IoT Based Smart Water Supply Management and Control System

(Automated Water Management and Conservation System Using IoT)

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Abstract
In recent years the demand for water has increased manifolds, and this has become a major challenge throughout the world. Cities in Southern Africa and India are nearing Day Zero, where people will not have sufficient water for their day to day needs. One of the major reasons for this crisis is the lack of proper water management on a large scale. To overcome this problem we present an IoT based design for water monitoring and control approach which supports internet based data collection on real time basis. The device comprises of: a central server (Central Hub), the IOT Module, the switching unit and the Zigbee module. IoT is not a single technology; rather it is an agglomeration of various technologies that work together in tandem which uses sensors and testers. These are devices which help in interacting with the physical environment to determine the water level and quality. The centralized hub is responsible for supplying water to different substations. The substations are present at various key locations throughout the city, based on the requirements of that particular area, water is supplied to that substation. The IOT assists the Central Hub, in integration of communications, control, and information processing across the entire network. This aids us in determining the requiredvolume and quality of water, at each units in one particular sector and it also provides the control over the supply of water, to the central hubthrough a remote access,Based on the paucityor excess water level in a tank, the centralized hub monitors and shares the water among the localized tanks or resupplies water from its reservoir. This scenario requires an establishment of a personal area network which can be done efficiently through wireless connections. The quality of water can be improved by subjecting the water to UV treatment before supplying them to individual households. Fluoride content level along with hardness checking is also done using respective test meters.

Keywords
IoT, Central Server, Microcontroller, Substations

I. Introduction
Water is an essential element for the survival of life on earth irrespective of its purposes. The increasing demand for potable water has become a huge problem throughout the world. The growing demand for potablewater has also increased the need for an efficient water supply system. Improper water management in individual households, changes in climatic pattern and destruction of natural water bodies for commercial purposes has further exhausted the resources. Highly populated cities are the ones which suffer most, if the same situation prevails then it would only be a matter of years before pure water runs out completely in certain locations. Through this paper we would like to demonstrate a water management and control system which relies on IoT module for real time data processing. This system can ensure availability of potable water for all people within a specific geographic location, during dry seasons. The control to the IoT module and Central Server, which are proposed in this paper, will be given to the relevant authorities, which can further ensure the reduction in wastage of water. For this purpose, the IoT enhances the interconnections of the network, with the help of devices equipped with it like microcontrollers, sensors that completes the module. IoT itself is not a single entity, rather it is a cluster of various technologies working together in unit which uses various input and output devices for the processing of data. Theseappliances work as an interface between the physical environment and the module and helps us in determining useful data such as rate of flow, water quality etc. The data collected by the sensors has to be stored and processed which can be done in a remote server. We use Zigbee protocol which is currently gaining traction in theLower Power WANgroup, is anopenglobal standardand is designed specifically to be used in WPAN. The technology is economical and also reduces power consumption thus making it an ideal solution for our issue.All the process of this network is overseen by a Microcontroller, it helps us in formulating the required process, which is to conserve surfeit amount of excess water and ensure proper distribution of potable water for people over a particular location.These devices work together as one single module, through which we can monitor and control the supply and quality of water.This entire module will be under the control of appropriate public sector, so that they can analyze and oversee the supply of drinking water. Thus ensuring proper distribution of drinking water based on the demands in each area over that specific location.

II. System Architecture
The module consists of a PIC16f877a microcontroller which is then connected to various input and output devices such as sensors, WSN-3226, IoT module (Zigbee 3.0), User cloud, pumping motors, relays, etc. The Central server has the control to the entire network and thus controls all the supply mechanism of water over a particular geographic location. All necessary information such as water quantity, quality, pH level, etc. are collected by the central server, then these raw data are processed and transmitted to the data base via WSN-3226 module. The IoT module plays a vital role in interconnecting the user cloud, local devices and the Central server to the respective systems used for transmitting data to the database and also helps in implementing Zigbee to enhance the wireless connectivity of that area.

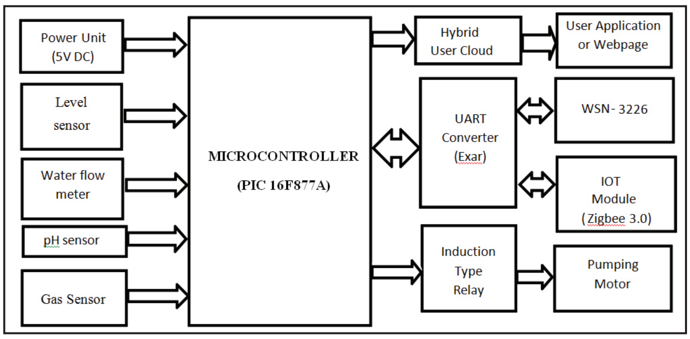

Fig. 1:

- The network comprises of a power supply unit, Microcontroller, sensors like pH Sensor, Flow meter, level sensor, gas sensor etc., pumping motors, IoT module, User cloud and WSN.

- The power supply unit used provides 5V DC which is sufficient for working of the entire network.
- The Microcontroller used in this system is PIC 16F877a which is a 40 pin microcontroller. The reason for using this microcontroller is that it is more advantageous features than many others like Flash memory, EEPROM, self-reprogrammable, has its own oscillator options etc.
- The pH sensor present in the network is used to determine whether the water is potable for drinking purposes. The pH sensor checks the potability of water by measuring the hydrogen-ion concentration in water and determines the acidity or alkalinity nature of water. The pH sensor is connected with the microcontroller to get the results digitally.
- The Microcontroller also gets data from a Gas sensor connected to it. This Gas sensor is present at individual units (water tanks), to check for any presence of toxic gases. Since water might be stored for prolonged periods, there is a chance for formation of methane and other harmful gases which can be detected using this sensor.
- The level sensor plays a vital role in determining the quantity of water required by each households, thus also determining the quantity of water required by individual areas. Continuous level sensor is attached to each unit which helps in calculating the required quantity of water.
- The User cloud has a dedicated web page that provides all required information such as water level, water flow speed, results from each and every sensors etc.
- Each unit is provided with two pumping motors: one inlet motor and one outlet motors. These two motors help in equal distribution of water to all the people over a a particular location.
- The IoT module consists of the IoT board which is designed to meet a variety of online applications. The module's UART feature and webpage control gives the network a distinct advantage. The IoT board is also aided with SIM900 GPRS modem which helps to connect with internet.
- The relays help to reduce the cost of individual units by connecting both the pumping motors together into the network. They help in switching on the required motor while turning off the other, so that water can be supplied without any interruptions.

III. Working

The main objective of this system is to ensure adequate water for all units (water tanks) brought under this system. This system can implemented over large areas like towns, cities etc. During the period of water scarcity, all available water resources of that particular area is brought under the control of a government sector and then the proposed network will help them in connecting these resources and ensures proper supply of water. Each individual unit in the network is connected to a substation and these substations are linked to the central server. The water in both, the unit and substation, are controlled by central server. If water in a unit runs out, the central server will either instruct the substation to either supply water from it or in case another unit within the control of the same substation has abundance of water will share the water among the units. If the water in the substation reduces below the advisable level then the Central Server will supply water from its water resource. These processes are carried out with the help of zignee protocol through WSN module.

The microcontroller and Database are present in the central server. The database helps in data sharing and communication with the user. The microcontroller aids in the water monitoring process. These both work together to determine whether the level of water in each tank is either greater or lesser than the prescribed level, and then the required process is carried out based on the information obtained. The central server not only analyses the water level in the user's water tank but also takes into consideration, other sources of water like rain water harvesting, RO plants etc., which are also connected to the network.

All the sensors used in the system, like pH sensor, leel sensor etc. are connected to the central server through the IoT module. The data collected from these sensors and various other devices are updated and stored in the user cloud. These data collected at the user cloud is processed and depending upon their results, distribution of water within the network takes place. To ensure efficient sharing of data through WSN module, UART converters are used. The relay motors used ensure that the supply of water to various units and substations takes place efficiently.

Water is collected form water resources such as reservoirs, lakes etc. by the central server. This water is sent to the substation based on its needs. Since water is directly fetched from some water resource, it is not guaranteed that the water supplied to substation is of drinking quality. To ensure the quality of water sensors like pH sensor, conductivity sensor and hardness sensor are installed to the substation. Based on the results from these sensors water purification process takes place within the substation. The purification process is done in several levels. Sedimentation tanks are the first level in purification process, since this is an easy, economical and efficient method, this is followed by processes such as RO treatment, UV treatment etc. After purification process the water is once again subjected to testing and if the results from all sensors are within prescribedlevels water is supplied to individual units. For these processes to happen a high speed data sharing and quicker water supply is needed, which is done using IoT module.

Each individual Unit (water tank) is also fitted with a pH sensor. Since water is stored for longer periods their properties might change, so pH sensors are used to ensure the potability of water in the unit. Each Unit also consists of a water level sensor and water flow sensor, to sense the water level and water flow rate respectively. The results obtained from these sensors can be viewed by the user using a user interface which can be in the form of a mobile application or a webpage. This user interface helps the user to analyze the quantity and quality of water that is supplied to them. If water at a particular unit is not used for a longer period of time (like days), the central server is made aware of this with the help of IoT module, the central server then removes the excess water from that unit using the outlet pumping motor and sends it to the substation for future use. Thus through this proposed system we can control the supply and management of water and also minimalize the excess wastage of water.

This system is mainly focused on helping the government to take charge of water management throughout the city or state during water crisis situation, thus reducing the wastage of water and also help in overcoming the crisis situation. The below diagram depicts the entire working process of the proposed network.

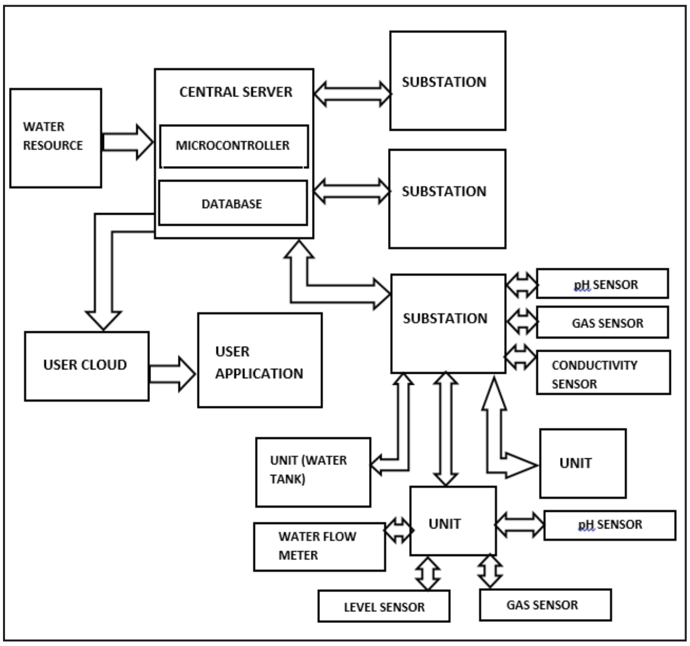

Fig. 2:

IV. Funtional Description

The functional decryption for the given system is as follows:

- All the hardware components are connected to a 5V DC power supply. The necessary configurations are done to the system and the entir network is established. Then these components are turned ON.
- The amount of calcium and manganese levels in water is updated to the user cloud with the help of hardness sensor present in the substation.
- Similarly, the pH sensor detects the acidity or basic nature of water at real time and sends these data to the user cloud with the help of IoT.
- At the user cloud, the data in the webpage are updated regularly with a time interval of 2 seconds, this helps in continuous monitoring of water quality and quantity.
- The data base receives all these real time values and it transports these data to the central server which then carries out the distribution and monitoring process efficiently.
- The IoT module along with the UART converter, WSN module, relays and pumping motors, helps the central server in communication and monitoring process with carious subsystems.
- The level sensor and the water flow meter together are responsible for measuring and updating the level of water in each unit to the central server.
- The water level is continuously monitored and updated to the central server with a time interval of every two seconds.
- If the water level in a unit goes below the preset level then the central server is made aware of this, with the help of IoT module, and it instructs the substation to supply water to that particular unit and subsequently turns on the pumping motor of that unit and thus water gets supplied to that unit.
- These processes takes place within few seconds or in case of some delays few minutes.
- Once the unit reaches the preset level, the central server turns off the motor, then the monitoring process gets started once again. This will be a continuous cycle till the end of crisis situation.

V. Results and Analysis

In this network the sensors like pH sensor, Water Level sensor and Conductivity sensor are connected with microcontrollerPIC16F877A and these sensors collects data and sends them to the database.The level measurement can be either continuous or point values. Continuous level sensors measure level within a specified range and determine the exact amount of substance in a certain place, while point-level sensors only indicate whether the substance is above or below the sensing point.. Generally the latter detect levels that are excessively high or low. The continuous level sensor measures the level of water at each units in terms of inches which is then converted to liters by user cloud. The water level is shown in liters.The graph is plotted by using sensor data. This sensor data are sent to the cloud using Wi-Fi module. The Water level sensor values measured over a period of five months is described below.

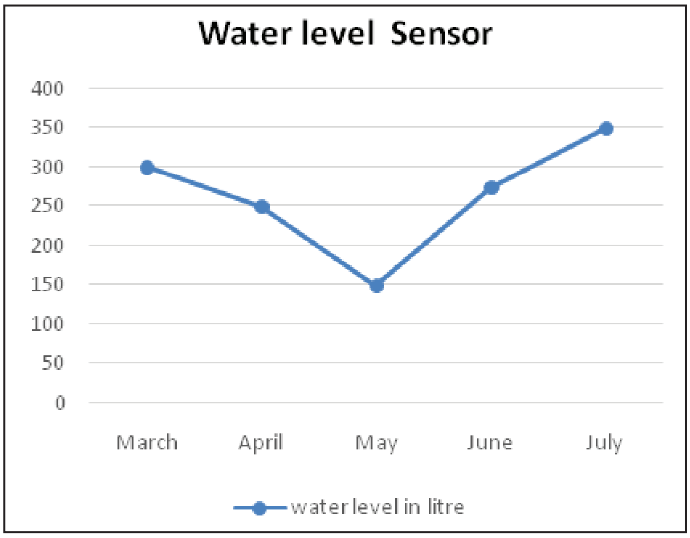

Fig. 3:

Potentiometric pH meters measure the voltage between two electrodes and display the result converted into the corresponding pH value. They comprise a simple electronic amplifier and a pair of electrodes, or alternatively a combination electrode, and some form of display calibrated in pH units. It usually has a glass electrode and a reference electrode, or a combination electrode. The electrodes, or probes, are inserted into the solution to be tested.

The design of the electrodes is the key part: These are rod-like structures usually made of glass, with a bulb containing the sensor at the bottom. The glass electrode for measuring the pH has a glass bulb specifically designed to be selective to hydrogen-ion concentration. On immersion in the solution to be tested, hydrogen ions in the test solution exchange for other positively charged ions on the glass bulb, creating an electrochemical potential across the bulb. The electronic amplifier detects the difference in electrical potential between the two electrodes generated in the measurement and converts the potential difference to pH units.

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The pH sensor values measured over a period of five months is described below.

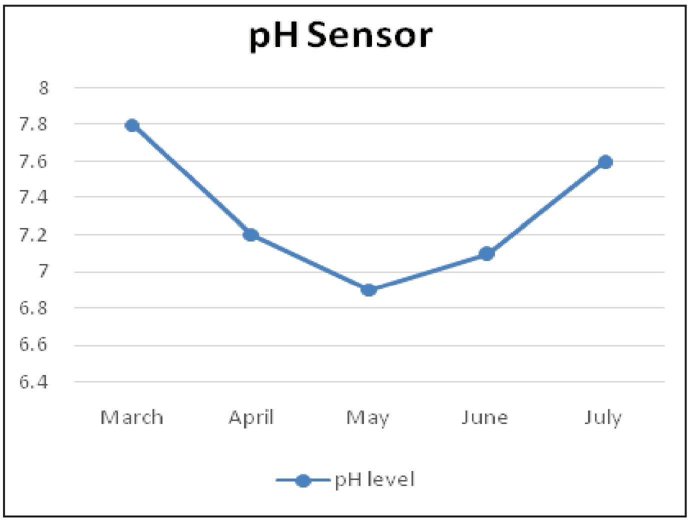

Fig. 4:

The conductivity sensor calculates the water's ability to conduct an electric current between two electrodes. In water the transportation of ions initiates current flow. Thus an increase in ion concentration increases the conductivity of water. The conductivity sensor values updated to the database over a period of five months (in µs/cm) is described below.

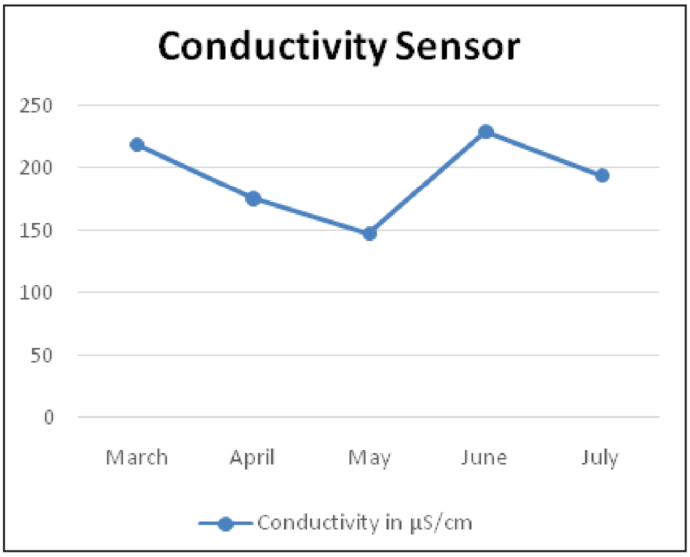

Fig. 5:

Thus by using our model we can monitor the quantity and quality of the water as well as improve it by various controlled purification systems such as UV and RO processes.

VI. Advantages

- Helps in conserving water resources over wide metropolitan locations.
- Helps to determine the exact water demands in the future.
- Centralized control over water distribution.
- Overall scarcity can be managed by interrupting the water supply and equally balancing the resources.
- It is a flexible system which allows utilities to be set for future objectives.
- The system will also help in reducing unbilled waters.

VII. Conclusion

Through this paper we have given a brief discussion about smart water monitoring and control across a particular location by harnessing the technological usage of IoT concept, and also simultaneously enhancing the quality of the Drinking Water. This system could be implemented by various government across the world to save the water bodies from drying up due to excess water usage. This system can also be implemented to reuse the water to prevent water wastage. Further this system can be enhanced by adding weather sensors which can be used to monitor weather pattern and compare those data with current water levels which will be helpful for predicting future availability of water.This system can also be further enhanced by including modules which could improve the given situation further in order to prevent the excess usage of water and saving Underground water table.

VIII. Acknowledgement

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