IOT based river water quality monitoring system using IBM Watson

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Contents:

Introduction:

Water quality degradation has been a grave problem that has been leftuntackled by the human society. Water covers 70% of the earths surface and 40% of it is already deemed as polluted.Every day, 2 million tons of sewage and industrial and agricultural waste are discharged into the world's water (UN WWAP 2003), the equivalent of the weight of the entire human population of 6.8 billion people. The UN estimates that the amount of wastewater produced annually is about 1,500 km3 , six times more water than exists in all the rivers of the world.

Worldwide, infectious diseases such as waterborne diseases are the number one killer of children under five years old and more people die from unsafe water annually than from all forms of violence, including war. (WHO 2002) .Unsafe or inadequate water, sanitation, and hygiene cause approximately 3.1 percent of all deaths worldwide, and 3.7 percent of DALYs (disability adjusted life years) worldwide. (WHO 2002). Unsafe water causes 4 billion cases of diarrhea each year, and results in 2.2 million deaths, mostly of children under five. This means that 15% of child deaths each year are attributable to diarrhea – a child dying every 15 seconds. In India alone, the single largest cause of ill health and death among children is diarrhea, which kills nearly half a million children each year. (WHO and UNICEF 2000).

Water pollution at any location cannot be dealt with the same solution so this project aims at providing an insight at the quality of water in a region thereby enabling a quicker and accurate solution. Integrated with IOT and IBM cloud services this could prove a simpler solution than most existing ones.

Problem statement:

Water quality has been devastatingly decreasing over the years wreaking havoc in our daily lives. Everyday hundreds of lives are lost due this issue. Various methods have been tried to maintain and upgrade the water quality but the primary problem till date is that a similar kind of solution is being implemented for any issue regarding water sources. But to tackle suvh a grave problem we need much more than a generalized solution, we need an answer that is specifically targeted at giving an accurate solution based in the locale.

Project Overview:

The project we have developed is intended to give us a better insight on the water quality of a specific locale thereby enabling us to develop a much better solution for that specific problem. For this we have used three sensors – turbidity sensor, temperature sensor and pH sensor connected to Arduino Uno board. This structural arrangement is simple to implement and handy to use. Since this project has been coupled with cloud services, the data can be easily accessed easily.

Technical requirements:

- NODE MCU
- Arduino Uno
- Turbidity sensor
- pH sensor
- Temperature sensor
- Arduino software
- Node red
- IBM cloud services
- MIT App inventor

Design Description:

pH sensor:

The ph sensor used in this experiment is a combination ph sensor i.e. it IS A type of electrochemical pH sensor that features both a measuring electrode and a reference electrode. The measuring electrode detects changes in the pH value while the reference provides a stable signal for comparison.

- pH Reading: 0 to 14
- mV Reading: -1250mV to 1250mV
- Solution Temperature: 0 to 100C
- Ambient Temperature: -40 to 70C
  (0C to 70C at rated accuracy)

In this Project, this sensor is used to get the pH

value of the water and finding the quality of the

water. Since the pH sensor has an analog input

we must connect it to the one of the analog inputs

of the auduino UNO board.

Temperature sensor:

Temperature is a crucial factor for determining the quality of water. The sensor used in this equipment is a ds18b20 model temperature sensor. This is a waterproof sensor that is cased in a stainless STEEL AND HAS OPEN END PROBES FOR EASY CONNECTIVITY.

Usable temperature range: -55 to 125°C (-67°F to +257°F)

Uses 1-Wire interface- requires only one digital pin for communication

Works with 3.3v as well as with 5v supply.

In this Project, this sensor is used to get the

Temperature of the water. Since the temperature

Sensor has an digital input we must connect it to

the one of the digital inputs of the auduino UNO board.

Turbidity sensor:

The Arduino turbidity sensor detects water quality by measuring level of turbidity. It is able to detect suspended particles in water by measuring the light transmittance and scattering rate which changes with the amount of total suspended solids (TSS) in water. As the TTS increases, the liquid turbidity level increases.

- Operating Voltage: 5V DC
- Operating Current: 40mA (MAX)
- Response Time : <500ms
- Insulation Resistance: 100M (Min)

In this Project, this sensor is used to get the

cloudiness of the water and finding the quality of the

water. Since the turbidity sensor has an analog input

we must connect it to the one of the analog inputs

of the auduino UNO board.

Arduino Uno:

The Arduino UNO is one of the many available open source microcontroller based on the AT328 microcontroller. It uses the Arduino IDE to interface with the computer wherein the user can code it to work as required.

In this project it is the central platform

That is connected to all the 3 sensors

(turbidity, temperature and ph). This is Also

Connected to the node mcu for Wi-Fi.

NODE MCU:

Node MCU is an open-source firmware and development kit that helps you to prototype or build IoT product. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The firmware uses the Lua scripting language.

In this project NODE MCU has been basically used as a wifi module for the Arduino uno board.

Wi-Fi module esp12e

Micro usb for power and data transfer

5v power supply

Arduino IDE:

The **Arduino integrated development environment (IDE)** is a cross-platform application (for Windows, mac OS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

In this project this ide is used for giving the input program of the 3 sensors to the Arduino uno board.

Node RED:

Node-RED is a flow-based development tool for visual programming developed originally by IBM for wiring together hardware devices, APIs and online services as part of the Internet of Things. **Node-RED** provides a web browser-based flow editor, which can be used to create JavaScript functions.

In this project node red has been used to create a flow structure for the entire circuit and the output has been monitored in the cloud as well as on a mobile app.

IBM cloud services :

IBM Cloud is a suite of cloud computing services from IBM that offers both platform as a service (PaaS) and infrastructure as a service (IaaS).

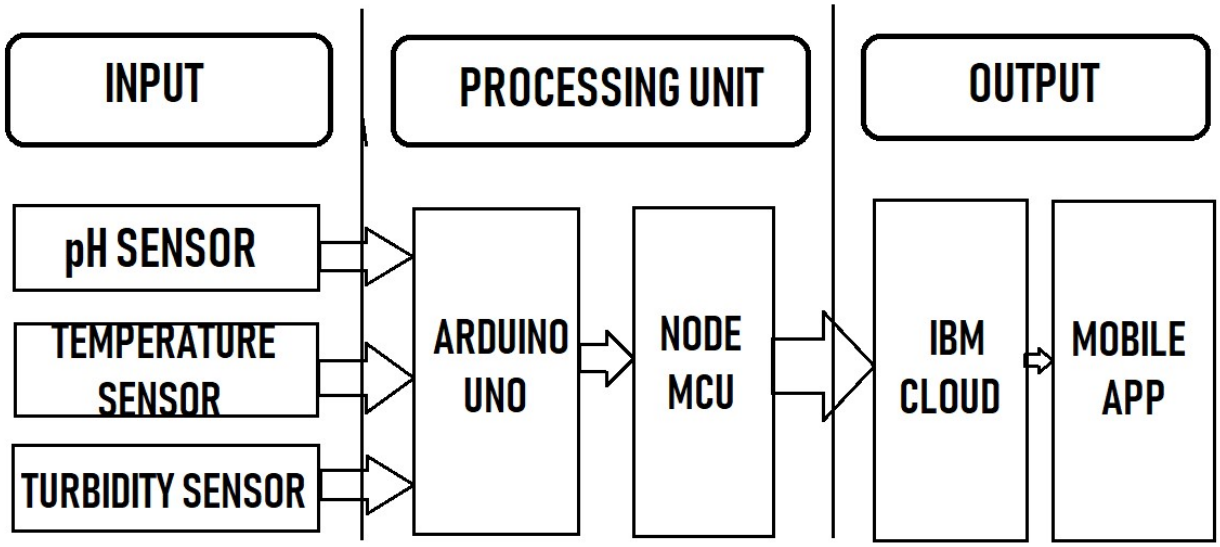
Ibm Watson is a question-answering computer system capable of answering questions posed in natural language, developed in IBM's DeepQA project.

In this project we have used ibm cloud services as a database for the outputs we obtain from the setup and Watson has been used as the processor for the simulation created.

MIT App inventor:

App Inventor for Android is an open-source web application originally provided by Google, and now maintained by the Massachusetts Institute of Technology (**MIT**), which allows newcomers to computer programming to create software applications for the Android operating system (OS).

In this project we have used MIT app inventor to develop a basic app that is cloud connected. It retrieves and displays data from the cloud. This app displays the temperature, turbidity and ph values determined the respective sensors.



BLOCK DIAGRAM FOR WATER QUALITY MEASUREMENT SYSTEM

Design Flow:

pH sensor:

The ph sensor in the equipment measures the ph value of a solution using the electricity flow between the reference electrodes and the normal electrode. This value is then converted to a pH value using the Nernst equation :

$$E_{cell} = E^{\circ} - \frac{RT}{nF}\ln(K_{eq})$$

The pH sensor is connected the arduino vcc,gnd,signal pins.

Temperature sensor:

Temperature sensor is a device, to measure the temperature through an electrical signal it requires a thermocouple or RTD (Resistance Temperature Detectors). The thermocouple is prepared by two dissimilar metals which generate the electrical voltage indirectly proportional to change the temperature. The RTD is a *VARIABLE RESISTENCE* , it will change the electrical resistance indirectly proportional to changes in the temperature in a precise, and nearly linear manner.

Turbidity sensor:

Turbidity is a property that is a result of particles of solid matter being suspended in water, rather than dissolved into it. If water is turbid it appears to be cloudy, so is a visual guide to water quality. Turbidity water testing is an important part of water quality maintenance.

Increased levels of turbidity raises water temperatures, because heat is absorbed by the suspended particles. Warm water holds less dissolved oxygen than cold, so increased water temperatures result in decreased levels of dissolved oxygen.

Arduino uno:

The Arduino Uno is a microcontroller board based on the ATmega328. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs), a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer (or appropriate wall power adapter) with a USB cable or power it with a AC-to-DC adapter or battery to get started.

Node MCU:

NodeMCUwas created shortly after the ESP8266 came out. On December 30, 2013, Espressif Systemsbegan production of the ESP8266.The ESP8266 is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core,widely used in IoT applications (see related projects). NodeMCU started on 13 Oct 2014, when Hong committed the first file of nodemcu-firmware to GitHub.Two months later, the project expanded to include an open-hardware platform when developer Huang R committed the gerber file of an ESP8266 board, named devkit

v0.9. Later that month, Tuan PM ported MQTT client library from Contiki to the ESP8266 SoC platform,and committed to NodeMCU project, then NodeMCU was able to support the MQTT IoT protocol, using Lua to access the MQTT broker. Another important update was made on 30 Jan 2015, when Devsaurus ported the u8glibto NodeMCU project,enabling NodeMCU to easily drive LCD, Screen, OLED, even VGA displays.

Arduino IDE:

The **Arduino integrated development environment (IDE)** is a cross-platform application (for Windows, macOS, Linux) that is written in the programming language Java. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

The source code for the IDE is released under the GNU General Public License, version 2. The Arduino IDE supports the languages C and C++ using special rules of code structuring.The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main()* into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution.The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

Node RED:

Node-RED is a flow-based development tool for visual programming developed originally by IBM for wiring together hardware devices, APIs and online services as part of the Internet of Things.

Node-RED provides a web browser-based flow editor, which can be used to create JavaScript functions. Elements of applications can be saved or shared for re-use. The runtime is built on Node.js. The flows created in Node-RED are stored using JSON. Since version 0.14 MQTT nodes can make properly configured TLSconnections.

In 2016, IBM contributed Node-RED as an open source JS Foundation project.

Description:

Initially, we connect the pH sensor, turbidity sensor and temperature sensor to the arduino UNO board based on the input types of each sensor

Now we will write the arduino code for each sensor and embed them in a single code and upload it to the arduino UNO board.

After checking the proper outputs of the sensors obtained after connecting all sensors to the arduino UNO, we must send these outputs to the Node MCU.

Node MCU has the wifi sensor which will help to send the data to the IBM cloud.So, the output values from the arduino board will be sent to the Node MCU.

After entering the credentials of the IBM cloud in the Node MCU code we will send the data to the IBM cloud and generate an API key inorder to retrieve data from the cloud.

To display the results in android mobile phone, we built an application to get the data from the IBM cloud and display them in the Android mobile.

Mobile application can be built using the platform MIT app inventor.

In this platform we will built an application that takes the data from the IBM cloud and display them on the Android Application.

In order to get the data from the IBM cloud to the MIT app, we must add the web components to the app and for each data we must call the API using valid parameters.

After obtaining the required values from the cloud we can display them on the mobile applicaton.

Conclusion:

The project here is a viable and simple solution to test water quality at any place. Since this equipment is connected to cloud storage the data can be easily accessed anywhere. The apparatus has been tested and has been proven to be quite successful.