6 demonstrates that the registered users have the necessary privilege to access and locate their WSN on the map, which is considered online monitoring. Additionally, the registered users can request alarming function via the Information Portal. Finally, the administrator having all privilege can retrieve data set for a certain time (Figure 7).

V. CONCLUSION

In this paper, we design and implement a WSN-based water quality monitoring system in testbed with an information portal and analternate sleep mechanism to prolong the network lifetime. The proposed framework can monitor the water quality in real-time andalso contains an alarming component that can quickly give a warning email in case any abnormal eventoccurs. Simulation results show that the lifetime of the proposed WSN framework with sleep scheduling mechanism is longer than the traditional WSN framework for water quality monitoring.

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VI. REFERENCES

[1] Anastasia Ailamaki, Christos Faloutsos, Paul S. Fischbeck, Mitchell J. Small, & Jeanne VanBriesen. *An environmental sensor network todetermine drinking water quality and security,* SCM SIGMOD Record,volume 32, Issue 4, Page 47-52. December 2003.

[2] I.F. Akyildiz, W.Su, Y. Sankarasubramaniam. *Wireless SensorNetworks: a survey*. Computer Networks, 2002, vol38, page 393-422.

[3] Marcin Brzozowski, Peter Langendoerfer. *On Prolonging SensornodeGateway Lifetime by Adapting its Duty Cycle*. IHP GmbH, Germany. 2005

[4] A. G. Davies, S. Chien, R. Wright, A. Miklius, P. R. Kyle, M. Welsh, J. B. Johnson, D. Tran, S. R. Schaffer & R. Sherwood. *Sensor Web EnablesRapid Response to Volcanic Activity*, Eos, Volume 87, No. 1. January 2006.

[5] Kevin A. Delin, Shannon P. Jackson, David W. Johnson. *EnvironmentalStudies with the Sensor Web: Principles and Practice.* Sensors vol 5,page103-117. 2005.

[6] Joao Gama & Mohamed Gaber. Learning from Data Streams, Springer. 2007.

[7] M. Ghazali& E. A. McBean. *Current Technologies for OnlineMonitoring of Quality of Water in Distribution Systems*, Workshop inUniversity of Guelph. 2008.

[8] Phillip B. Gibbons and Brad Karp. *IrisNet:An Architecture for aWorldwide Sensor Web*. IEEE ComSoc, 2003, vol. 3, pp. 22-33.

[9] Howard B. Glasgow, JoAnn M. Burkholder, Robert E. Reed. *Real-timeremote monitoring of water quality: a review of current applications, and advancements in sensor, telemetry, and computing technologies*. Journal ofExperimental Marine Biology and Ecology. 2004, Page 409-448.

[10] W.R. Heinzelman et al., *Energy-scalable algorithms and protocols forwireless sensor networks,* in: Proceedings of the International Conferenceon Acoustics, Speech, and Signal Processing (ICASSP Õ00), Istanbul, Turkey, June 2000.

[11]Steve H.L. Liang, ArieCroitoru, C. Vincent Tao. *A distributedgeospatial infrastructure for Sensor Web*. Computers and Geosciences,2005, vol-31, page 221-231.

[12] R. Min et al., *Low power wireless sensor networks*, in: Proceedings of International Conference on VLSI Design, Bangalore, India, January 2001.

[13] C. Schurgers, M.B. Srivastava, *Energy efficient routing in wirelesssensor networks*, MILCOM Proceedings on Communications for Network-Centric Operations: Creating the Information Force, McLean, VA, 2001.

[14] M. Younis, M. Youssef, K. Arisha, *Energy-aware routing in cluster-based sensor networks*, in: Proceedings of the 10th IEEE/ACMInternational Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication System, Fort Worth, TX, October 2002.