An IoT Based Approach for Detection of Water Leakages in buildings

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Abstract
Leakage from water supply is posing a serious problem for the water supply industry that has to supply water to the buildings, houses, offices etc. Water pipes are usually buried underground and it is not rare that a pipe is used for long period (more than forty years). These old water distribution networks are prone to variety of leakages. These leakage detection and localization in water pipes is one of the main concerns for the water management department. Similarly the leakages of water pipes in buildings leads to degradation of the buildings because it starts corrosion of steel used for reinforcement and further it decreases the life span of the building. So detection of water leakages is necessary to stop degradation of infrastructure. Various techniques have been developed to detect the location and size of leakages previously. Leakage detection is one of the problems because of lack of monitoring tools, manual work, and costly labour. In this paper a novel approach for water Leak Analysis based on the simple sensor network is proposed, In this work sensors are employed at water pipeline joints and bends while fitting the pipelines during the construction of the building, as the maximum possibility of leakages are at the joints and bends.

Keywords: water leakage, leakage detection, water management.

I. Introduction

Water plays an important role in day to day life of all human beings. In fact it is the most precious and valuable resource of life. Due to increased urbanization, water supply department is facing many problems in real time operation such as proper distribution of water, irregular water supply, leakages in pipelines, quality of water, etc.

A leakage is a physical phenomenon caused due damage or hole in pipeline which is of any irregular size, and can occur at anytime, anywhere in the water supply pipeline. The problem of water leakage detection gained much importance in this era because it is not just an environmental issues but it is economic issue as well.

Water distribution network plays a vital role of transporting water from the place of origin to place of consumer. Any leakage in the pipe can cause major financial losses and along with environmental damages. Currently, buried pipelines are only monitored at key points, which can be spaced several kilometers apart. A system with a higher spatial resolution would provide operators with a better understanding of their network. Most of the water pipes are buried underground, making it difficult to find the location of leaks. In the proposed work a novel approach for water Leak Analysis based on the simple sensor network is established. In this method the simple sensor network based on IoT platform is discussed. During the experimentation the sensors are deployed at vulnerable points (i.e. mostly joints and bends) of the pipeline because maximum probability of occurrence of event of leakage is there.

The rest of the paper is organized as follows: section 2 describes the related work is discussed and brief review of various approaches used for detection of water leakages. In section 3 describes the proposed system is to be applied for the design and implementation. Section 4 shows the experimental results & their analysis. Section 5 shows conclusion & future scope for our System.

II. Related Work

Ms T. Deepiga et. al. define the water monitoring systems such as Tank water level sensing monitoring, water pollution monitoring and water pipeline leakage sensing monitoring [1]. By using Wireless Sensor Technology they avoid the huge amount of water being wasted by uncontrolled use in large apartments/offices. The microcontroller based water level monitoring is used to indicate the level of water in the tank to agent. Sensor Based Water Pollution Detection, that checks the water quality by using these parameters such as the pH level, turbidity and temperature are measured in real time by the sensors and it would monitor by an agent. For Leak detection in water pipelines, they measure pressure into the pipes using force sensitive resistors (FSR). The pressure difference generated

due to leak is detected, it will be indicated by an LED meter and sound alert get generated.

Fukushima Kei et. al. demonstrated water leakage detection in the period from September 2013 to March 2014. Authors made a demonstrative test on actual water pipes jointly with KASIX Corporation, local information processing company, and under collaboration from the Gas and Water Supply Bureau of the City of Kashiwazaki (Niigata Prefecture), Japan [2]. As a result of assessment using about twenty sensor loggers under various test conditions, succeeded in detecting four water leak cases with position errors of less than 1 meter.

Athanasios Anastasopouloset. al. deals with the technical description and the physics of the AE leak detection technique, presents the advantages, limitations and requirements of the method, describes the necessary functions of AE equipment for performing such a task, and, finally, reports on several case-studies of successful leak detection and location of buried pipelines [3]. The case studies cover both new and in-service buried pipelines of different sizes.

DídiaCovaset. al. uses the methodology is the identification of location of leaks in pipe networks using observed pressure data, collected during the occurrence of transient events, and the minimization of the difference between observed and calculated parameters [4]. This approach is presented conceptually and implemented in a software tool. The methodology is tested and verified with laboratory data collected in an experimental facility at Institute Superior Technical (Technical University of Lisbon). Based on this preliminary data analysis, the main practical difficulties of the implementation of this methodology in field network systems are outlined.

Ali M. Sadeghioonet. al. presents the design, development and testing of a smart wireless sensor network for leak detection in water pipelines [5], based on the measurement of relative indirect pressure changes in plastic pipes.A non-invasive (to the pipe) pressure measurement method based on FSR sensors has been presented. FSR sensors detect the changes in pressure and the leak test is based on variations in normal pressure along with the temperature using temperature sensor.

N. Merziet. al. presents a methodology to estimate, to determine and to locate water losses from water distribution network [6]. Various techniques are used to reduce the losses by employing limited manpower and simple instruments. Alternatives requiring sophisticated equipments are also introduced. Related case studies from Ankara Municipal Water Distribution Network are presented.

Jihoon Choi et al suggested a method of Leak Detection and Location of Water Pipes Using Vibration Sensors and Modified ML Prefilter [7]. The proposed method construct a channel model for vibration signals in buried water pipes based on the field measurement data. Additionally, the modified ML pre-filter can be applied to correlation-based leak detection systems utilizing the STFT and the wavelet transform. This leak detection method was verified by field measurements using a practical leak detection system. This leak detection system is useful in developing an automatic leakage management solution that collects leakage data, alarms about the risk of leaks, and informs about the specific leaklocations.

A. Candelieriabet. al. proposed a study dealing with the application of graph-based analysis to develop an effective computational leakage localization approach [8]. This approach is basedon a combination of simulation of different leaks, in terms of location and severity, and the graph-based clustering analysis of the pressure and flow variations. The demonstration of this method performs several simulation runs, through EPANET, by placing, in turn, a leak on a pipe and varying its severity in a given range. At the end of each leakage simulation, the EPANET software outputs pressure and flow value at each junction and pipe, respectively. Only the values in correspondence of the position of monitoring devices in the real network are considered. This method is efficient as compare to the traditional one but it requires a lot of computation.

D. Salaaet. al. presents Detection of leaks in a small-scale water distribution network based on pressure data [9]. This methodology enabling the leak detection based on the adaptation of the VDM-related identification problems in structural mechanics for the leak detection problem in water distribution networks operating at steady state flows. The method uses the relationships between pressures and flows within the network to detect the leakages.

C.M. Giorgio et .al. suggested a Methodology for Leakage Isolation Using Pressure Sensitivity and Correlation Analysis in Water Distribution Systems [10]. The proposed method uses the Apulian hydraulic network. A leakage localization method based on the pressure measurements and sensitivity-correlation analysis of nodes in a network has been proposed in the system.

Pranita Vijay kumar Kulkarni et. al. presents an IOT based Water Supply Monitoring and Controlling System with Theft Identification [11]. In their system, they

are focusing on continuous and real time monitoring of water supply in IoT platform. Water supply with continuous monitoring makes a proper distribution so that, a record of available amount of water in tanks, flow rate, abnormality in distribution line can be stored. Using Adafruit as free sever data continuously pushed on cloud so observation of data in real time operation is possible. Using different sensors with controller and raspberry pi as Minicomputer can monitor data and also control operation from cloud with efficient client server communication.

III. Proposed System

The Proposed system works on the principle of Water Leak Analysis based on the simple sensor network which is employed at water pipeline joints and bends while fitting the pipelines during the construction of the building, as the maximum possibility of leakages are at the joints and bends. The proposed system consists of a sensor to detect the leak, interfaced with IoT set up. Also for interfacing with cloud Wi-Fi Module, Router along with the client and server programming is used.

The following block diagram shows the architectural schematic of the proposed system

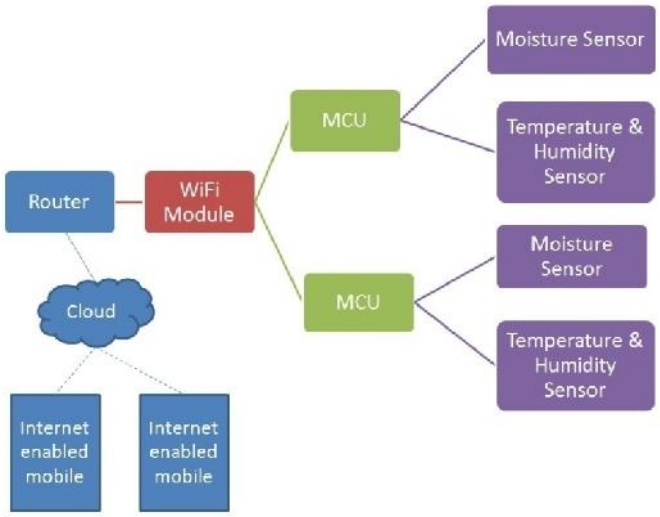

Figure 1: Architecture of Proposed System

In this implementation model we have used NodeMCU (ESP 8266), DHT 11 (as temperature and humidity sensor), Moisture sensor as embedded device for sensing and storing data. Arduino IDE is used as development environment for writing software for NodeMCU. ThingSpeak is used as cloud based Internet of Things (IoT) platform that lets you collect and store sensor data in the cloud and develop this IoT application

3.1 Proposed Algorithm

Step 1: Initialization of peripherals self check i.e. All the setup is done and check the equipments

Step 2: Setup network
i.e. turn on the devices and network connectivity

Step 3: Initialize database

Step 4: Read sensors one by one along with location informationi.e. read the data (moisture here) given by the sensor and compare with the threshold and confirm it with temperature and humidity.

Step 5: Find the leakage location from the received sensor data

If leakage is found then generate the alert,

If not then go to step 4

Step 6: Save the findings along with the received data in database

Here in the form of location of the leak (sensor id, date and time, etc.)

Step 7: Flash the alert

Step 8: Continue to Step 4

3.2 Flowchart of Proposed System

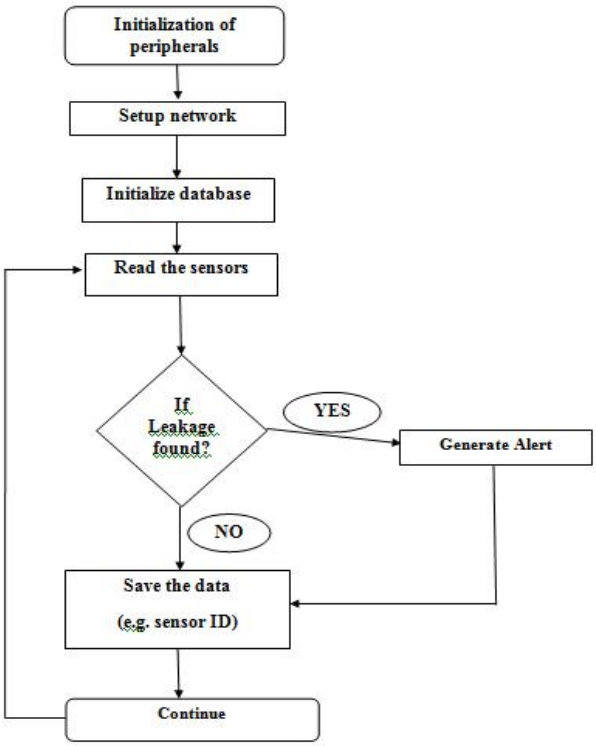

Figure 2: Flow of proposed System

3.3 Experimental Setup

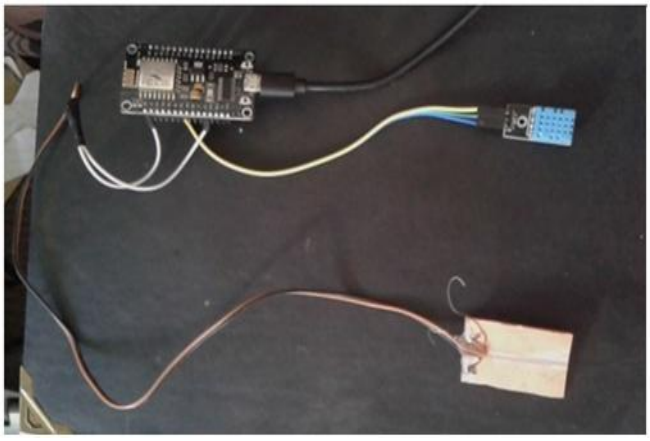

Figure 3: Node sensors of the proposed system

Figure 4:Experimental setup of embedded devices

The above figure 4 shows the experimental setup implemented of embedded devices. The nodal embedded devices (as shown in figure 3) are placed at joints and bents of the pipeline as shown in above figure. All the devices are connected with Wi-Fi and power. Proper connection is established with the cloud and the event of leakage is sensed in this way. (Sand boxes are kept purposefully since water pipelines are buried underground and there may be variations in parameters while underground and while in open surrounding).

3.4 Experimental Results and Discussion

This section describes the actual experimentation of the described system. This model will detect the leakages at the point where sensor setup is installed (i.e. at the joints and bents probably where leakage occurs the most).The setup include a facility to start and remove a leak condition at any node for experimentation.

3.4 Simulation Results :

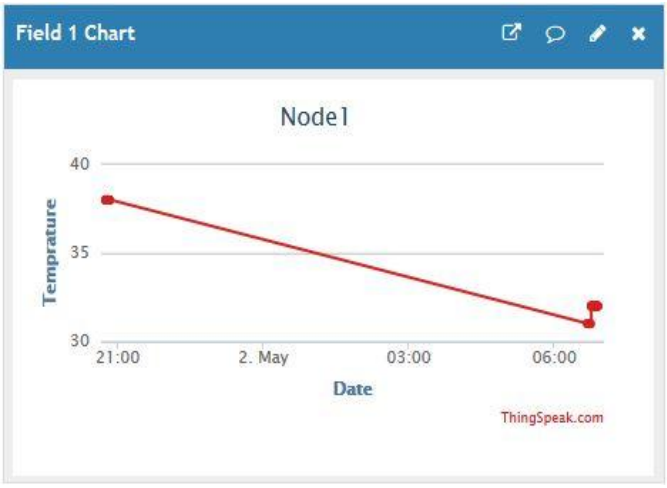

Figure 5: Temperature at Node 1 when there is leakage

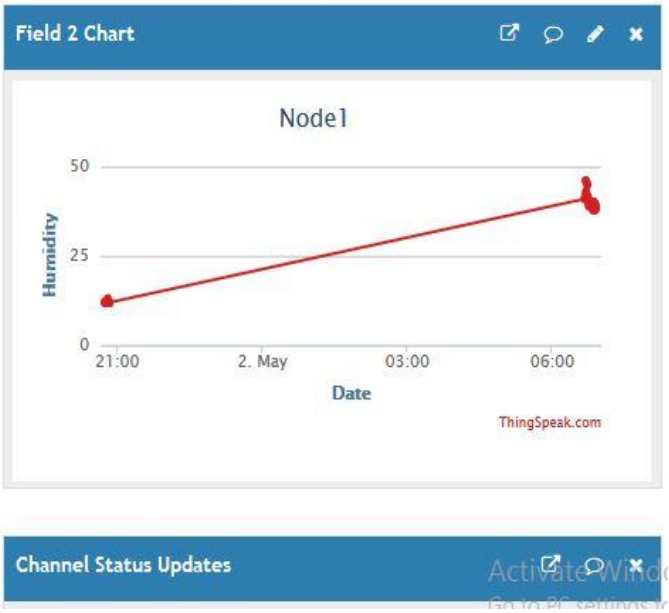

Figure 6: Humidity at Node 1

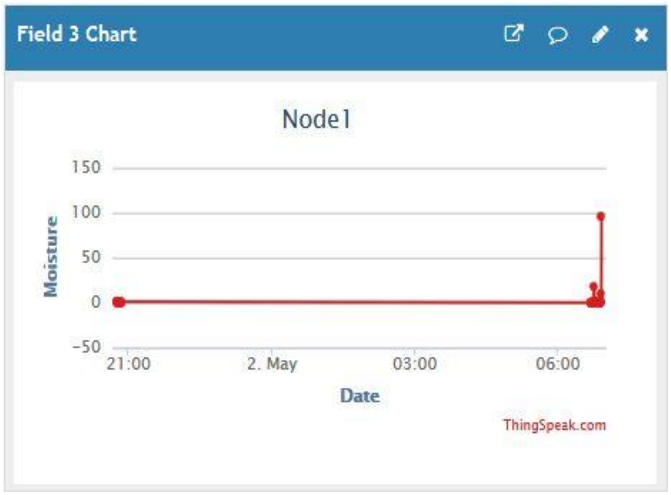

Figure 7: Moisture at Node 1 when there is no leak constantly

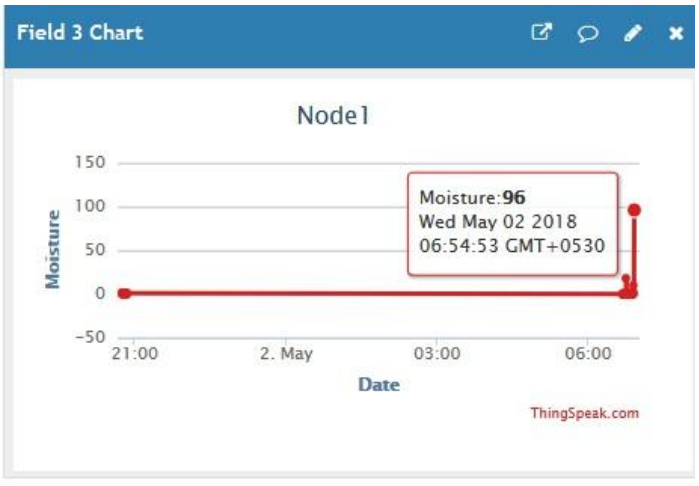

Figure 8: Moisture at node 1 when leakage occurs

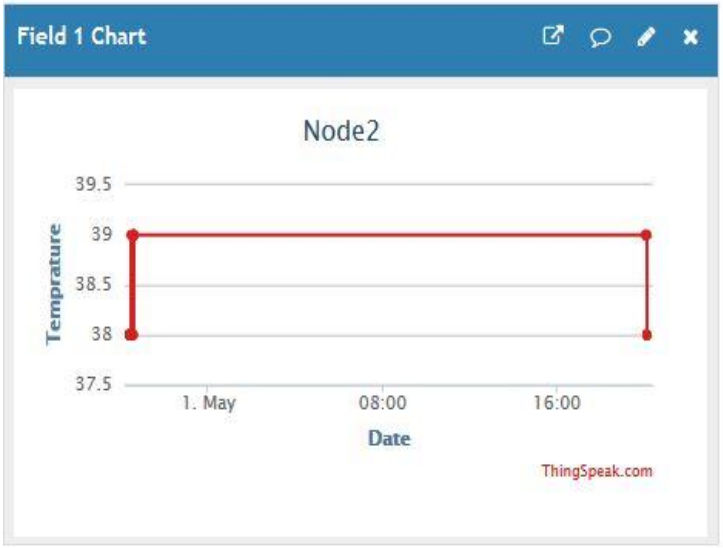

Figure 9: Node 2 When there is no leak

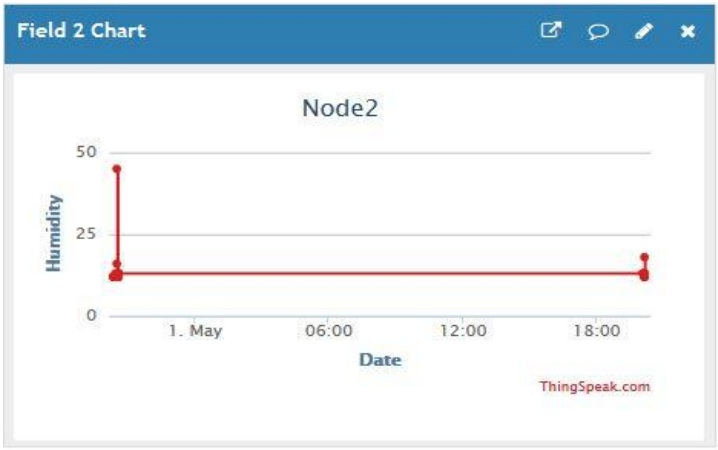

Figure 10: Humidity at node 2 when there is no leakage

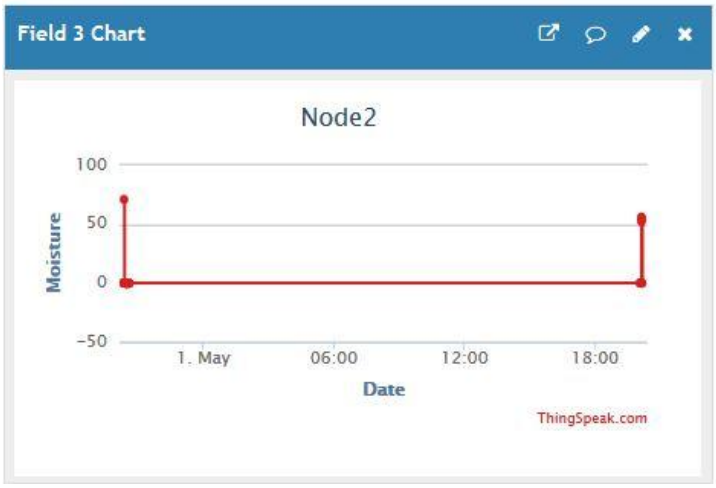

Figure 11: Moisture at node 2 when there is no leakage

The below table 1 shows the summarized result of all sensor nodes when there is leakage observed and when there is no leakage. The value of parameters observed is

Nodes	When Leakage found			When Leakage not found		
	Temp ^{0}C	Humi %	Moist %	Temp ^{0}C	Humi %	Moist %
1	31	61	80	35	30	1
2	35	71	87	34	30	0
3	34	89	81	34	31	1

Table 1 : Summarized results of all the sensor nodes when leak & no leak observed in summer

compared with the threshold value and according to that alert is generated when condition of leak is there. The threshold set for moisture is 20% for now. During rainy season we must set the threshold for humidity and temperature too. Because there is a chance of getting walls wet due to external water and it may detect the leakage activity, by using these two parameters we can avoid the condition.

Figure 12: Values of parameters displayed on mobile using ThingSpeak widget

IV. Conclusion & Future scope

Water leakage detection is important aspect of water supply or distribution system for sustainable development of cities Using this novel approach the life and health of various buildings can be maximized. Detection of leakage is possible with the correlation of the sensor location. So there is no need to go on actual leak location for monitoring, thus manual work has been reduced. Data can be retrieved and monitored from anywhere on the cloud.

The proposed system reduces the human efforts to identify the leak location.By deploying the embedded devices at the key points of water supply pipeline for monitoring leakages ultimately enables self protection by increasing health and life of buildings. To implement this system in buildings, it is needed to deploy the sensor devices under the pipeline for collecting the data and analysis.In future perspective whole water distribution main network pipeline may be put under surveillance to detect and locate leakages in the cities, industrial areas and so on.

In this work the IoT based Water leakage detection at delivery pipes is proposed. A NodeMCU based node circuits are tested for the Wireless Sensor Network using Wi-Fi module. The Humidity, Moisture and Temperature are used to detect the leak. The results are very promising.

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