Monitoring and Control System by Using Wireless Sensor Network for Ground water Well's Field in South of Iraq

Alaa. Qassim Rahima, Hiba. A. Tarish, Narjis. Sapih
Civil Engineering Department, University of Technology, Baghdad, Iraq

ABSTRACT

Recently, the using of wireless sensor network as the most important technique necessary according different application, such as water resources conditions for living in safe. This is due to the shortage in groundwater, river resources and rain level. This project design a structure of complete wireless sensor network structure to monitor the different water levels and verity water quality according to water well-field and the consumed electrical power of the installed pump. The utilized sensors use the energy saving techniques and allocate the controller sensor to work as a PAN coordinator. The designed structure has been implemented and tested using SQL,GUI under the environment of visual studio C#. The obtained results from the simulator appear the efficient of the system in monitoring the wells factors.

Keywords : Wireless Sensor Network, Wells Field, SQL, Visual Studio C#, GUI.

I. INTRODUCTION

Water is one of nature's most valuable resource and fresh water supplies are pushed to the brink of non-renewability by the growing demands on them, [1]. Groundwater resource management is an important issue, especially with regard to agricultural potential [2]. Therefore, it is essential to presents a monitoring system for groundwater wells using wireless sensors and preparation of the control system that has updated information. This is to monitor the critical parameter that affects the groundwater, such as wells water level, EC, consumed power, providing a mechanism to build pumps operation system. For minimizing the consumed operation power and supplying the required water demand.

In [3], groundwater monitoring system has been proposed using wireless pressure sensor network. This is to offer an access to the ground water information by researcher. In [4] authors proposed an irrigation management system based on ZigBee technology. The study showed the suitability of ZigBee for precision agriculture due to its low power consumption, cost and data rate of operation which meet Precision Agriculture (PA) requirements. In [5], real-time monitoring system of groundwater in Korea has been proposed as a mini- review. This is to introduce a continues monitoring of the current status of the ground water networks that can be works in Korea in which some suggestions were presented to enhance the situation of current control and decision making in Korea ground water.

In this paper, a model of wireless sensor network structure is proposed to monitor the essential parameters in the water field of a considered site in Karbala, Iraq. In this structure, a PAN coordinator nodes have been used to control the data flow between the sensor nodes to reduce the periodic time in this network.

II. METHODS AND MATERIAL

The Description of the proposed system

In this section, the proposed system is explained in sub-section to ease the reading influence:

2.1 Structure of Wireless Sensor Network (WSN)

WSN uses the IEEE 802 .15.4 network standard for PAN's nodes. In addition, the physical layer adopts to operating in 2.4 GHZ rate of data, it's the limitation band low data rates are suitable for environmental monitoring application like agriculture [6]. Based on the network structure, the WSN can be classify as flat (data centric), hierarchical (cluster-based) and location based (geographical) protocols. These protocols can minimize the total of message passing in efficient way [7] and [8]. The star topology is the best choice for the irrigation applications as it is suitable to small networks in low density of nodes deployment [9]

The model of proposed system is shown in Figure (1). It explains the distribution of wells amongst the groundwater field. In addition, the pipes as well as the pumps on these well. The data is transmitted to the control station in wireless techniques throughout the sink (PAN) nodes. The sensor nodes are classified into the following: the main controller node in this network is PAN coordinator, the (FFDs) node supports the data movement and routing by connecting verity type of networks constriction then forwarding the received messages from the end node until reaching the PAN coordinator. Every node receives a massages coming from all wells in the farm for more processing. In order to manage the traffic model, the network can be classified into: proactive (time-driven model), reactive (exception-driven model), and hybrid network .The sensor nodes in the proactive network [10] and [11]. The hybrid network is efficient in agricultural application due to limited time and fast response to the environmental changes provided from the value of the parameters of sensor [12]. Table I

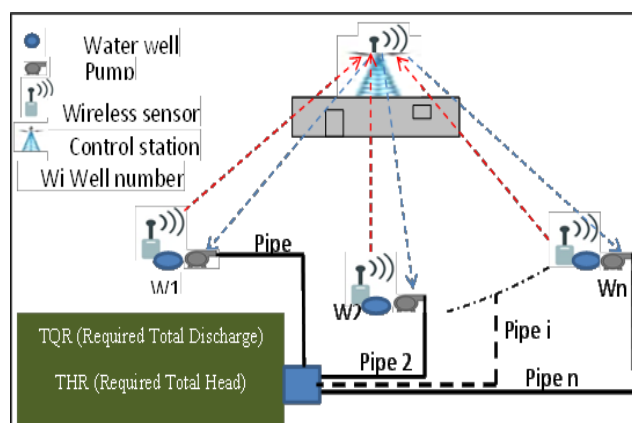shows the important parameters of the utilized sensor network [6].

Figure 1. Structure of WSN based model for well-field operation

III. RESULTS AND DISCUSSION

3.1 Groundwater Well- Field

According to agriculture applications, there is a limited distance between the considered nodes [12]. Therefore, the distance between the nodes in the designed structure is reduced to minimum in which the system works efficiently. In proposed system, three farms (A,B, and C) with complete area of 1000 Dunam.The field includes 24 sensor nodes distributed over 24 wells. These wells are distributed into (4) wells in farm A. 16 wells in farm B and (4) wells in C.

3.1 Simulated Results

As highlighted previously, the proposed system has been designed in visual studio C# environment in addition to build the database for storing the considered information using SQL server software. The designed GUIs of the proposed system are introduced to simulate the real life of the wells working and to ease the using of it by unskilled users. Figure (2) shows the main interface GUI that provides the user with easy method of implementing the guided procedure.

A database contains the well-field characteristics and the farm irrigation requirements are conducted and linked with the control system as an input files. The well-field characteristics file includes number of wells and well names, well discharge (Q), Pipe length (L), Pipe diameter (D), pump discharge (Qw) and pump efficiency constants (A, B, and C). While the farm irrigation requirements includes the daily required total discharge (TQR) and the total required head (THR) at the farm, such as these listed in Appendix A. in this study, to simplify the application and evaluation of proposed control system the TQR inputted manually as single value for one day. Whereas, in real application of the system it can be inputted as a database file.

The Drawdown in well (HS), EC and actual consumed power (Pact) sensors reading data are directly transmitted and inputted to the system as mentioned in section 4-2. Also, the threshold values of the alarm system (EC threshold, Day threshold are manually inputted. This enables the decision maker to change these values for inclusion or exclusion the alarmed wells from the turn-on or turn-off of criteria

Figure 2. The the main GUI fram

From this figure, the top right side includes the fields of required information that contains(Farm selection, Q Total: total required discharge of the selected farm, EC Threshold: allowable electrical conductivity of water in the considered wells, Days Threshold: the allowable number of well turnoff days, Tolerance:

difference between the actual power according to sensor readings and the computed power value.

Evaluation of Farm A: Farm A includes four wells each one includes three sensors to measure drawdown in well (HS), EC and actual consumed power (Pact). Table (4.3) shows the received sensors' readings at the control center that have been stored in the built database. This table represents the stored sensors' readings and related information of the adopted wells of Farm A.

Where Q: well discharge, L: pipe length, D: pipe dimeter, (A, B and C) are constant values used for evaluating the pump efficiency, HS: sensor reading of drawdown in well, EC: sensor reading of electrical conductivity, Pact: sensor reading of consumed power of pump It is important to note that the Pact is considered as zeros for turning on the power alarm of wells in testing case.

It is important to note that the EP: power efficiency, Pfinal: consumed power, TH: total head loss and HL: head loss of each well
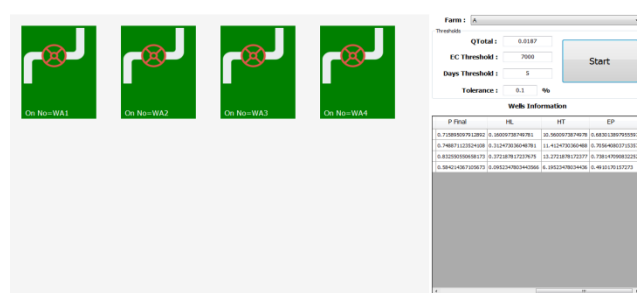
FARM A: Scenario 1

Figure 3. GUI of first scenario / Farm A.

Table 1. well- information in Farm A

WELL NAME	Well-field characteristics						Sensor reading		
	QW	L	D	A	B	C	HS	EC	Pact
W1	0.00472	311	1.5	-0.3343	10	-0.0199	10.4	6350	0
W2	0.00472	607	1.5	-0.3343	10	-0.0199	11.1	6230	0
W3	0.00472	723	1.5	-0.3343	10	-0.0199	12.9	6490	0
W4	0.00472	185	1.5	-0.3343	10	-0.0199	6.1	6280	0

Table 2. obtained results of first scenario / Farm A

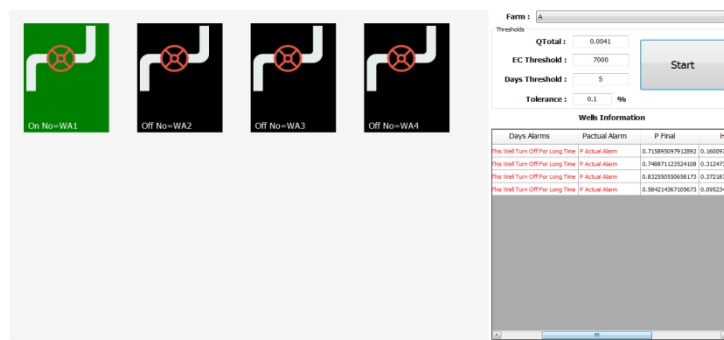| Well Name	EC Alarm	Days Alarms	Pact Alarms	Pfinal	HL	HT	EP	Operation
WA1	CLEAR	This well turn off for long time	Pactual Alarm	0.7158	0.1600	10.5600	0.6830	On
WA2	CLEAR	This well turn off for long time	Pactual Alarm	0.7488	0.3124	11.4124	0.7056	On
WA3	CLEAR	This well turn off for long time	Pactual Alarm	0.8325	0.3721	13.2721	0.7381	On
WA4	CLEAR	This well turn off for long time	Pactual Alarm	0.5842	0.0952	6.1952	0.4910	On

FARM A : Scenario 2

Figure 4. GUI of second scenario / Farm A.

Table 3. obtained results of second scenario / Farm A.

Well Name	EC Alarm	Days Alarms	Pactual Alarms	Pfinal	HL	HT	EP	Operation
WA1	CLEAR	This well turn off	P Actual	0.7158	0.1600	10.5600	0.6830	Off

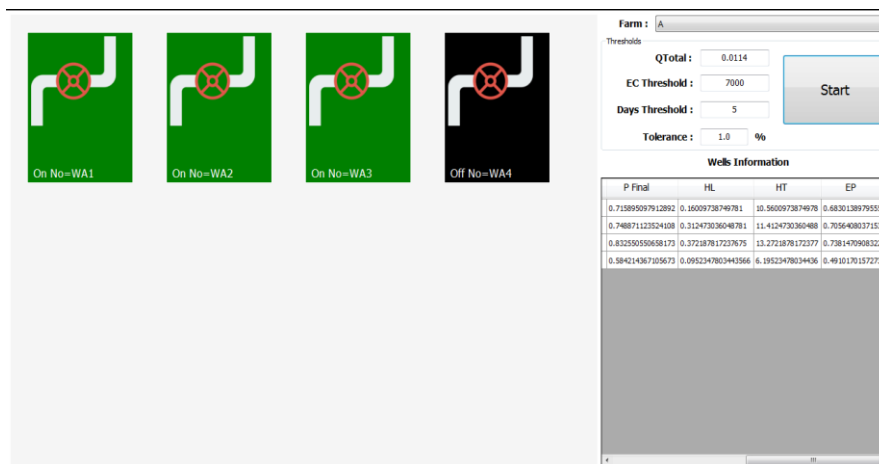|		for long time	Alarm					
WA2	CLEAR	This well turn off for long time	P Actual Alarm	0.7488	0.3124	11.4124	0.7056	Off
WA3	CLEAR	This well turn off for long time	P Actual Alarm	0.8325	0.3721	13.2721	0.7381	Off
WA4	CLEAR	This well turn off for long time	P Actual Alarm	0.5842	0.0952	6.1952	0.4910	On

FARM A: Scenario 3

Figure 5. GUI of third scenario / Farm A

Table 4. obtained results of third scenario / Farm A.

Well Name	EC Alarm	Days Alarms	Pactual Alarms	Pfinal	HL	HT	EP	Operation
WA1	CLEAR	This well turn off for long time	Pactual Alarm	0.7158	0.1600	10.5600	0.6830	On
WA2	CLEAR	This well turn off for long time	Pactual Alarm	0.7488	0.3124	11.4124	0.7056	On
WA3	CLEAR	This well turn off for long	Pactual Alarm	0.8325	0.3721	13.2721	0.7381	Off

		time						
WA4	CLEAR	This well turn off for long time	Pactual Alarm	0.5842	0.0952	6.1952	0.4910	On

Evaluation of Farm B

In Farm B, sixteen wells have been considered. The received sensors' readings and the related important information are saved in the built database as shown in Table (4.7). Moreover, the adopted parameters are the same as in Farm A. Three scenarios are chosen to test the system on Farm B.
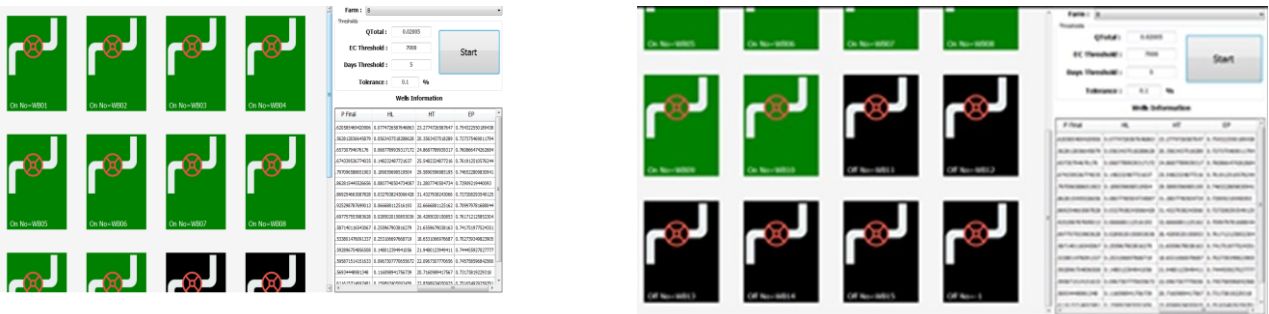

Figure 6. Resulting GUI of third scenario / Farm B.

Table 5. obtained results of third scenario / Farm B

Well Name	EC Alarms	Days Alarms	Pactual Alarm	Pfinal	HL	HT	EP	Operation
WB1	CLEAR	This well turn off for long time	Pactual Alarm	0.6205	0.0774	23.2774	0.7543	On
WB2	CLEAR	This well turn off for long time	Pactual Alarm	0.5628	0.0563	20.3563	0.7273	On
WB3	CLEAR	This well turn off for long time	Pactual Alarm	0.6573	0.0687	24.8687	0.7608	On
WB4	CLEAR	This well turn off for long time	Pactual Alarm	0.6743	0.1482	25.5482	0.7639	Off
WB5	CLEAR	This well turn off for long time	Pactual Alarm	0.7970	0.1890	29.5890	0.7465	Off
WB6	CLEAR	This well turn off for long time	Pactual Alarm	0.6828	0.0807	31.2807	0.7290	Off
WB7	CLEAR	This well turn off for long time	Pactual Alarm	0.6892	0.0327	31.4327	0.7272	On
WB8	CLEAR	This well turn off for long time	Pactual Alarm	0.9252	0.0666	32.6666	0.7099	Off
WB9	CLEAR	This well turn off for long time	Pactual Alarm	0.6977	0.0285	26.2485	0.7617	Off
WB10	CLEAR	This well turn off for long time	Pactual Alarm	0.5871	0.2559	21.6559	0.7417	On
WB11	CLEAR	This well turn off for long time	Pactual Alarm	0.5338	0.2531	18.6531	0.7027	On
WB12	CLEAR	This well turn off for long time	Pactual Alarm	0.5928	0.1480	21.9480	0.7444	On
WB13	CLEAR	This well turn off for long time	Pactual Alarm	0.5958	0.0967	22.0967	0.7457	On
WB14	CLEAR	This well turn off	Pactual	0.5693	0.1160	20.7160	0.7317	On

		for long time	Alarm					
WB15	CLEAR	This well turn off for long time	Pactual Alarm	0.6116	0.1598	22.8598	0.7516	On
WB16	CLEAR	This well turn off for long time	Pactual Alarm	0.784	0.1798	23.8598	0.7716	Off

IV.CONCLUSION

A designed wireless sensor network structure has been proposed. This sensors are distributed amongst the well-Fileds in agricultural site; Karbala city, Iraq. The structure monitored the important parameters of each well individually and then collected the overall data

for processing and decision making. A complete analysis is provided for the sensor nodes in terms of power consumption and other factors. Comparison results of the manually selected optimal well-field operation scenarios for the considered farms, listed in Appendix B, with these of the proposed control system, mentioned in Section 4.3, appeared complete similar. This approves the accuracy of the proposed control system in selection of the optimal operation scenario. Generally, the automation of the traditional system provides it with efficiency in terms of accuracy, consumed time and cost. The proposed system tackles the problems of manual management of ground water well field by introducing automated WSN based system. These problems can include labors, operation cost, consumed time, consumed power, and accuracy. In the proposed system, modern software environments are used including C# for designing the GUI frames and SQL server for building the considered database. These software environments provide the system with more flexibility and reality that can support the performance efficiency in computing the required parameters. The proposed system reduces the number of employed labor, the consumed power in addition to provide the farms with enough irrigation water with specific scheduling in accurate begins and ends.

V. REFERENCES

[1]. David Tood , Larry W.Mays, GroundWater Hydrology , third Edition.

[2]. Jassas H. and Merkel B., "Estimating Groundwater Recharge in the Semiarid Al-Khazir Gomal Basin, North Iraq", Water Journal, Vol. 6(8), pp. 2467-2481. (2014)

[3]. Srikanth Anumalla , and David C. Gosselin , "Ground Water Monitoring using Smart Sensors" IEEE International Conference on Electro Information Technology, 2005.

[4]. M. Mafuta, M. Zennaro, A. Bagula, G. Ault, H. Gombachika and T. Chadza, "Successful Deployment of a Wireless Sensor Network for Precision Agriculture in Malawi", International Journal of Distributed Sensor Networks, Vol.2013, PP.1-13, 2013

[5]. Jin-Yong Lee , and Kideok D. Kwon, "Current Status of Groundwater Monitoring Networks in Korea "article ,water http://creativecommons.org/licenses/by/4.0/2016. 66]M. Popa, O. Prostean and A.S. Popa, "A Classification of Solutions for the Energy Limitation in Wireless Sensor Networks", IEEE 9th International Conference on Computational Cybernetics, PP.293-297, 2013.

[6]. P. Tyagi and S. Jain, "Comparative Study of Routing Protocols in Wireless Sensor Network", International Journal of Advanced Research in Computer Science and Software Engineering, Vol.2, No.9, PP.134-140, 2012.

[7]. S. Ahirwar and P. Tanwar, "A Review of Power Optimization Strategies in Wireless Sensor Network", International Journal of Emerging Technology and Advanced Engineering (IJETAE), Vol.3, No.10, PP.212-218, 2013.

[8]. P. Jurmk, "Real-time Communication over Cluster-tree Wireless Sensor Networks", Ph.D. thesis, Czech Technical University in Prague, 2010.

[9]. K. Kondaiah, R.B. Babu and S. Umar, "A Study on Routing Protocols in Wireless Sensor

Networks", International Journal of Computer Science Engineering and Technology (IJCSET), Vol.3, No.3, PP.94-98, 2013.

[10]. S. E. Díaz, J. C. Perez, A. C. Mateos, M.-C. Marinescu, and B. B. Guerra, Computers and Electronics in Agriculture 76, 252 (2011).

[11]. S. M. Abd El-kader and B. M. M. El-Basioni, "Precision farming solution in Egypt using the wireless sensor network technology", Egyptian Informatics Journal, Vol.14, No.3, PP.221-233, 2013.

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