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Detection and Localization of Water Leaks in Water Distribution Network of Smart Cities Using IOT

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ABSTRACT: Artificial intelligence for the urban water supply network, and in particular, the application of the internet of things - IoT for detecting and locating leakages on the water supply network, including hidden leakages; is the theme of this work. Smart water management in supply systems is essential to optimize the use of water resources and the quality of service. In this paper, the Internet of Things (IoT) or artificial intelligence can be a valuable tool, it will enable the integration of multiple technologies, storing and analysing data from different sources in real-time, and extracting contextual data. For smart cities, it is essential to make domestic water available uninterrupted. The 24X7 water supply is a challenging task and that too with optimum pressure. The pressure drop in the pipeline is one of the indicators of leakages. Along with the identification of a location of leakages in pipelines another important task is to control the same. The detection and localization of water leaks in water distribution piping networks will be solved by an ICT system with an artificial intelligence approach. Providing the pressure sensors at some fixed nodes or points in the distribution networks. Accordingly, at every junction, a pressure and flow sensor will be installed. The leakages in the pipeline would be measured by fluctuations in the pressure at these nodes. An online system will be designed which will alert or send signals of leaking of pipes. Immediate, detection of leakages in the distribution network will help to control the same effectively

KEYWORDS: Internet of things, EPANET, smart cities, water supply distribution network, pressure sensors, flowsensors and GPS, etc.

I. INTRODUCTION

It is known the necessity of water for human mankind, water has become an issue because of less rainfall, and increase in population. Many cities and drought regions are facing this problem. People have to suffer from this problem because of the increase in need of the demand for water with high living standards. To lack monitoring water can't be supplied properly, few areas in the city get water while other areas can't get enough water so, there is a need for continuous monitoring, water supply schedules, and proper distribution. Wastage of water due to overflow of tanks, leakage in the pipeline, interrupted water supply. Water many times with lack of monitoring, another thing because of overflow in the pipelines with more pressure and it will enhance the chances of the bursting of the pipeline, leakage detection is one more problem all these problems are because of lack of monitoring, manual work, less workforce. The water leakages in distribution pipes are a very important issue that occurs in many countries in the world. Many methods and research have been carried out, from manual methods using detection devices to the most current methods using artificial intelligence. The leakage is detected by monitoring the pressure changed in every event of leakage in pipelines. The development of computerized technology that is the Internet of Things (IoT) is the need of future development that will replace the manual detection of water leakage. The leakage in the pipe network is due to the diameter of the pipe, age of the pipe, the material of the pipe, pressure in the pipe, corrosion, incorrect installation, water hammer effect, etc. In Mumbai city, water loss due to leakages is nearly 70%. The clean and treated water is wasted due to leakages. It not only causes wastage in water but also indoor flooding of water, reduction in water pressure in the pipeline the proper water management system is needed to implement using the latest technology. To



avoid such loss smart water management is necessary. It can be successfully implemented by the Internet of things (IoT). IoT consists of a sensor, mobile, actuator which can send the data and receive it through the communication channel. Artificial intelligence is about empowering computers so that they can see, hear and smell the world for themselves. The concept of the Internet of Things (IoT) is considered an easy and powerful technique to solve real-life problems. It can be used for smart industry, smart healthcare, smart transportation, smart irrigation, animal tracking, smart environment.

II. RELATED WORK

Many research efforts are carried out on the detection and monitoring of the leakages using the sensors the prototype with the modern technology for the detection and monitoring of the leakages consists of water flow measurement by using flow sensors. used the concept of the internet of things. The basic principle of this is the Hall effect. The rate of flow is analysed and sudden change in the flow is monitored by the microcontroller. IG. M. Tamilselvan et al. [14] proposed work is implemented using SCADA and PLC by using IOT they built the solenoid valve which controls the flow. They used the flow sensors and set the specific values of the discharge for the habitats I Rosiberto Gonçalves et al. [15] established the Reflex Water architecture, a solution for intelligent water management that uses IoT, Complex Event Processing, and declarative processes. The evaluation demonstrates the practical use of Reflex Water through a real water distribution system installed in a Brazilian city this paper proposes a small lab-scale model for monitoring the leakages in the pipeline using sensors, we use the pressure transducer which senses the sudden drop in the pressure this approach enables early leak detection and the user also get notified about the position of leakage, we use the Arduino UNO GPS, GIS This system enables the user-friendly approach.

III. METHODOLOGY AND MATERIALS

STUDY OF EPANET: In EPANET software we can design the distribution network in which it contains the parameters such as tank, pump, valve, node, or junctions' points which are connected by the network of pipelines of various diameters and varying length according to the design parameters. The software generates the data which consists of input data at each of the junctions and the output data in the form of magnitude and location of leakage in the pipe. After giving all the data to the software, the data is processed using one of the artificial intelligence methods. The test result of the method is proven to be able to detect the magnitude and location of leakage.

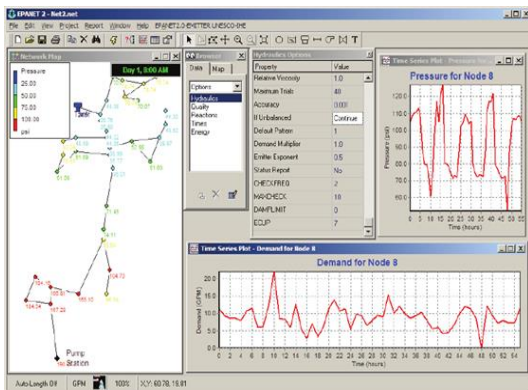


Figure 1 Epanet Software Display Menu



Figure 2 Actual Pilot Scale Model

LAYING OF LAB SCALE PIPING NETWORK: The laying of all the piping networks in the lab is shown in the following fig. In laying all the plumbing work was done as per the EPANET drawing to make a similar lab-scale model and check the various parameters. In this network, we used different diameter UPVC pipes to connect each other to check this model for different pipe size diameters in actual scenarios. On the field, pipes are of different sizes and diameters to meet this change in this system. The following network was connected to the zeal college tank which is at a height of 25 Meters.



Figure 3 Pressure Gauge

After finishing all the plumbing and connections, we placed the pressure gauge at 1st junction to calculate the pressure value of water. After placing the pressure gauge, we open the flow valve, and water will pass through the distribution network and measure the pressure reading. On the pressure gauge, we get the pressure value in the range of 2.5kg/cm² to 4kg/cm². So, by applying the following equation we calculate all the pressure gauge values at each of these junctions compared with EPANET values.

Calibration Factor

$$\text{Pressure gauge value at each junction} = (0.061 \times \text{Pressure value from EPANET}) + 0.0995$$

Design and development of lab-scale water distribution network using EPANET

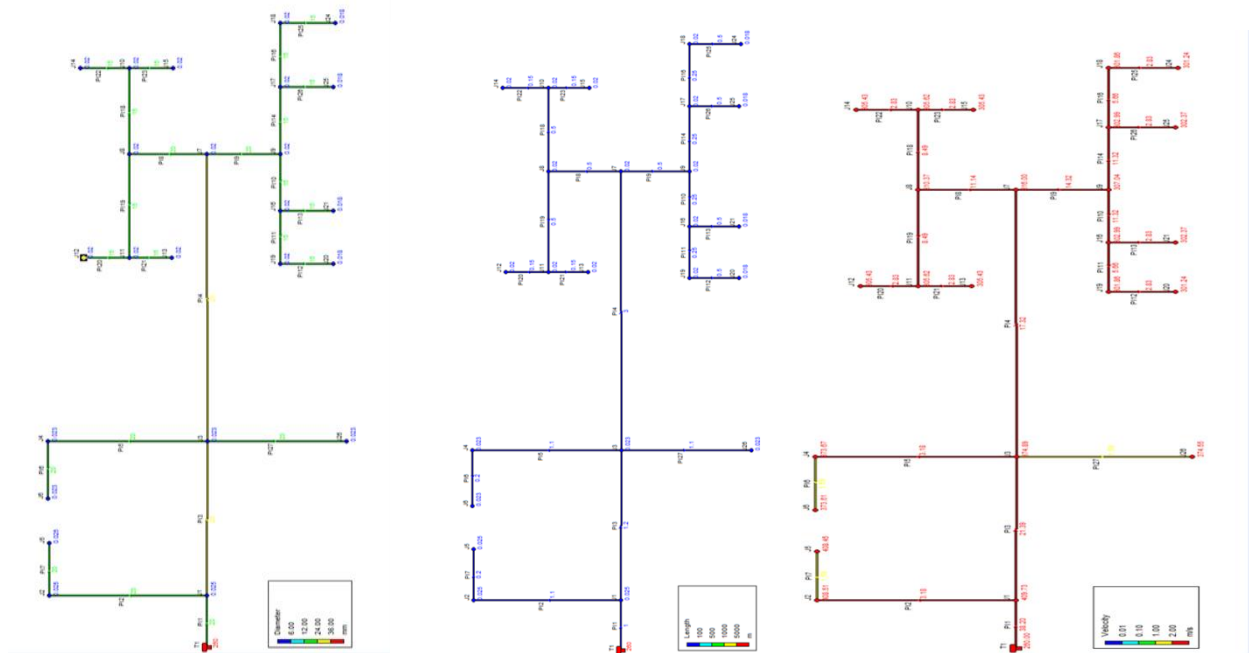


Fig 4 Layout of Elevation and DíaFig 5 layout Of Elevation and LengthFig 6 Layout of Pressure and Velocity

Materials used in this project

- 1. UPVC Pipes:** We used UPVC pipes of different diameters is 1inch, ½ inch, and ¾ inch. The plumbing layout consists of different types of network shapes such as square, L shape, and T shape, etc. at junctions or nodes we used elbow joint, T joint, two-way T- joint, etc. We used pipes reducers at junctions where pipe diameter changes
- 2. Arduino R3:** Simply connected to the computer with the help of a USB cable. Arduino is useful for connecting our pressure sensors, GSM, and GPS module with each other. So, once the leak was detected by the pressure sensors it will transfer the data to Arduino and then it will be shown on the LCD and laptop or it will send an SMS to the consumer end.
- 3. SIM900A Wireless GSM GPRS Module:** It consists of on the board two sets of the power supply interface VCC5 of 5V and VCC4 of 3.5 -4,5V. works on the optional and default mode for the control. SIM900A interface reserved

reset. The size of the module is 49X50. It also offers the computer debugging USB module power supply, a very large amount of data under the condition of the recommended current of more than 1A. It supports 2 mobiles with 3G or 4G network.

4. 16 x 2 LCD Screen: It is a 1602 parallel LCD which is a cost-effective solution for adding a 16x2 White on RGB Liquid Crystal Display into the project. The display is 16 characters by the 2-line display and has a very clear and high contrast white text upon a blue background/backlight. values that are displayed are either in numeric format or text.

5. Standard Jumper Wire Set: 20 cm and consists of 40 jumper wire sets. It is very flexible and can easily be detached. Wires are placed at 2.54 mm. These are cables with connectors at each end. It is used to interconnect components of breadboards or test circuits. consist of 40 pcs chromatic colour.

6.U- Blox NEO- 6M GPS Module with EPROM: It is Ublox NEO-6M. This unit uses the latest technology from Ublox to give the best possible positioning information. the additional battery is provided so that we get GPS lock faster. The module enables us to best position information systems for better performance with Arduino Uno. It also provides a high precision binary output, high sensitivity, better power backup, and EPROM for storing configuration settings. The Ublox GPS module has serial TTL output, it has four pins: TX, RX, VCC, and GND. Works at 3.3 Voltage of power supply. The cold start time of 38 s and Hot start time of 1 s 5 Hz posting rate. Support SBAS (WAAS, EGNOS, MSAS, GAGAN) Separated 18X18mm GPS antenna.

7. Breadboard:400 Tie Points Solderless Breadboard a high-quality breadboard with power lanes and printed top face for easy prototyping. It is used to connect LCD and some jumper wire connections. No soldering is required so it is easy to change connections and replace components.

8.PRESSURE TRANSDUCER SENSORS: Features: It Adopt stainless steel shell, having advanced pressure ceramic core and special processing chip; With high accuracy and lightweight, it has easy installation and smooth working operation. Stable performance, long-term drift, and long life; perfect EMC protection; Using high-quality materials, strong and durable, has a long service life. Small size, easy to carry and store, convenient to use, and with good performance



Figure 7 Pressure sensors

9. FLOW SENSORS: Features: flow sensor is used to measure the quantity of waqter in the network it is placed at startind and end point of the system.. it works at pressure less than 1.2 mpa and flow range is 1.60 l/min.its working voltage is 5-15 v



Figure 8 flow sensors

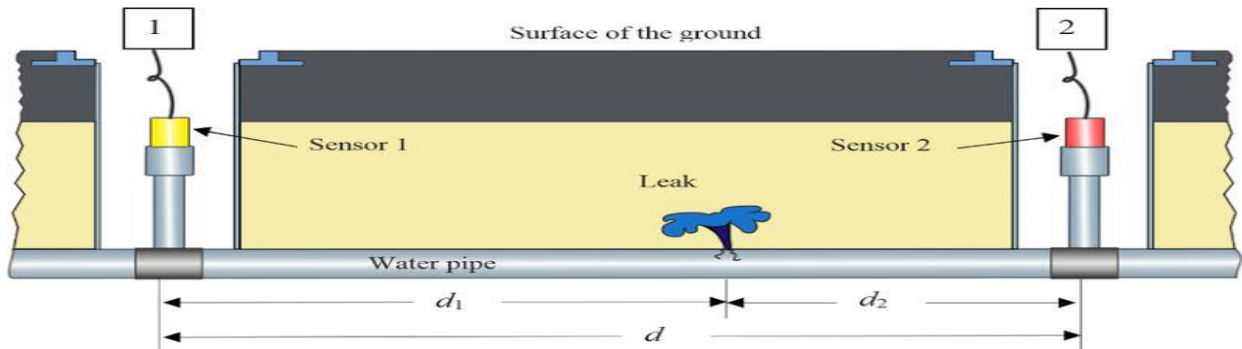


Figure 9 leaks in pipeline

IoT and Connections

The connections of our model prototype are shown in the following figures.

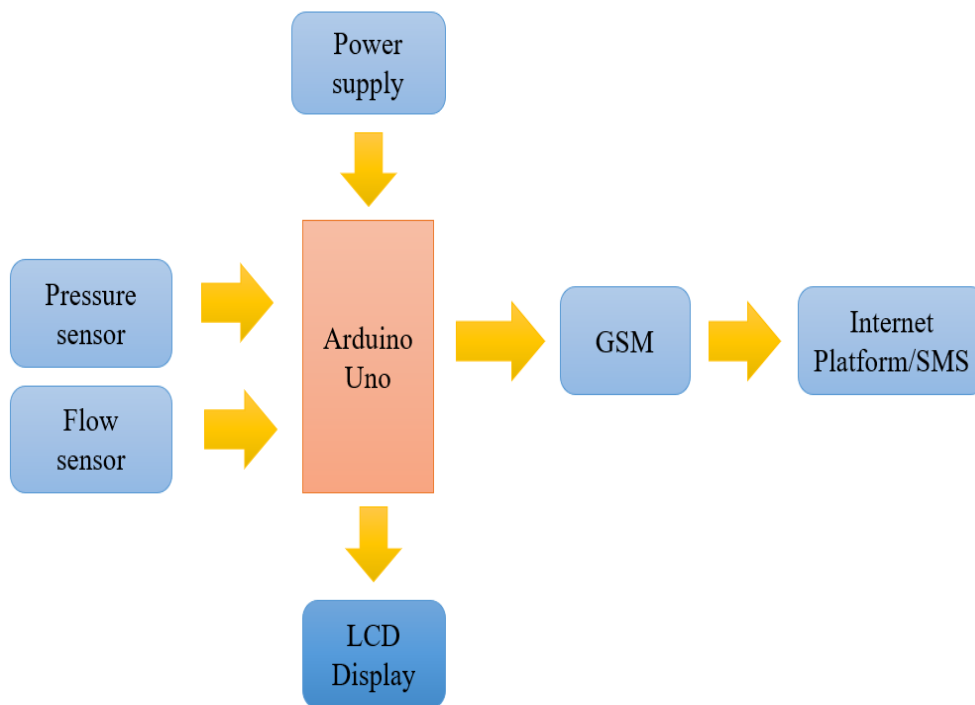


Figure 9 Block Diagram of the leakage monitoring system



IV. EXPERIMENTAL RESULTS

EPANET software simulation values in which we get the readings of our model prototype. In EPANET software we get the values of Head of water, pressure, velocity, flow in LPS, unit head loss, etc. Are shown in the following tables.

Table 1 Network Tables- Nodes

Node ID	Elevation m	Base Demand LPS	Demand LPS	Head m	Pressure m	Pressure on the gauge in m
Junc J1	0.025	0.5	0.5	409.76	409.73	25.09303
Junc J2	0.025	0.5	0.5	408.54	408.51	25.01861
Junc J3	0.023	0.5	0.5	374.91	374.89	22.96779
Junc J4	0.023	0.5	0.5	373.7	373.67	22.89337
Junc J5	0.025	0.5	0.5	408.48	408.45	25.01495
Junc J6	0.023	0.5	0.5	373.64	373.61	22.88971
Junc J7	0.02	0.5	0.5	316.02	316	19.3755
Junc J8	0.02	0.5	0.5	310.39	310.37	19.03207
Junc J9	0.02	0.5	0.5	307.06	307.04	18.82894
Junc J10	0.02	0.5	0.5	305.64	305.62	18.74232
Junc J11	0.02	0.5	0.5	305.64	305.62	18.74232
Junc J12	0.02	0.5	0.5	305.45	305.43	18.73073
Junc J13	0.02	0.5	0.5	305.45	305.43	18.73073
Junc J14	0.02	0.5	0.5	305.45	305.43	18.73073
Junc J15	0.02	0.5	0.5	305.45	305.43	18.73073
Junc J16	0.02	0.5	0.5	303.01	302.99	18.58189
Junc J17	0.02	0.5	0.5	303.01	302.99	18.58189
Junc J18	0.02	0.5	0.5	301.88	301.86	18.51296
Junc J19	0.02	0.5	0.5	301.88	301.86	18.51296
Junc J20	0.018	0.5	0.5	301.26	301.24	18.47514
Junc J21	0.018	0.5	0.5	302.38	302.37	18.54407
Junc J24	0.018	0.5	0.5	301.26	301.24	18.47514
Junc J25	0.018	0.5	0.5	302.38	302.37	18.54407
Junc J26	0.023	0.5	0.5	374.58	374.55	22.94705
Tank T1	260	#N/A	-12	520	260	15.9595



Network Table Links

Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s	Unit Headloss m/km	Friction Factor	Status
Pipe PI1	1	20	100	12	38.2	110244.7	0.03	Open
Pipe PI2	1.1	20	100	1	3.18	1105.89	0.043	Open
Pipe PI3	1.2	25	100	10.5	21.39	29034.07	0.031	Open
Pipe PI4	3	25	100	8.5	17.32	19631.3	0.032	Open
Pipe PI5	1.1	20	100	1	3.18	1105.89	0.043	Open
Pipe PI6	0.2	20	100	0.5	1.59	306.21	0.047	Open
Pipe PI7	0.2	20	100	0.5	1.59	306.4	0.047	Open
Pipe PI8	0.5	20	100	3.5	11.14	11254.53	0.036	Open
Pipe PI9	0.5	20	100	4.5	14.32	17925.16	0.034	Open
Pipe PI10	0.25	15	100	2	11.32	16210.58	0.037	Open
Pipe PI11	0.25	15	100	1	5.66	4490.44	0.041	Open
Pipe PI12	0.5	15	100	0.5	2.83	1243.91	0.046	Open
Pipe PI13	0.5	15	100	0.5	2.83	1243.91	0.046	Open
Pipe PI14	0.25	15	100	2	11.32	16210.58	0.037	Open
Pipe PI16	0.25	15	100	1	5.66	4490.44	0.041	Open
Pipe PI18	0.5	15	100	1.5	8.49	9515.07	0.039	Open
Pipe PI19	0.5	15	100	1.5	8.49	9515.07	0.039	Open
Pipe PI20	0.15	15	100	0.5	2.83	1243.83	0.046	Open
Pipe PI21	0.15	15	100	0.5	2.83	1243.83	0.046	Open
Pipe PI22	0.15	15	100	0.5	2.83	1243.83	0.046	Open
Pipe PI23	0.15	15	100	0.5	2.83	1243.83	0.046	Open
Pipe PI25	0.5	15	100	0.5	2.83	1243.91	0.046	Open
Pipe PI26	0.5	15	100	0.5	2.83	1243.91	0.046	Open
Pipe PI27	1.1	20	100	0.5	1.59	306.32	0.047	Open

V. CONCLUSION

A pressure transducer sensor is used to measure the pressure difference of water at different junctions, eliminating the drawbacks of existing water leakage systems. Flow sensors are placed at start and end of the network to regulate the discharge. Water leakage IoT systems will be used for detecting and localizing leaks in the distribution network which will eliminate the drawbacks of traditional water leak systems and enhance speedy operations. By using GSM and GPS modules in the distribution network at different junctions we can easily identify the leaks in the network. In the future, the use of IoT-based water distribution systems can include the Turbidity sensor, pH sensor, Water Hardness Sensor, Water Conductivity Sensor, and Fluoride Sensor for Quality of water. Detecting more parameters for security purposes

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