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S.J.I.T.N Saba Journal of Information Technology and Networking

Article

Evaluation –Based WSN For Groundwater Monitoring System

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Article info

Article history:

Accepted: Des. 2020

Keywords:

Blockchain;
Scrum;
Development process;
BScrum

Abstract

In the last decade, WSN used in various aspect of environmental conditions monitoring. due to Rise in the population, climate instability, and unregulated groundwater mining threaten the preservation of aquifers worldwide. Effective and data-driven control of groundwater supply is essential for sustaining critical water-dependent functions. Recently, the water crisis in Yemen has become a problem threatening the lives of many residents. This is due to the manager's lack of cost-effective, scalable, and reliable groundwater monitoring systems needed to gather vital groundwater data. In this study, we developed a fully automated real-time groundwater level system for data collection and visualization based on wireless sensor network (WSN). The study was applied in Taiz City, Yemen. The steps used to develop the system, including dividing the study area into different zones, and each zone uses a local base-station to collect the data from the sensors deployed in the same zone. All local base-station send the data to the master base station located remotely. The master bases station collects the data and sends it to the web-servers that are used to save and visualize the data permanently. The proposed system was designed and evaluated using the web design techniques and the system performance investigated based on network bandwidth and the sensors' power consumption.

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1. Introduction

Groundwater is the primary source of water for 80% of the population in Yemen, and it is the second source of water after surface water resources [1]. In recent times, the drought problem threatens the economic and agricultural lives of many of the society's residents. In coinciding with the scarcity of rainwater, the dramatic increase in population, and random urbanization, in addition to the complete absence of water management, groundwater consumption has become five times the annual recharge rate [2]. There is a complete absence in how to manage and allocate the use of groundwater, as it is used by 90% in the agricultural aspect. Groundwater management suffers from many difficulties, and the most notable of these is the access of work teams to well sites. Since they use traditional methods to collect data manually, the accuracy of measuring groundwater levels is inaccurate. Therefore, monitoring systems lose their functions and do not perform well. In addition to that, the expansion of drilling wells and the use of large depths reduce the quality of the groundwater and increase the cost required for pumping [3]. Using an automatic monitoring system for groundwater fields is the most important effective solution [4]; this was the motivation for designing a wireless remote sensing system to monitor these fields. It provides full knowledge of decision-making systems for making future strategic decisions and plans, such as laying pipes for drought-affected areas and the development of policies that organize groundwater management operations and reduces these crises [5].

Recently, Wireless sensor networks are widely used in all aspects of environmental monitoring applications, and environmental conditions variation as pressure, weather condition, temperature [6]. WSNs support the lowest duty cycle monitoring application [7] [8]. WSN consist of connected small electronic devices (sensors) uses to collect precision and real-time data at a different location [9]. The environment of water is considered as a factor that effects on the WSN to monitor and get the efficient points [10]. 6LoWPAN (IPV6-based low-power personal Area Network) is low-cost, reduced energy consumption defined by Internet Engineering Task Force (IETF) to enhance the WSN by adding TCP/IP implementation [11]. 6LoWPAN allows many wireless networks to connect with each other via the internet and offer IP communication by implementing a new layer. This layer is adaptation layer which implemented by routers at the edge of 6LoWPAN regions to represent the physical and MAC layer of this protocol to make compatibility the ipv6 packet with IEEE802.15.4 link [12][13].

This paper aims to design a real-time groundwater monitoring framework to help manage and reduce the loss of groundwater. The sensors node gathers some. of precision water's parameters as, PH, dissolved oxygen and so on. The proposed framework uses a web site to visualize the collected data.

2. Previous Studies

The development of groundwater monitoring systems took the interest of many researchers and conducted many studies. In [14], the system has been proposed to manage the changes in the water resources over time and offer long term groundwater level data. They used a data logger as a component to measure the water level and stored recorded data in the database. The system uses GIS to manage the data of water level and visualize the information to the user to understand the relation between borehole’s location and topographic. J. Wang et al. [15] proposed a water monitoring system based on

WSN with ZigBee protocol. ZigBee node uses GPRS/CDMA techniques to forward data to the base station. A set of fixed sensors were deployed in the study area to monitor a different kind of water parameters. In [16] they developed a system that depends on the context of electrical conductivity of water to measure the water level using water level sensor and Microcontroller, water level indicator. The water level was implemented on the tank to determine the state of the tank (i.e., empty or full) to control the pump operation. The main finding of this study is to investigate the idea of water management.

Another study in [17] implemented the cluster structure of wireless sensor networks in the department of the kingdom of Saudi Arabia to monitor the water quality of water resources. A vast number of sensors were deployed to collect the data, and the controller used to forward the data to the central unit. Real-time wireless monitoring and control of the water system using ZigBee 802.15.4 in [18] designed to monitor flood areas, reservoirs, rivers, and automated the operation of the pump. They use PH sensors, oxygen dissolved sensors to monitor water quality—the data sent from e node to the coordinator by the router through wireless technology. Many emerging technologies are used in this study such as: ZigBee, GSM and 74HC14 Hex Inverting Schmitt Trigger. In which the Schmitt used to reduce the cost of the system. GSM technology has been used to send data to user's phones from the flood area. This system implemented a testbed on water tanks. The proposed structure designed to automated the well's operation and monitor essential parameters of water quality, water level and EC by using WSN based on IEEE 802.15.4. It uses wireless sensors deployed at twenty-four wells of the agricultural area of Karbala, Iraq. The data movement in the network is controlled by the PAN coordinator. The operation of the pump is automatically controlled by the PAN coordinator decision. Collected data will be relayed to the main base station wirelessly. However, this system does not offer remote control [19]. Real-time groundwater level observation (GWO) application depends on WSN, programing language (R language), and an open-source framework in the South American Sub-basin of California.

They found pressure transducers sensor is more suitable for giving groundwater level time series data than manual water level meter measurement [20].

3. Methodology

The main structure of the proposed system is shown in Figure 1 it encompasses four main parts: study area, base stations (BS), web server, and end-users. The study area is divided into four different zones, and each zone uses a local base-station to collect the data from the sensors deployed in the same zone. All local base-station send the data to the master base station located remotely.

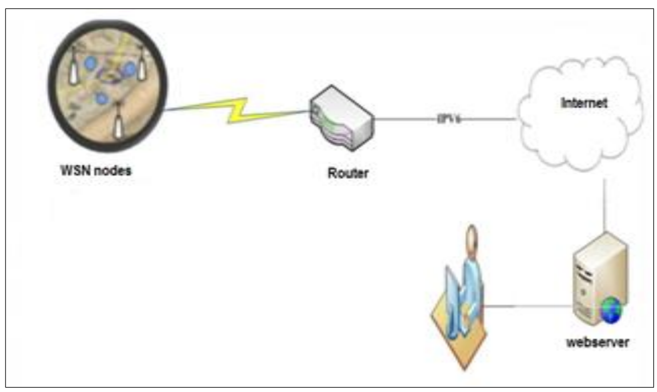

Figure 1. Groundwater Network Architecture

The master bases station collects the data and sends it to the web-servers that are used to save and visualize the data permanently. The data saved on the web-server based on a web-model developed to help reduce the traffic (see Figure

2). This model passes through three stages: safe, updating, and visualization, more details of these stages as follow:

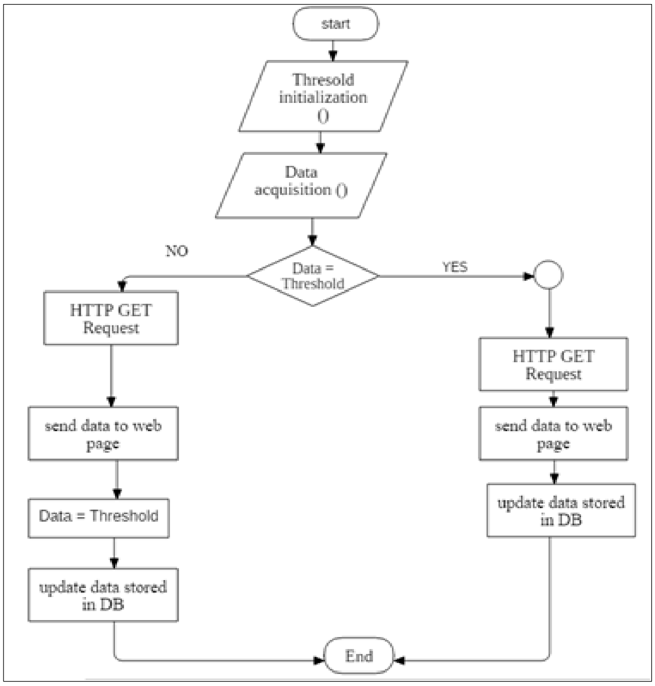

Figure 2. Flow chart of updating DB

3.1. Data safe

All data were collected from the study area, which considered well's data are stored in the SQL Database to be safe for a long time and visualize using web-application. The database consists of monitored well's characteristics as name, number, groundwater level and time and date of sensor reading.

3.2. Data updating

Because we are continuously collecting data in real-time, we need to keep the data updated in the databases. Figure 3. shows the algorithm used to update the data in the database. The updating process depends on the threshold value, which is the initial data collected from the field. The backup of data was considered to avoid indirect data loss caused by any unexpected malfunction in the network and the data saved in the SQL database on the cloud.

Data visualization

Once data stored, it visualizes to the end-users by using a web application (website), which is connected directly to the SQL database. Detail information about the well's area and level of groundwater visualize to end-users in real-time. It allows the users to interact with data and manage it in an efficient way anytime from anywhere.

4. Results

As mentioned previously, the proposed system was designed and simulated using the web design environment. Different experiments have been applied; the first experiment is to measure and evaluate the communication between the water level sensors deployed in the study field and the local base stations in each zone. The second experiment is to measure and assess the communication between local base-stations and the master base station that use to collect all packets and forward it to the web-server. The performance matrices used to evaluate the proposed system are the number of packets and the energy consumption of each sensor. Different communication technologies have been used to manage the connection between the sensors and the local base station, and the local and master base stations

Figure 3 indicates the main structure of the proposed system that shows the communication method of communication in different layers. The first layer, the communications between the sensors and the local base-stations, uses the ZigBee that allows for the packets to be transmitted for a few meters. The second layer, the communication between local and master local base-stations, and for this long-distance communication technology such as Lora or 3G used to transfer the packets. The third layer, the communication between the master base-station and the web-servers, the 6LOWPAN communication technology used for this part.

Last part, our application (website) is designed to save and visualize the data on the web server and to determine the change in well field storage. from the page in Figure 4 the end user can be accessed to the characteristics of the wells by selecting the well name based on choosing Isolation, Directorate and owner.

When desired well selected Figure 5 shows such an example from the website; in this result, the data collected from the study filed are presented with a full description of the data such as location, date, depth of wells, etc.

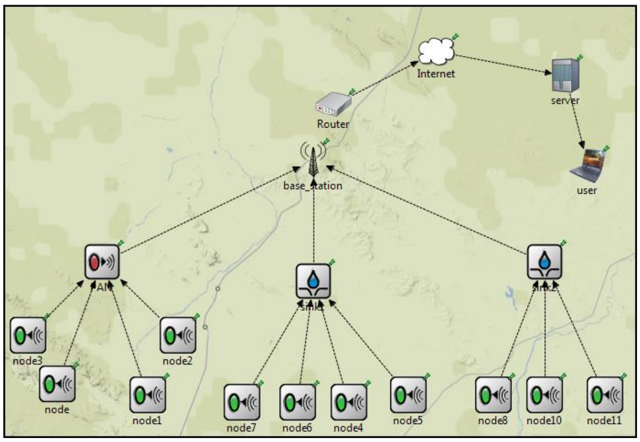

Figure 3. present a snapshot to the structure of framework designed

Report on the wells in the province of Taiz

Directorate name	Isolation name	Village / Valley	Well number	Owner name	Type of well	Currently Available Water	Well condition	Depth of well	Width of well	Warning level	Date of registration
Mountains Habashee	Hathran	The fog	1	Yosof	Tubular	2562	Work	1114	2	5	2020-05-22
Mountains Habashee	Hathran	The fog	2	Corporation	Tubular	65111	Work	1104	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	3	Ghee factory	Tubular	25773	Work	1067	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	4	Grop Haul	Tubular	109423	Work	1082	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	5	General authority	Tubular	77872	Work	1148	10	3	2020-05-22
Sala	AA	Hogla	6	Ahmed	Tubular	84001	Work	1410	8	2	2020-06-22
Sala	AA	Hogla	7	Adalluh	Tubular	47100	Work	1130	10	3	2020-06-22
Sala	AA	Hogla	8	Mohmad	Tubular	44619	Work	1200	7	3	2020-06-22
Sala	AA	Hogla	9	Reayidh	Tubular	22608	Work	1100	6	4	2020-06-22
Sala	AA	Hogla	10	Saeed	Tubular	3077	Work	900	7	3	2020-06-22
Saber	bb	Saber	11	Tamer	Tubular	38151	Work	1020	9	3	2020-06-22
Saber	bb	Saber	12	Sadam	Tubular	18840	Work	1030	10	3	2020-06-22
Saber	bb	Saber	13	Name	Tubular	1385	Close	950	7	2	2020-06-22
Saber	bb	Saber	14	Adrees	Tubular	9385	Work	1000	7	3	2020-06-22
Saber	bb	Saber	15	Mosaa	Tubular	21540	Work	1050	7	2	2020-06-22

Figure. Main page of well's report.

Repoting Of State Well

Name of Directorate	Name of Isolation	Wadey	Name Holder	Depth Well	Width Well	Date Insert	State Well	Count the Water of m3	Ratio Presser	Date Reading
Mountains Habashee	Baney Jesus	Althbab	Mohamad	1000	2	2020-04-09	Work	735	44	2020-04-09
Mountains Habashee	Baney Jesus	Althbab	Saeed	1200	1	2020-04-10	Work	351	44	2020-04-09
Mountains Habashee	Baney Jesus	Althbab	Ahmed	800	1	2020-04-28	Work	561	44	2020-04-09
Mountains Habashee	Baney Jesus	Althbab	Mohamad	1000	2	2020-04-09	Work	656	44	2020-04-09
Mountains Habashee	Baney Jesus	Althbab	Saeed	1200	1	2020-04-10	Work	752	44	2020-04-09
Mountains Habashee	Baney Jesus	Althbab	Ahmed	800	1	2020-04-28	Close	960	44	2020-04-09

Figure 5. Report of well's data.

Figure 6 represents the important well's data which updated automatically (see Figure 2) in real time by the data collected by the sensors deployed in the study area.

Directorate name	Isolation name	Village / Valley	Well number	Owner name	Type of well	Currently Available Water	Well condition	Depth of well	Width of well	Warning level	Date of registration
Mountains Habashee	Hathran	The fog	1	Yosof	Tubular	2562	Work	1114	2	5	2020-05-22
Mountains Habashee	Hathran	The fog	2	Corporation	Tubular	65111	Work	1104	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	3	Ghee factory	Tubular	25773	Work	1067	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	4	Grop Haul	Tubular	109423	Work	1082	12	3	2020-05-22
Mountains Habashee	Hathran	The fog	5	General authority	Tubular	77872	Work	1148	10	3	2020-05-22
Sala	AA	Hogla	6	Ahmed	Tubular	84001	Work	1410	8	2	2020-06-22
Sala	AA	Hogla	7	Adalluh	Tubular	47100	Work	1130	10	3	2020-06-22
Sala	AA	Hogla	8	Mohmad	Tubular	44619	Work	1200	7	3	2020-06-22
Sala	AA	Hogla	9	Reayidh	Tubular	22608	Work	1100	6	4	2020-06-22
Sala	AA	Hogla	10	Saeed	Tubular	3077	Work	900	7	3	2020-06-22
Saber	bb	Saber	11	Tamer	Tubular	38151	Work	1020	9	3	2020-06-22
Saber	bb	Saber	12	Sadam	Tubular	18840	Work	1030	10	3	2020-06-22
Saber	bb	Saber	13	Name	Tubular	1385	Close	950	7	2	2020-06-22
Saber	bb	Saber	14	Adrees	Tubular	9385	Work	1000	7	3	2020-06-22
Saber	bb	Saber	15	Mosaa	Tubular	21540	Work	1050	7	2	2020-06-22

Figure 6. Evaluation of well's data.

The monitoring groundwater level has been applied in various period of time (week, month, etc.) to investigate real time data. Figure 7 shows the variation of groundwater level of desired field over time (summer recharge and winter drawdown).

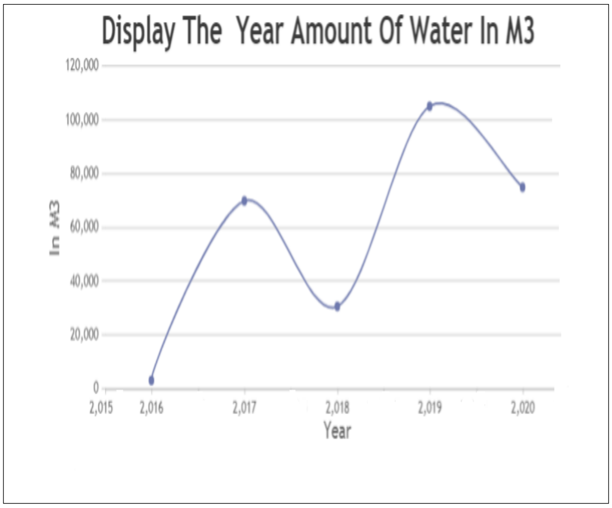

Figure 7. year result of water level.

The current amount of water in the considered zone of individual well as gathering from sensors. Figure 8 indicates the sensors' readings of current amount of water.

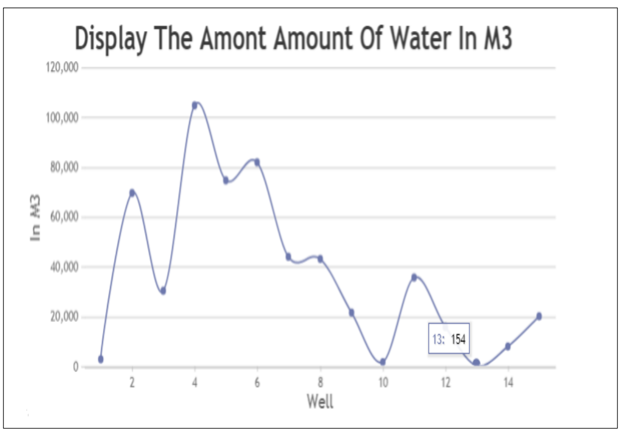

Figure 8. Current amount of water of one zone.

5. Conclusion

In this study, a groundwater level monitoring system is proposed based on a wireless sensor network. The sensors are deployed in the study area to monitor the water level in the individual well. The data collected and send wirelessly to be store and visualize in the cloud. Different performance metrics used to investigate and evaluate the performance of the proposed system, such as and increase the system efficiency such as: environment of web techniques and using the SQL server to build the database. Results show the distribution of data collected from individual well of different zones, and its visualize to end user in real time.

6. References

[1] Q. Y. A. Al-Asbahi, "Water resources information in Yemen," United Nations Intersecretariat Working Group on Environment Statistics (IWG-ENV), International Work Session on Water Statistics, Vienna (June 20-22), available at: http://unstats. un. org/unsd/environment/envpdf/pap_wasess3a3yemen. pdf, 2005.

[2] T. M. Taher, "Groundwater abstraction management in Sana’a Basin, Yemen: a local community approach," Hydrogeology Journal, vol. 24, pp. 1593-1605, 2016.

[3] C. Ward, The water crisis in Yemen: Managing extreme water scarcity in the Middle East: Bloomsbury Publishing, 2014.

[4] S. Moore and J. B. Fisher, "Challenges and opportunities in GRACE-based groundwater storage assessment and management: an example from Yemen," Water resources management, vol. 26, pp. 1425-1453, 2012.

[5] G. Pau and V. M. Salerno, "Wireless sensor networks for smart homes: A fuzzy-based solution for an energy-effective duty cycle," Electronics, vol. 8, p. 131, 2019.

[6] T. R. Sheltami, E. Q. Shahra, and E. M. Shakshuki, "Fog computing: Data streaming services for mobile end-users," Procedia computer science, vol. 134, pp. 289-296, 2018.

[7] N. Azmi, L. Kamarudin, M. Mahmuddin, A. Zakaria, A. Shakaff, S. Khatun, et al., "Interference issues and mitigation method in WSN 2.4 GHz ISM band: A survey," in 2014

2nd International Conference on Electronic Design (ICED), 2014, pp. 403-408.
[8] B. M. Al-Madani and E. Q. Shahra, "An energy aware plateform for iot indoor tracking based on rtps," Procedia computer science, vol. 130, pp. 188-195, 2018.
[9] D. Chandrasekar, Y. Srinivas, and N. Chandrasekar, "The Application Of Wireless Sensor Network In Ground Water Table Monitoring In The Placer Mineral Mining Areas," International Journal of Advanced Research in Computer Science, vol. 1, 2010.
[10] A. Alkandari, Y. Alabduljader, and S. M. Moein, "Water monitoring system using Wireless Sensor Network (WSN): Case study of Kuwait beaches," in 2012 Second International Conference on Digital Information Processing and Communications (ICDIPC), 2012, pp. 10-15.
[11] A. Y. Barnawi, G. A. Mohsen, and E. Q. Shahra, "Performance analysis of rpl protocol for data gathering applications in wireless sensor networks," Procedia Computer Science, vol. 151, pp. 185-193, 2019.
[12] B. Kampfer and T. Haspl, "ZigBee vs. 6LoWPAN," Architecture, vol. 3, p. 7, 2020.
[13] I. A. ISMAILI, A. Azyat, N. Raissouni, N. B. Achhab, A. Chahboun, and M. Lahraoua, "Comparative study of ZigBee and 6LoWPAN protocols," in Third International Conference on Computing and Wireless Communication Systems, ICCWCS 2019, 2019.
[14] H. Nazran and H. C. K. Ahmad, "Groundwater Level Monitoring using Levelogger and the Importance of Long-Term Groundwater Level Data."
[15] J. Wang, X.-l. Ren, Y.-l. Shen, and S.-y. Liu, "A remote wireless sensor networks for water quality monitoring," in 2010 International Conference on Innovative Computing and Communication and 2010 Asia-Pacific Conference on Information Technology and Ocean Engineering, 2010, pp. 7-12.
[16] S. K. Reza, S. A. M. Tariq, and S. M. Reza, "Microcontroller based automated water level sensing and controlling: design and implementation issue," in Proceedings of the world congress on engineering and computer science, 2010, pp. 20-22.
[17] E. Aleisa, "Wireless Sensor Networks Framework for Water Resource Management that Supports QoS in the Kingdom of Saudi Arabia," in ANT/SEIT, 2013, pp. 232-239.
[18] S. Maqbool and N. Chandra, "Real time wireless monitoring and control of water systems using ZigBee 802.15. 4," in 2013 5th International Conference and Computational Intelligence and Communication Networks, 2013, pp. 150-155.
[19] A. Q. Rahima, H. A. Tarish, and N. Sapih, "Monitoring and Control System by Using Wireless Sensor Network for Ground water Well’s Field in South of Iraq," 2018.
[20] A. J. Calderwood, R. A. Pauloo, A. M. Yoder, and G. E. Fogg, "Low-Cost, Open Source Wireless Sensor Network for Real-Time, Scalable Groundwater Monitoring," Water, vol. 12, p. 1066, 2020.