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An Internet of Things Based Model for Smart Water Distribution with Quality Monitoring

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ABSTRACT: Water is an important resource for life and its existence. Nowadays, due to increase in migration from a rural area to urban areas, the population in cities is increasing rapidly. To meet the need of water requirement, its distribution and quality check, a novel approached is proposed which is based on IoT (Internet of Things). The proposed system consist different sensors like water flow sensor, pH Sensor, water control valve and a raspberry PI as a core controller. A water control valve is controlled through web interface based on water flow sensor value to ensure equal and adequate water distribution to each connection (end point).

KEYWORDS: Water management; water distribution; water quality monitoring; architecture model; IoT; cloud computing.

I. INTRODUCTION

Water is an important resource for life and its existence. Due to a shortage of the fresh water, it is necessary to have control over water distribution. Hence, there is a need for better water distribution technology while also considering its quality.

Traditionally water distribution is carried out zone wise. If the new area is developing around the city, a new water distribution zone is developed with a new municipal water tank in that zone. Even in the specific zone, area or society wise manual water control valves are used for water distribution among the different societies or areas. This manual water control valves are used because of the limitation of the required water pressure to supply water to all the areas or societies within that zone. This manual water control valve is opened to provide water in the specific area at a specific time while other valves in that specific zone are closed to have minimum water pressure so water can reach to its destination. Another important thing is that the water quality is observed only at the Municipal water tanks which are located zone wise and hence water quality is not been checked at end points where chances of water contamination is present due to rust in the pipeline, hole in the pipeline and some other reasons. Even if water quality is checked at end points, it is time consuming, labour intensive and all end points are not going to cover. Hence, there is need of smart water distribution system with continuous water quality check.

By focusing on the above issues, we have proposed model base on IoT environment to overcome the above problems. In our proposed model, we have used raspberry Pi as a controller and different sensor which can upload data to the cloud. Some sensor can be controlled through the cloud using web interface.

The rest of paper is organized as follows: The sections II shows related works. Section III consists of overall proposed diagram and working of the proposed system. Section IV shows the conclusion of our proposed model. Section V shows the future work that can extend a system to a new height.

II. RELATED WORK

The Internet of Things (IoT) is a novel paradigm that is rapidly gaining popularity in the modern technologies. IoT makes possible the development of a huge number of applications, of which only a very small part is currently available to our society [1]. The IoT domain includes Healthcare domain, smart environment (Home, Office, Plant), transportation and logistics and many more [1].

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N. Vijayakumar & R. Ramya [2] proposed The Real Time Monitoring of Water Quality in IoT Environment where they are sending, storing and viewing the data. The water quality can be monitored anywhere in the world. They developed a system using different sensor and raspberry PI B+ model. The scope of the work is to monitor the water quality without taking any necessary steps when water quality starts degrading.

IoT for water management increases the productivity by allowing real-time control, process optimization, service time reduction, new business models, resource conservations, and the capability to do all of this globally [3]. It increases efficiency by allowing the tracking, monitoring and enabling continuous improvement.

Prachet Verma et al. [4] proposed IoT based water management system for a campus where water distribution based on the water level in a tank across the campus. The developed system distributed enough water to each tank to satisfy local demands. Ultrasonic sensor has been used to know the water level in the tank.

Alessio Botta, Walter de Donato, Valerio Persico, Antonio Pescape [5] provided the in-depth knowledge of integration of cloud computing and Internet of things. They described wide set of the application based on IoT and Cloud Computing like healthcare, smart home and smart metering, smart city, video surveillance and more. They explained the importance of cloud for IoT environment.

III. METHODOLGY

A. Overall Block Diagram: Figure 1 shows an overall block diagram of proposed model. The proposed model consist

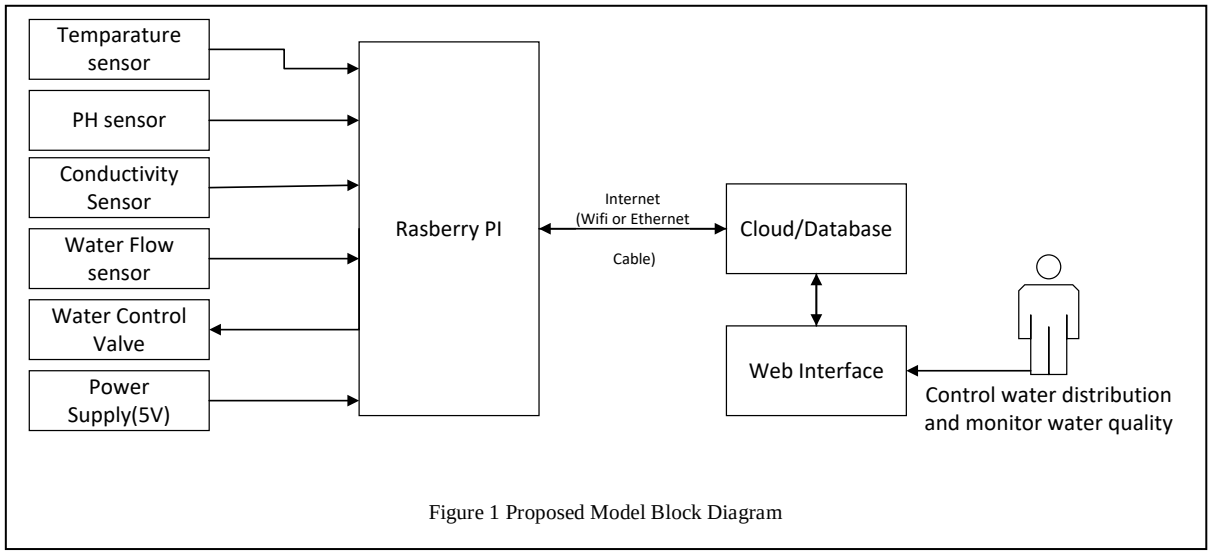

Figure 1 Proposed Model Block Diagram

5 sensors where three of them are for water quality monitoring and two of them are for smart water distribution. The sensors are controlled by the raspberry Pi controller which is connected to the internet via Ethernet cable or Wi-Fi. Using the internet, Raspberry PI sends and receives the data or command to/from Cloud or Hosted Database for performing the real-time operation. A user can control system using web interface.

B. The proposed system and its working:

Smart Water Distribution: In the introduction, we have gone through how traditionally water distribution is carried out in a specific zone. In traditional water distribution, the valves are turned on/off area or society wise for water distribution to each end point. Even though some end points doesn't receive the water or receives water at low water pressure. To overcome such problem, the embedded Device having control valve can be turned on/off using web interface. Using the proposed IoT device each endpoint can be controlled and monitored so it can receive the adequate

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water with Pressure. The Flow sensor sends the data to the cloud using Controller via internet. The generated data can be monitored in real time and control valves can be turned on/off for water distribution with pressure. The flow rate is measured using water flow sensor. The pressure of water flow is computed using following relation:

$$P \propto Q^2 \quad (1)$$

$$P = (\rho \times Q^2) / (2 \times A^2) \quad (2)$$

Where P is pressure at the output side, Q is volume flow rate, water density is 1(Constant) and A is an area of pipe (Constant).

Using this technique, we can monitor each end point for adequate water supply and immediately a necessary step can be taken for any type of problem. By this technique, we have control over each end point rather than having water valve controls society or area wise in the traditional system. The advantage of having control over each end point is that if any end point doesn't receive the water with adequate pressure, we can supply the water to that end point at a different time by turning off all other control valves within that area or society. Another advantage of this System is that we can turn off control valve when the predefined liters of water is supplied to the specific end point.

Water Quality Monitoring: Different sensors such as pH sensor, conductivity Sensor, temperature sensor are used for monitoring the water quality. The values from the sensor are uploaded to cloud by the raspberry PI controller through Internet channel at random interval. The reason for choosing the randomness is to avoid all the devices firing the request at the same time. These values can be monitored location wise in real time. If the supplied water is fresh and passed all the tests, even though water reaching to end points is contaminated then we can detect the source of problem e.g. if the supplied water is fresh but water reaching to end point is contaminated then we can find till which region or end point the water reaching is fresh and not contaminated, its means till that point there is no problem, the problem is thereafter.

Some healthy measure can be taken such as turn off control valve automatically as water quality reduces to some predefined level and generate a warning message.

Algorithm: A pseudo code for raspberry PI is given below.

1. While (True):
2. Read control valve value
3. Is Control Valve Open = true
4. Read pH sensor value, temperature value, water flow value and conductivity sensor value.
5. Water quality value != good
6. Turn off control valve
7. Generate warming message
8. Calculate pressure from water flow
9. Upload pH sensor value, Temperature value, pressure value and conductivity sensor value to hosted database or cloud.

The raspberry PI also contains command handling code, which not motioned above in pseudo code, by which user can turn on/off water control valve.

IV. EXPERIMENTAL RESULTS

We have carried out an in-house experiment with three endpoints and attached a proposed device to all the three end points. We have supplied water to end points from an overhead tank. The attached proposed device sends sensors values to the database using a raspberry PI controller. Figure 2 shows all three devices with device number and location. With particular device number, the sensor values are shown with live updates. As soon as values in the database get

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updated the values on Web UI also get updated. For each particular device, a button is placed to on/off water control valve. The user can turn on/off the water control valve using web UI and manages the distribution.

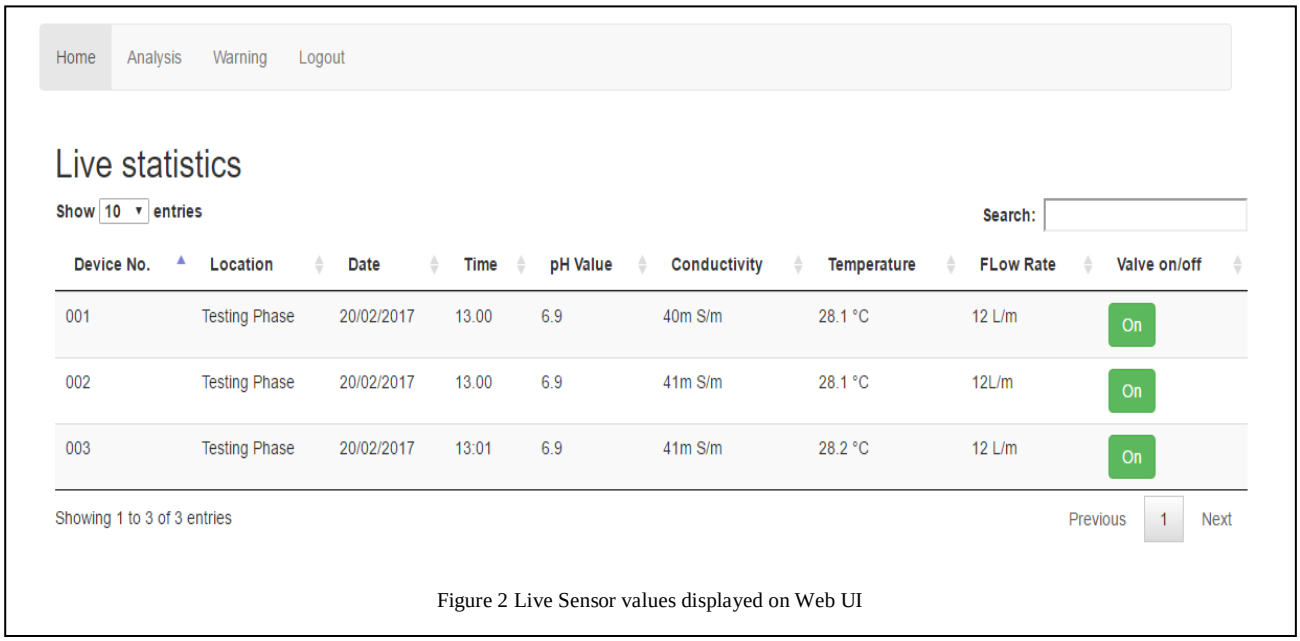

Figure 2 Live Sensor values displayed on Web UI

For analysis of water quality, we have implemented 2D graph with y-axis having quality measure and x-axis having time. Figure 3 shows graph of Temperature values v/s time of specific device ID 001 (end point), on specific date. As we have used overhead tank's water, obtained results of water quality are almost same for all three endpoints. Under warning tab, warning message is being generated when water quality is degraded or particular end point doesn't have minimum water pressure or predefined limit of water has been received by particular end point.

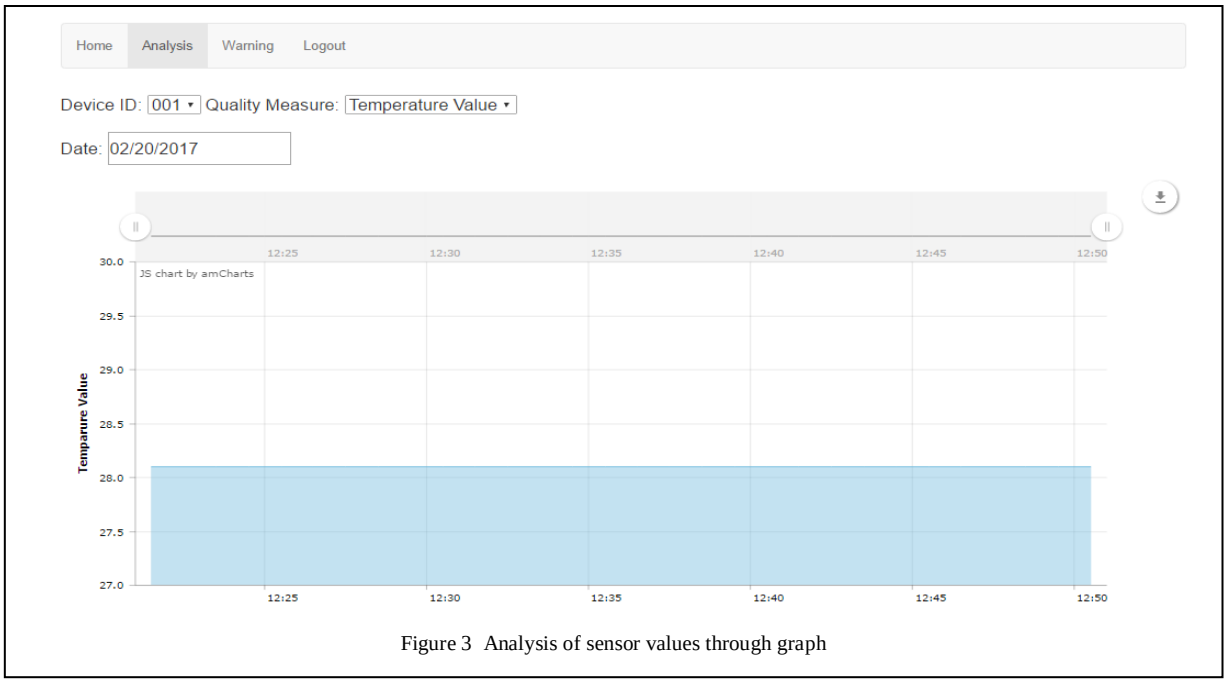

Figure 3 Analysis of sensor values through graph

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V. CONCLUSION

In this paper, the model of smart water distribution with water quality monitoring is presented. The proposed system is created with the use of different sensors, Raspberry Pi as controller and Cloud for storing the data from Raspberry Pi and sending the command to raspberry PI for measuring water quality and controlling water distribution. The generated data can be viewed using web interface all over the world. The advantage of the system is to provide the adequate water supply with pressure and good quality water to each house, industry, and others. The proposed model can be implemented as a part of the smart city.

VI. FUTURE WORK

In future, proposed system can be made fully autonomous by embedding the artificial intelligence with some predefined set of rules and standard. With the use of Artificial intelligence, smart water distribution can be carried out automatically without human intervention. If any problem is detected in water quality, the system will automatically send a notification to remotely handled devices to carry out necessary steps by the authorized person or dedicated authorities.

As per predefined interval, the proposed model generates data and sends it to cloud. Hence, proposed model generates a huge amount of data in the cloud. Therefore, some big data processing framework such as Hadoop framework will be required for analysis of generated data, for obtaining necessary information and generating the set of rules for training AI.

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