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WATER PIPELINE MONITORING AND LEAK DETECTION USING SOIL MOISTURE SENSORS: IOT-BASED SOLUTION

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***Abstract*—**One of the main concerns in the water management field are the leakage detection and location of water pipes. In recent years, Water Pipeline Monitoring (WPM) has attracted attention worldwide due to the necessity to minimize water production costs as well as to protect public safety. Therefore, a great deal of research work has tried to propose approach to water leak detection. In this paper, we propose a novel solution based on soil moisture sensors and Arduino MEGA as a microcontroller. Varieties of different leak scenarios were performed during the experimental trials and leaks in different places were examined. The results show that the proposed solution is able to work stably to detect and locate the leak.

***Keywords*—**IoT, moisture sensor, water pipeline monitoring, real experiences.

I.INTRODUCTION

Today, smart grids, smart homes, smart water networks and intelligent transportation are infrastructure systems that make our world more connected. Based on several type of sensors the totality of the physical infrastructure is firmly combined with information and communication technologies. The main concept is the internet of things. The main motivation of IoT is to make things or objects around us connected through internet, so that they can automatically share information. Many technologies appear. Radio Frequency Identification (RFID) tags, mobile phones, sensors, actuators, embedded systems and nano-technology help things to communicate together via distributed sensor networks[1]. Wireless sensor network (WSN) are composed of sensor nodes to detect physical phenomena such as light, heat, pressure, etc. These sensors are small, with limited processing and computational resources. In addition, the nodes are autonomous and operate with limited power sources (batteries) and dialogue among them to route information to a

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control unit. WSNs are regarded as a revolutionary information gathering method to build communication system. It greatly improves the reliability and efficiency of infrastructure systems [1]. In recent years, compared to the wired solution, WSNs feature easier deployment and better flexibility of devices. With the rapid technological development of sensors, WSNs will become the key technology for IoT. After formation of these networks, they can be deployed in many interesting applications from various fields, like military, medical, environmental, control of production processes, monitoring of critical infrastructure and observing human activity [2]. In this paper, our target application is water pipeline monitoring. Indeed, water has an essential and a critical role in the life of human beings. Huge pipeline infrastructures are required to ensure the efficient transportation of water. The fact that most countries depend on water resources is a thing of interest. Therefore, small, low power and low-cost sensor devices are applied in the water pipelines to protect them from many damages, in particular the loss by leakage. We focus on detection of leaks in water pipeline. In water distribution networks, a large proportion of the water is usually lost during transport between the sources and the consumption points. The missing volume, which is generally very high, is mainly due to the occasioned leaks. Water leaks cause a waste of money and a risk to valuable natural resource and are perilous to public health. IoT has emerged as an effective solution for water pipeline monitoring. In fact, IoT are designed to provide a remote service to monitor and report the current state inside and outside the pipeline at real time. This paper presents the design, development and testing of an IoT solution for leak detection in water pipelines, based on the measurement of moisture sensor changes in pipes. A novel moisture sensing method is investigated for its performance and capabilities by both laboratory and field trials. The sensors were capable of measuring moisture changes due to leaks. These moisture profiles can also be used to locate the leaks. The remainder of the paper is organized as follows. Section II provides the proposed solution. Section III describes experiences and scenarios applications followed by conclusions in Section VI.

II.LITERATURE SURVEY

water pipeline monitoring and detection in water pipes have been conducted before. Reference [2] conducted a research in monitoring the level of water flow, by

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utilizing web services and Zigbee as a communication device as well as some sensors such as level sensors, water flow sensors, and temperature sensor. In addition to web monitoring, the owner of the sensor can also get important information about the flow of water via SMS to a personal mobile phone number of the owner. Reference [3] was conducted to detect leakage of water pipeline. The research investigated the impact of various pipe diameter on pressure of the water flow in the pipes and the temperature changes around the pipe. FSR sensor is used to measure changes in the pipe diameter, and temperature sensors are used to measure the temperature around the pipe. In this research, they used 40 mm diameter PVC pipe with a constant pressure of 3 bar. The other work in Reference [4] analysed vibration in the pipe wall caused by collisions between the water flows to the pipe wall. Vibration is measured using an MEMS sensor. Leakage is analyzed by comparing the vibration of the normal water flow and the vibration when there is a leak in the pipe. Tests are conducted by varying the pressure from 3 to 10 bar with a constant water flow rate of 300 m3 /hr. A research that compared the consumption savings of tap water using wireless sensor network has been conducted in Reference [5]. This research uses Rfbee sensors to gather data received from the water flow rate transducer, as a sender and a recipient of the data. Data collected by Rfbee sensors will be transmitted by wireless network to a computer connected directly to the sensor Rfbee. A research to monitor and control the water flow through a web server is carried out in Reference [1]. Monitoring and controlling is done by using Hall Effect Flow Sensors, Arduino, Raspberry PI, and Solenoid Electro Valve. Hall Effect Flow Sensor with Arduino will measure fluid flow, while Raspberry PI will control solenoid electro valve, which is used to close or to open the flow of fluid through the pipe.

III.PROPOSED SYSTEM

We developped an IoT architecture applying various sensors nodes and smart devices that can be easily connected. In fact, using the IoT concept, with sensors, and embedded systems provide smart management and monitoring. All the devices of the dynamic system are interconnected. Indeed, the transmission of useful measurement information as well as the control instructions is ensured. It includes several requirements that should be achieved [3]. The IoT architecture based solution is presented in fig1 below.

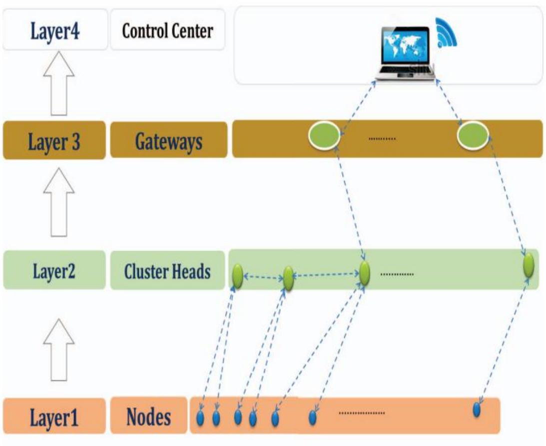

Fig. 1. IoT architecture based solution

The proposed solution is based on a hierarchical model.We use different types of sensor nodes such as normal sensor nodes connected and placed on the pipelines, cluster head nodes (CH) and gateway with a control center for remote monitoring. A variety of different leakage scenarios were executed during the experimental runs. Three different location leakage incidents were examined. Fig2 depict the soil moisture experiment for the first leakage scenario using one soil moisture sensor[4].

Fig.2. Soil moisture experiment for the first leakage scenario.

In the fig. 2 the scenario lasted 465s (7min 45s), was initiated with the water poured at a distance of 1cm from the soil moisture sensor. No parameters were varied other than the amount of water poured. During this experiment, the total water poured was 1L. The findings showed that it took 5min 33s to detect soil moisture change and after 49s it reaches the saturated point. Fig 3 presents the moisture value of the first leakage scenario.

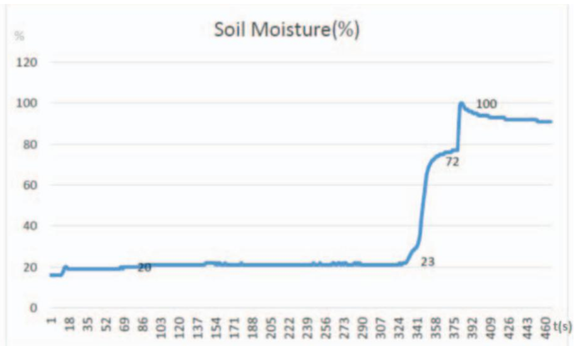

Fig.3. moisture values of First leakage scenario.

The second experiment in Fig.4 lasted 13min 32s and the same amount of water as the first experiment was poured.

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Fig.4. Soil moisture experiment for the second leakage scenario

The findings showed that it took 13min 21s to reach the saturated point of the soil. Fig. 5 presents the soil moisture value of the second leakage scenario.

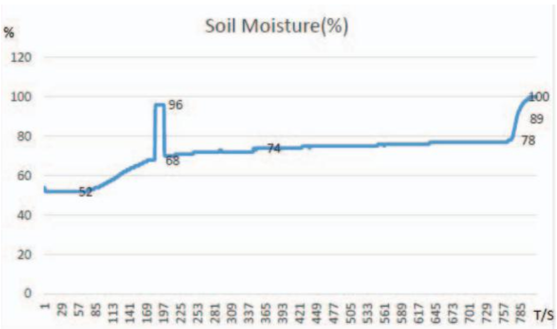

Fig.5. Soil moisture values of the second leakage scenario

The third experiment detailed in fig. 6 lasted 52min 13s and the water was poured at a distance of 12.5cm from the soil moisture sensor. During this experiment, the total water poured was 2L.

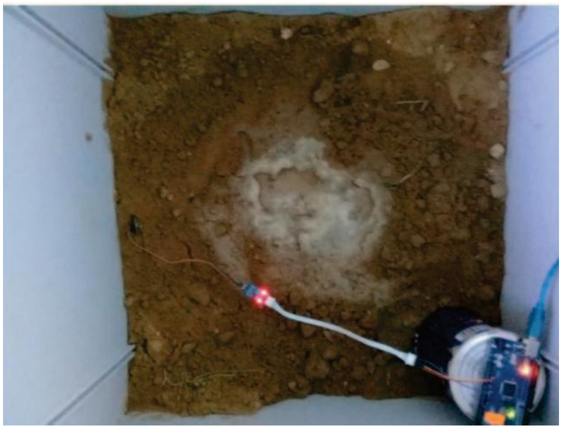

Fig.6. Soil moisture experiment for the third leakage scenario

The results showed that it took 40min 12s to reach the saturated point of the soil. Fig. 7presents the Soil moisture values of the second leakage scenario.

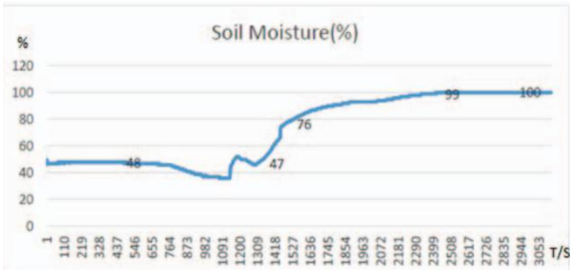

Fig.7.Soil Moisture values of the third Leakage scenario .

From these differents experiences , we conclude that these experiments are not sufficient to detect soil moisture change because we need several moisture sensors placed at different locations and pressurized water from the pipeline.

IV.RESULTS

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In order to enhance the results showed in the previous part, we propose a novel leakage experience based on three moisture sensors and using a real scenario in real cases. The experience is based on ARDUINO MEGA platform with three moisture sensors as described in the figure below.

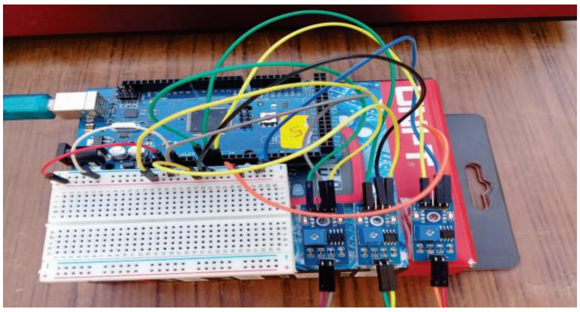

Fig8. Mounting with Arduino and moisture sensors.

Based on this mounting a real experiment has been done as mentioned in figure 9 and 10 below with different distances:

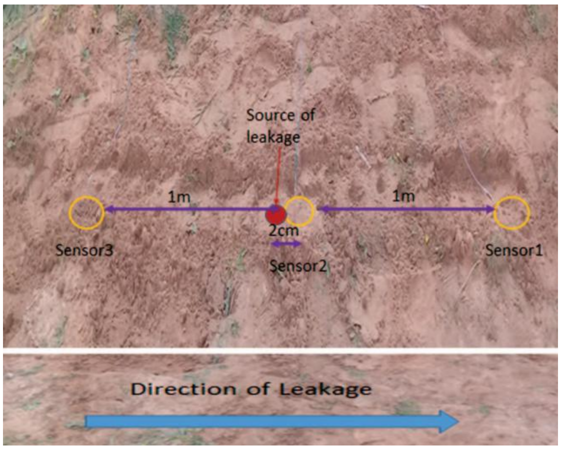

Fig.9. Placement of the three soil moisture sensors in equal distances.

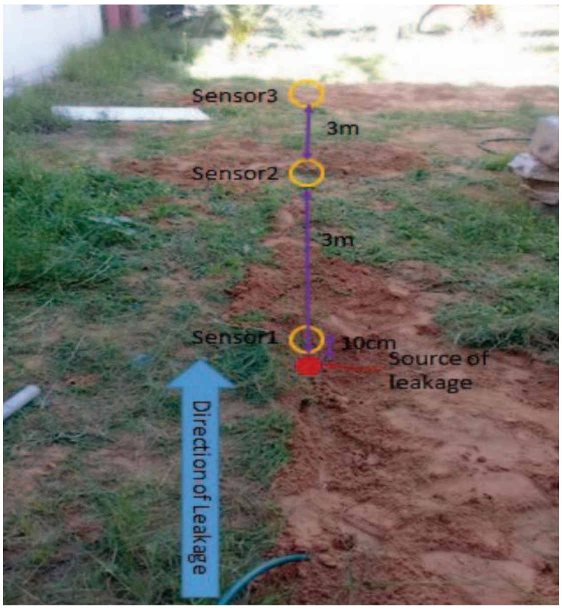

Fig.10.Placement of the three soil moisture sensors in different distances We worked on the real space in the CRNS centre. In fact, we placed the sensors alongside the pipeline. In fact, in the first experience(Fig9) we used the three sensors. The first node (sensor2) is in the middle and the two other are distant from it by the same distance. In addition to that, the source of leak is placed in the middle and the leakage direction is as shown in Fig 9. However, in the second experience (Fig. 10), the distance between the sensors is changed as well as the source of the leak. It will be at the end and is not in the middle. These two experiences allowed us to compute the percentage of moisture that is presented in the following figure.

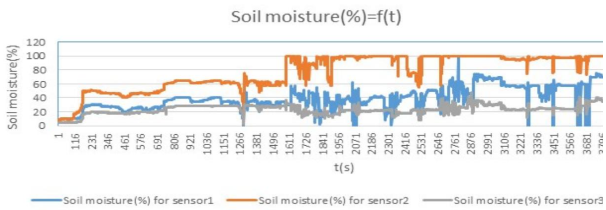

Fig.11. Soil moisture values for three sensors

From Fig 11, we conclude that the moisture values are well presented and computed. In fact, for the three sensors, it can be seen that the leak detection time is well found and it is presented by the first spike as shown in the curve. Thus, the leak detection time and its location are well defined. After that, this leakage information will be sent by the sensor node to the CH that communicates with the gateway. The gateway sends the location of the leak. Overall, the proposed solution provides great advantages in terms of leak detection and localization. To ameliorate the results, in the future work, we will extend the proposed solution with other low power IoT platforms and evaluate the performance in terms of energy and time.

information to the control PC to make the necessary corrections. So, we demonstrate that the proposed solution has good results using this experience in comparison to the first one. Indeed, this solution helps to detect leakage with highly probability and the concept is easy.

IV. CONCLUSION

In this paper, we presented the proposed solution for water pipeline monitoring and Leak Detection using soil moisture sensors based on IoT technologies. The proposed solution measure moisture percentage of the soil to detect the leak. Several experiences are made to find the optimal solution to determine the time and the

V.REFERENCES

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