Cloud Based Water Quality Monitoring System Using Nodemcu And Azure

CSE - 2

IoT PROJECT REPORT

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Water Quality Monitoring System using IoT and Cloud Computing

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I. Abstract

World Economic Forum ranked drinking water crisis as one of the global risk, due to which around 200 children are dying per day. Drinking unsafe water alone causes around 3.4 million deaths per year. Despite the advancements in technology, sufficient quality measures are not present to measure the quality of drinking water. By focusing on the above issue, In this paper we propose a low cost water quality monitoring system using emerging technologies such as IoT, Machine Learning and Cloud Computing which will replace traditional way of quality monitoring. This helps in saving the people of rural areas from various dangerous diseases and also some minor diseases such as fluorosis, bone deformities etc. In our project we also included temperature sensor which takes a linear regression equation build through temperature dataset and adjusts temperature of water so as to suit outside temperature. Based on our model we have achieved R-squared score of 0.933.

II. Introduction

Nowadays, Due to limited water resources and increasing population water has become a vital resource for mankind. Clean and safe drinking water is the most important resource for mankind. As most of the diseases these days spread through water there is a need for online real time water quality monitoring system. The methods used for water quality assessment at present involve collection of random samples of water at various locations weekly or monthly and analyzing them in the laboratories. This approach is not much efficient because they have various drawbacks such as long time consumption, only water samples from few areas can be determined simultaneously. This method also involves manual work to monitor the quality of water regularly. Theses methods are also costly and are not capable enough in large populated countries like India. In order to overcome these above mentioned drawbacks and to automate the process we are in need of real time system which monitors the sensor values such as pH, turbidity and temperature and updates those values in Cloud service.

Our system consists of several sensors which measure the chemical composition of water. These sensor values are then passed to NodeMCU microcontroller which has inbuilt WiFi module, using which the data is passed over to Azure Event Hub. From Event Hub data is stored in Azure Storage hub in the form of structured data. Thereafter we use Stream hub to stream the database to external services. PowerBI which is also a microsoft platform is used to display the sensor values in the form of Webpage. The sensors we used in this project are turbidity sensor and temperature sensor. We are also using MQTT client broker architecture to transmit data from microcontroller to external MQTT broker service.

Turbidity measures the large number of suspended particles in water that is invisible. Higher the turbidity higher the risk of diarrhea, cholera. Lower the turbidity then the water is clean. besides turbidity, pH is also an important measure which measures the acidic level of drinking water. Temperature sensor measures how the water is, hot or cold.

Other part of our project is to sense the external temperature near the water storage and control heater or cooler respectively depending on temperature. This part of project uses machine learning, where the system predicts the weather conditions using previous labeled dataset and controls heater and cooler according to external weather conditions. This makes our system completely automated without any manual interventions. Whenever the value of turbidity reaches predefined threshold an email alert will be sent to concerned authorities informing the situation, forcing them to take immediate action.

III. Literature Survey

Pradeepkumar M, Monisha J, Pravenisha R, Praiselin V, Suganya Devi K entitled “The Real Time Monitoring of Water Quality in IoT Environment”. This paper discusses not only sensor based system but also it introduces cloud computing architecture into IoT which makes the sensor data accessible worldwide.

Nikhil Kedia entitled “Water Quality Monitoring for Rural Areas-A Sensor Cloud Based Economical Project.” This paper not only highlights embedded sensor systems, but also discusses the challenges and economic viability of the system involving Mobile Network Operator and Government. This system directly contacts Government to take action based on the severity of quality issue.

R.Karthik Kumar, M.Chandra Mohan, S.Vengateshapandiyan, M.Mathan Kumar, R.Eswaran entitled “Solar based advanced water quality monitoring system using wireless sensor network” uses solar node to power the wireless sensor network and displays results using GUI created through Matlab.

Jayti bhatt, Jignesh patoliya entitled “IoT based water quality monitoring system”. This paper shows the design of water quality monitoring system using pH, turbidity, dissolved oxygen and temperature sensor. It uses raspberry Pi as core controller and used Zigbee protocol to transmit data remotely.

Fiona Regan, Antóin Lawlor and Audrey McCarthy, "Smart Coast Project– Smart Water Quality Monitoring System”, designed smart water quality monitoring system. In that system they made water quality smart sensors so the sensors send data wirelessly to the device which collects data from all the nodes. This system is highly scalable, faster and user friendly, but it is costly because of type of sensors used.

Vaishnavi V. Daigavane, Dr. M.A Gaikwad entitled “Water Quality Monitoring System Based on IOT”. This paper measures Turbidity, pH and also flow of water using flow sensor. This paper shows the most economical and convenient method of water monitoring system by using the existing GSM network to transmit sensor values.

ZulhaniRasin and Mohd Rizal Abdullah, “Water Quality Monitoring System Using Zigbee Based Wireless Sensor Network,”. This paper uses ZigBee based wireless sensor network to develop water quality monitoring system. This paper also shows the usage of c++ to create a GUI to make the data publicly accessible.

IV. IoT Architecture

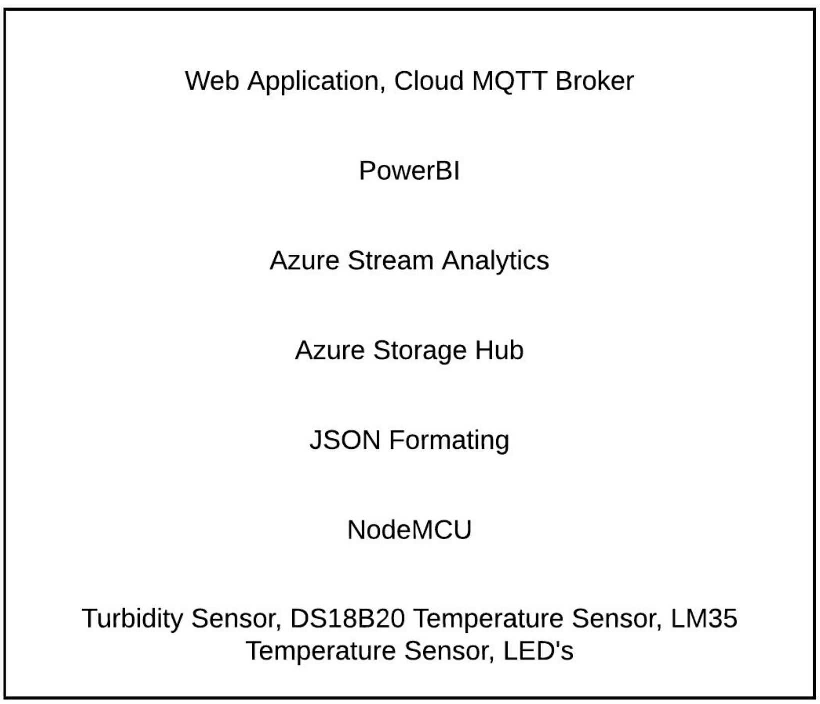

Figure 1: IoT Reference Model

Layer 1: Layer 1 consists of all the sensors such as Turbidity sensor, Temperature sensor and actuators such as heater or cooler LEDs.
Layer 2: To ensure reliable communication between devices and cloud we choose WiFi as connecting technology such that there is reliable delivery of messages across the network.
Layer 3: Azure Event hub only accepts the data which is in structured format. So, Before sending the data to cloud, it is formatted to a JSON packet and then sent to Azure Event Hub.

Layer 4: For data accumulation we are using Azure storage hub to store the data on cloud servers which ensures reliability and cost effective. Several instances of data is also made which ensures backup ability in case of physical damage of main server.
Layer 5: Data from Storage hub is transmitted to Azure stream analytics which makes data accessible to other devices outside azure who have access to data.
Layer 6: For analytics and reporting we are using PowerBI which is a Microsoft tool for data analysis and visualization part of data.
Layer 7: We built a web application where user can enter his credentials and login into web page, where he can access all the visual charts which depict the quality of water. Besides web page to demonstrate working of MQTT we used an MQTT broker to transmit the data from client which is our gateway to broker which is cloudMQTT.

V. Proposed Algorithm

First part of our algorithm is to send an email alert to concerned authorities when there is compromise in quality. To achieve it first we take value of turbidity from turbidity sensor. Then we initialize count to a threshold limit which defines number of times to send an email before taking action. This makes sure that emails are not sent continuously. Then based on the value of count and turbidity we call sendEmail function which sends a Email to authority with turbidity values so that he can take necessary action and resolve the issue.

Algorithm 1 Sending Email

---

1. *turbidity = getTurbidity()*
2. *count = Threshold limit*
3. ***if** turbidity < 3.5 **then***
4.   ***if** count > 0 **then***
5.   *sendEmail()*
6.   *count = count - 1*
7.   ***endif***
8.   *polluted = true*
9. ***endif***

Next part of our algorithm is to control heater and cooler based on external temperature. After receiving temperature values we check weather the outside temperature is hot or cold. If it is hot ie., temperature is greater than 30 degrees, then we check temperature of water, if it is greater than 10 degrees then we switch on the cooler and switch off the heater. Similarly if it is cold outside heater gets on and cooler is switched off.

Algorithm 2 Adjusting temperature

```
External temperature = getExternal()
Temperature = getTemperature()
if External temperature > 25 then
    if temperature > 15 then
        heater = OFF
        cooler = ON
    endif
endif
if External temperature < 10 then
    if temperature < 15 then
        heater = ON
        cooler = OFF
    endif
endif
```

We also used machine learning model to predict the temperatures of environment and feed those temperature values to microcontroller so that the process of temperature management is automated even without the need of external temperature sensor. The model we used to extract temperature is linear regression model. In linear regression the target value is expected to be a linear combination of the input variables.

In mathematical notation, if $\hat{y}$ is the predicted value.Across the module, we designate the vector as coef_ and w_0 as intercept_.

$$y(w,x) = w_0 + w_1x_1 + \ldots.w_nx_n$$

According to our dataset, sklearn linear regression module predicted

coef_ as [-0.00056244 , 0.19589288] and intercept_ as 24.80431407431011.

So, our equation to predict temperature is as follows:

$$y(year, month) = 24.80431407431011 + year(-0.00056244) + month(0.19589288)$$

VI. Experiment And Simulation Setup

Block Diagram

Figure 1 shows the complete block diagram of project. The block diagram consists of temperature sensor, turbidity sensor, external temperature sensor, NodeMCU microcontroller, power supply, Azure cloud platform and website display. Azure cloud platform has 3 sub blocks, Event hub, Storage unit and Stream hub. The event hub acts as a first line of interface between the sensors and azure cloud. Event hub then transfers the data to storage unit of azure. Then we use stream hub to export the data to powerBI.

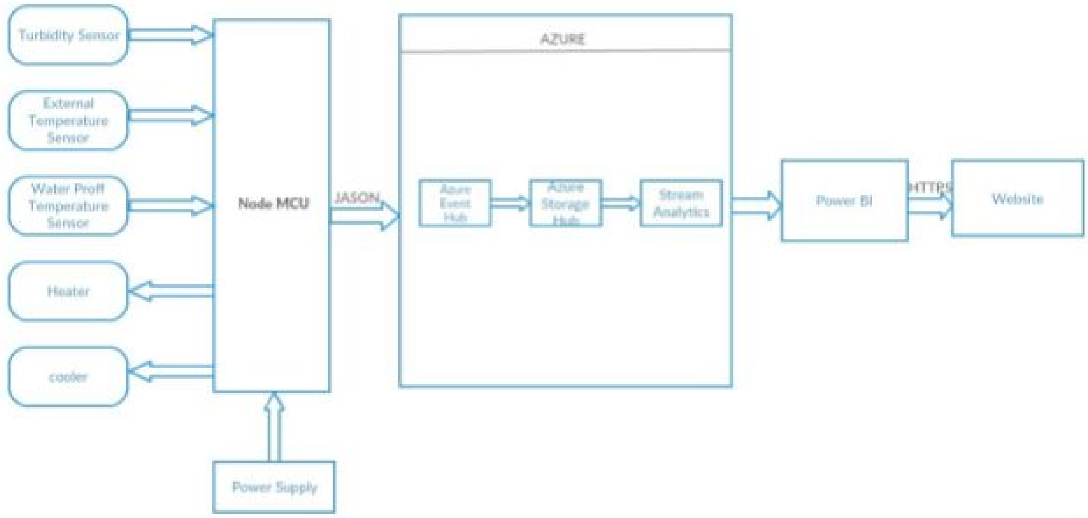

Figure 2: Block Diagram

Different hardware and software platforms used in our project are listed below:

NodeMCU: NodeMCU is a microcontroller with inbuilt wifi module present. This makes it suitable for IoT models involving less number of sensors or actuators. it runs on 3.3v. It has 17 GPIO pins and 1 analog pin. It supports 802.11 b/g/n. It is also economical when compared to other microcontrollers.

Turbidity Sensor: Turbidity is the quantitative measure of suspended particles in a fluid. When the value of turbidity is less than 3.5 NTU then water is said to have dissolved solids in it. If it is greater than 3.5 NTU then water is safe to drink. It consumes operating current of 40mA.

To interface turbidity to NodeMCU we followed the below connections:

- Connect the data signal to analog pin of NodeMCU.
- Connect the ground pin to ground of microcontroller.
- Connect the voltage pin to 3.3v of microcontroller.

LM35: To sense the external temperature we used LM35 module. It has temperature range of -55 to 150 degrees centigrade with an accuracy of 0.5 degree centigrade. It operates from 3V to 30V voltage range.

DS18B20: Water Temperature indicates how water is hot or cold. To measure temperature we are using waterproof DS18B20 temperature sensor which has are range from -55 to +125 °C. This temperature sensor is digital type which gives accurate reading.

Azure: Azure is a cloud platform created by Microsoft for deploying and testing applications. Azure has an IoT portal which helps to transfer sensor values from gateway to websites or database in the form of JSON packets.

PowerBI: Power BI is a business analytics service provided by Microsoft. It provides interactive visualizations where end users can create reports and dashboards. We used powerBI for visualization and analytics part of our project.

VII. Results and Analysis

In this project, the implemented several sensors that are used to determine the contamination of water and the results were produced. We used low cost sensors and hence the implementation cost for this system is minimal. Moreover, efficient algorithms are also being used here to co-ordinate the information collected by the sensors and hence there is no data loss and also the efficiency of transmission is increased. Whenever the quality of water is below threshold an email will be sent alerting concerned authorities.

Figure 3 shows the complete hardware setup of the project, which includes NodeMCU, turbidity sensor, DS18B20 and LM35 temperature sensors connected through breadboard.

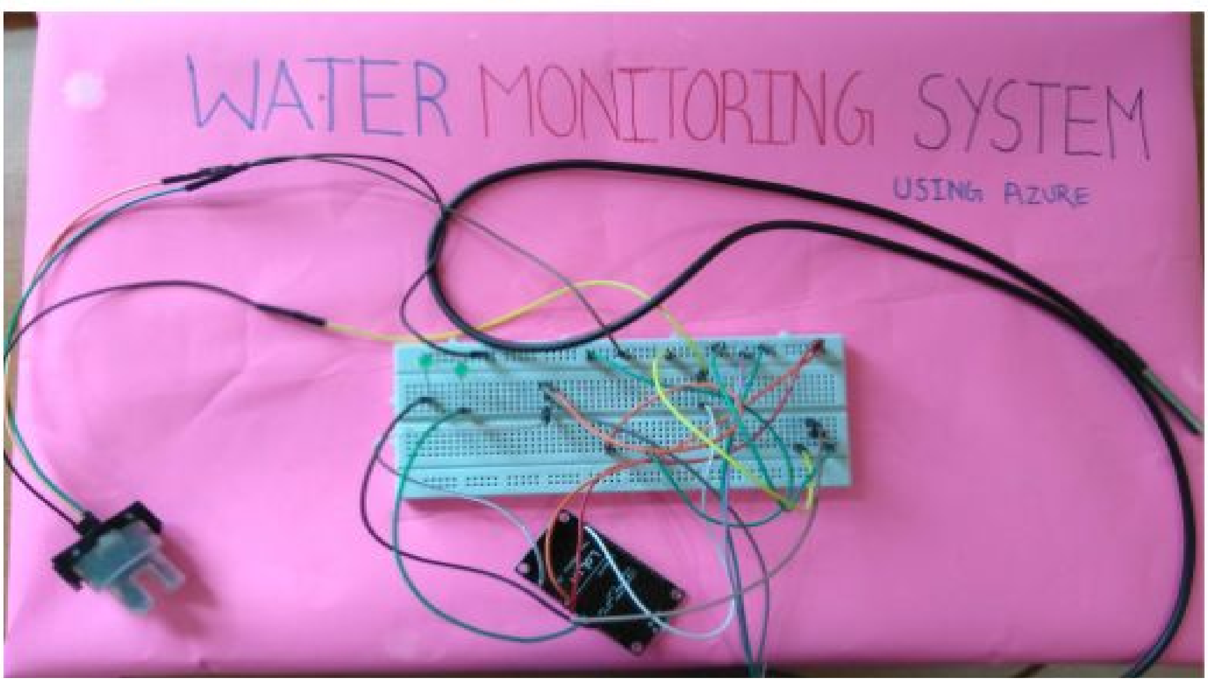

Figure 3: Hardware setup

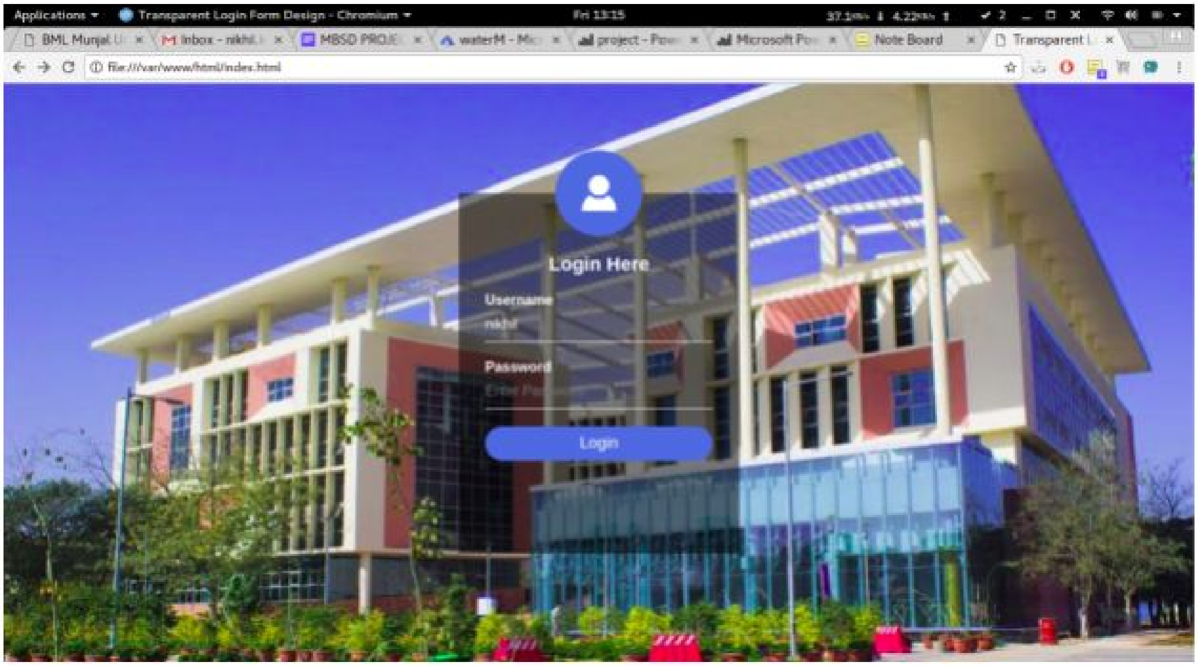

Figure4: Website

Figure 4 shows the login portal of our webpage, through which authorized users can login and get access to the sensor values in visualized form as shown in Figure 5.

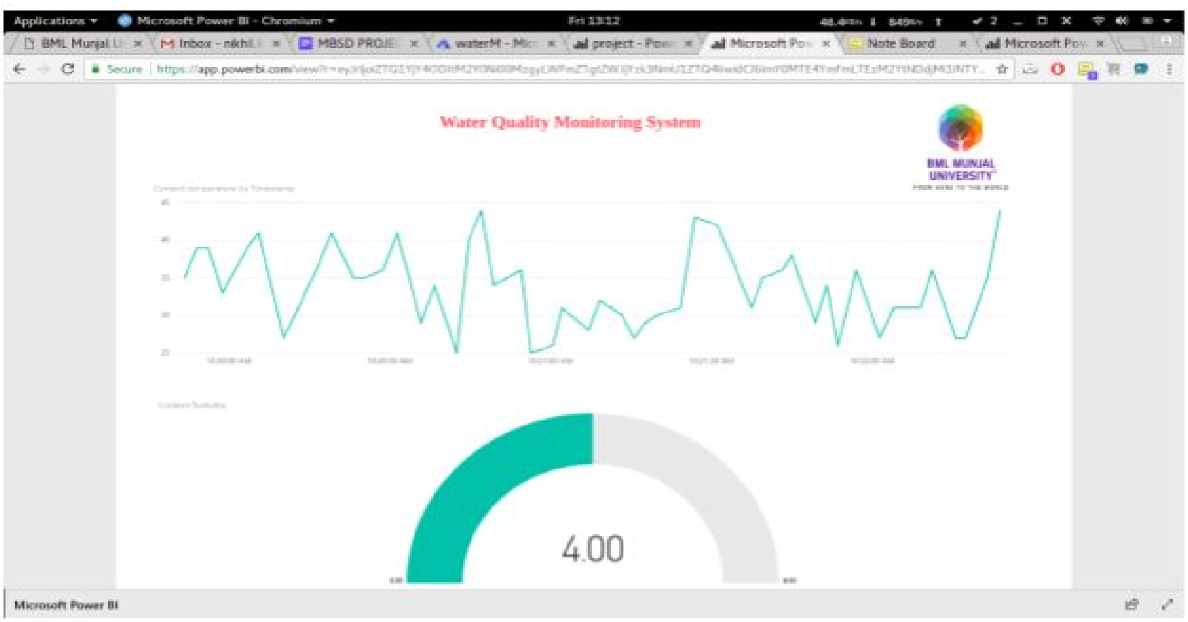

Figure5: Website

Figure 6 shows number of messages transferred through Stream analytics job in Microsoft azure cloud platform.

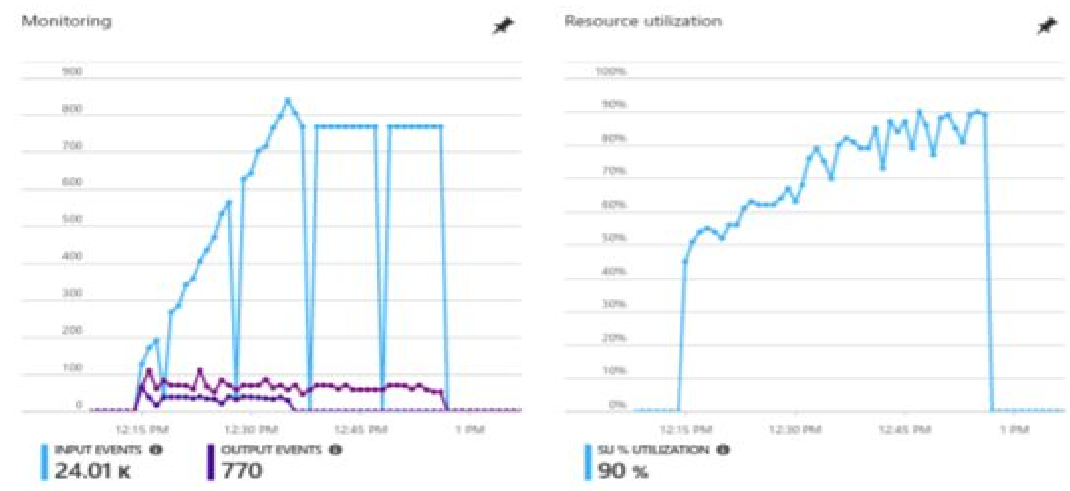

Figure6: Stream Analytics Job

VIII. Conclusion and Future Work

This paper presented a practical and economical solution to real time water quality monitoring system which does not require an human intervention especially for rural areas using sensor cloud mechanism. We used latest technologies such as cloud computing, machine learning and IoT to solve this problem.

Future work:

- As future work we can integrate this system with state and central government workflow enabling fast response rate from government depending on the problem.
- Since most of the villages in contemporary India doesnt have wifi access we can add a Mobile GPRS module to our system enabling it to transmit data over 2G or 3G channel.
- Adding more quality sensors can improve our results and thus making our system effective.

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