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# IoT Based Automated Fish Farm Aquaculture Monitoring System

Sajal Saha
*Departement of Computer Science and Engineering*
*Patuakhali Science and Technology University*
Patuakhali, Bangladesh
sajal.saha@pstu.ac.bd

Rakibul Hasan Rajib
*Departement of Computer Science and Engineering*
*Patuakhali Science and Technology University*
Patuakhali, Bangladesh
rajib3hasan@gmail.com

Sumaiya Kabir
*Departement of Computer Science and Engineering*
*Green University of Bangladesh*
Dhaka, Bangladesh
sumaiya@cse.green.edu.bd

***Abstract*—Internet of Things (IoT) is a very fast growing technology and the field of IoT is extending its wings in every one of the areas today. With the progression in computers like Arduino, Raspberry pi, the innovation is achieving the ground level with its application in farming and aquaculture. In this work, we have outlined and actualized monitoring of water quality of aquaculture utilizing Raspberry Pi, Arduino, various Sensors, Smartphone Camera and Android application. Water quality parameters used in this work are Temperature, pH, Electrical Conductivity and Colour. Sensor acquisition is conducted by Arduino and Raspberry Pi is used as data processing device as well as server. Photo acquisition is also performed by Raspberry Pi with the help of the smartphone camera to detect the colour of the water. Android phone is used as the terminal device. A user can monitor the water condition using an android app through Wi-Fi within Wi-Fi range and through Internet from anywhere in the world. Some analysis is performed with the four parameters value to determine the overall approximate condition of the water and required action. Every feature in this checking gadget can work legitimately and easily.**

***Keywords—Internet of Things (IoT), Aquaculture, Water Quality Monitoring, Raspberry Pi, pH, Temperature, Conductivity, Water Colour, Sensors, Wi-Fi, Internet, Smartphone.***

## I. Introduction

Aquaculture is one of the thriving areas in many countries in the world since demand for fish and the fish prepared food is expanding day by day. According to The United Nations Food and Agriculture Organization (UNFAO) "2012 State of World Fisheries and Aquaculture ", Worldwide yearly production of fishery items add up to around 128 million tons. The animal protein intake per individual is about 15% and increase the human reliance on fishery resources. The average consumption of fish products is 19 to 20 kg per person per year today and will be 16.7 kg per year in 2030 according to UNFAO. Production of fisheries, advancement and future food needs are firmly related [1].

Aquaculture comprises of the set of exercises, information and techniques for the rearing of aquatic plants and a few animal groups. This activity has an awesome significance in financial improvement and food production. Commercial aquaculture is confronting numerous issues because of sudden climatic vacillation leading to changes in water quality parameters. Aqua farmers are relying upon manual testing for knowing the condition of the various parameters of the water. But this manual testing is time consuming and also give inappropriate results as parameters for measuring water quality changes continuously. It will be better if automatic monitoring can be done somehow. So modern technology should be brought to aquaculture to overcome this problem. For rural development, technologies have to support several key application areas, for example, living quality, wellbeing, environmental change etc. [20]. So we have to be more selective in choosing the appropriate technologies for this kind of advancement.

An integrated on chip computer Raspberry Pi is used in our system as data processing and storing device which has an inbuilt Wi-Fi module. Using the Dataplicity service we can also access the Raspberry Pi through internet [18]. So, no additional Wi-Fi or Internet module is required. Smartphones are very obtainable and most of the smartphones have Media Transfer Protocol(MTP) today. Using these and performing some analysis on the water quality parameters make our work unique.

## II. Literature Review & Realization

A few papers in literature overview centers around how the aquatic life will impact because of progress in water quality parameters [2] and how IoT is utilized to overcome the issue. A great deal of research work is done with IoT to take care of this kind of issues as recently IoT is achieving the ground level with its application to agriculturists [3], [4].

A lot of numbers of the papers focuses on few kind sensors like pH, DO, Turbidity [5], [6], [7] and so forth and a solution for those issues. Be that as it may, the optimum fish production is absolutely subject to numerous chemical, physical and biological characteristics of water to the vast majority of the degree Thus, effective pond management requires a realization of water quality. Water quality is determined by factors like Dissolved Oxygen (DO), temperature, turbidity, transparency, water colour, pH, carbon dioxide, alkalinity, hardness, conductivity, salinity, TDS, unionized ammonia, nitrate, nitrite, primary productivity, plankton population, BOD, etc. [8].

K.Raghu Sita Rama Raju and G.Harish kumar Varma (2017) performed a work entitled as “Knowledge Based Real Time Monitoring System for Aquaculture Using IoT” which uses several sensors such as Dissolved Oxygen, Temperature, Ammonia, Salt, pH, Nitrate and Carbonates [9]. But maintaining lots of sensors is costly and tedious. So a system is needed which is not much costly and can

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determine the overall quality of the water effectively. This is the point which is the base of our research.

After a lots of study, we have realized that all parameters need not to be monitored. Because there are some parameters whose imbalances cause the imbalances of other parameters and from the quantity of some parameters we can assume the condition of others. We have taken temperature, pH, conductivity, water colour as our first, second, third and fourth working parameters respectively. Now we will mention the reasons behind this.

Temperature pronouncedly affects biological and chemical procedures. Rates of biological and chemical responses double for each 10˚C increment in temperature in general. Temperature significantly influences chemical treatments. Fish have poor resistance to sudden changes in temperature. Often, a quick change in temperature of as low as 5˚C will stress or even slaughter fish [10]. pH, DO, conductivity, salinity etc. are directly dependent on temperature [8], [10], [11], [12]. So, temperature should be in the expected range first before checking other parameters. General threshold range for temperature is 21˚C-33˚C [9] which can be maintained easily. For these reasons, we consider temperature as our first working parameter.

The pH is a ration of the hydrogen ion concentration and designates whether the water is acidic or basic in reaction. Phytoplankton and other marine plant life eliminate carbon dioxide from the water during photosynthesis, so the pH water body increases during the day and drops during the night. Waters with low aggregate alkalinity regularly have pH estimations of 6 to 7.5 preceding sunrise, however when phytoplankton development is substantial, at evening pH esteems may ascend to 10 or significantly higher [10]. The pH of natural waters is significantly impacted by the convergence of carbon dioxide which is an acidic gas [8]. pH changes in pond water are for the most part affected via carbon dioxide and ions in harmony with it. Control of pH is necessary for diminishing ammonia and $H_2S$ poisonousness [11]. We see that pH is directly or indirectly related to many other parameters and controlling it is comparatively easier. That's why pH is our second consideration.

Salinity is characterized as the aggregate concentration of electrically charged ions (anions – $HCO_3^-$, $CO_3^-$, $SO_4^-$, $Cl^-$; cations – $Na^+$, $K^+$, $Ca^{++}$, $Mg^{++}$ and other constituents such as $NH_4^+$, $NO_3^-$ and $PO_4^-$). Salinity is a noteworthy driving element that influences the density and development of aquatic being's populace [8]. By and by, one is rarely able to measure concentration of all ions in water. A conductivity sensor can be used to quantify conductivity and estimate the approximate salinity and there is relationship between conductivity and TDS [10]. Conductivity of water relies upon its ionic fixation and varieties of dissolved solids. So, it is enough to measure only conductivity instead of measuring TDS and other ions individually. Salinity is our third consideration for these.

The colour of the water gives a sign of what kind of turbidity it is. If it is greenish, it is due to plankton and if it is brown, it is often due to clay [12]. If water is clear, it indicates low biological production - not sufficiently fertile and fish won't develop well in it. Muddy water is not good fish culture because fish can have their gills obstructed by the clay particles and this can bring about death. Dark green water demonstrates over-generation of planktons that are served as food for fish yet happen because of utilization of more than sufficient composts, excrement or supplement rich sustains to a pond. Bluish green/ brown greenish, green colour of water indicates good plankton population thus, useful for fish wellbeing [8].

DO is one of the most important factors in aquaculture. But we are not measuring this because DO decreases as the temperature and salinity (conductivity) increase and increases as the temperature and salinity (conductivity) decrease. Again, it also fluctuates in a similar fashion to pH level [11], [12]. So, we can expect that if temperature, pH and conductivity are balanced, DO will also be balanced. Then we can again assume the condition of DO in water from its colour such as greenish water colour implies that there are sufficient DO as adequate amount of DO develops phytoplankton which makes the water greenish.

Acceptable range and desirable range of the four parameters are shown in TABLE I.

TABLE I. RANGES OF THE PARAMETERS

| Sr. | Parameter | Acceptable range | Desirable range | Stress |
|---|---|---|---|---|
| 1 | Temperature (˚C) | 15-35 | 20-30 | <12, >35 |
| 2 | pH | 7-9.5 | 6.5-9 | <4, >11 |
| 3 | Conductivity (µS/cm) | 30-5,000 | 60-2,000 | |
| 4 | Water colour | Pale to light green | Light green to light brown | Clear water, Dark green & Brown |

## III. PROPOSED METHOD & SYSTEM ARCHITECTURE

This section comprises of two subsections which are the introduction of required hardware and software technologies and description of the functionality of the architecture.

### A. *Required hardware and software*

*1) Sensors:* Analog pH Sensor for Arduino (SEN0161) from Dfrobot (shown in Fig.1(a)) is used to measure pH of water in this work. This pH sensor is specially intended for Arduino and has built-in convenient connection and features. A BNC connector is required to connect the sensor with Arduino. The range of this sensor is 0-14 pH. It has an accuracy of ±0.1 pH at a standard temperature of 25ºC and operating temperature range is 0-60°C. Just a few sections of the sensor may be inserted into the water. The reliability of this pH sensor can last for a half year when the water is clean and one month for water with high turbidity [13].

Analog EC (Electrical Conductivity) meter for Arduino (DFR0300) from Dfrobot (shown in Fig.1(b)) is used to measure EC. This EC sensor also has inbuilt simple connection and features and is also specially intended for Arduino. Temperature sensor (DS18B20) connected to the connecting terminal of the terminal sensor adapter is also required as EC is dependent on temperature and a BNC connector is required to connect the EC sensor with Arduino. This sensor has an accuracy of <±10% F.S and operating temperature range is 5-40°C [14].

We also use Waterproofed DS18B20 Arduino Temperature sensor (DFR0198) from Dfrobot (shown in

Fig.1(c)). It has ±0.5°C accuracy from -10°C to +85°C. The upside of this sensor is just required one pin data communication for multiple sensors at once. One Wire Library for Arduino is used to measure temperature with this sensor [15].

(a) pH (b) EC (c) Temperature

Fig.1 Sensors

*2) Arduino:* As the sensors we use in this work are specially designed for Arduino, we use Arduino for sensor acquisition. Our Arduino version is Arduino UNO (shown in Fig.2).

Arduino Uno is a microcontroller board which is based on the ATmega328P. It has 6 analog input pins and 14 digital input/output pins. Its operating voltage is 5V and recommended input voltage range is 7-12V. Arduino IDE is required to program it. Arduino Uno should be connected to computer with USB cable to be programmed through USB-to-serial converter. It can conduct data communication with computer via serial port [16].

*3) Raspberry Pi:* The central processing unit of this work is Raspberry Pi3 (shown in Fig.3) which is the heart of this system. Raspberry pi3 is small, low cost computer board using Noobs, a Debian version of the Linux operating system. It has higher speed and number of processor core than previous versions of Raspberry pi. It has already inbuilt Wi-Fi and Bluetooth [17]. Raspberry pi can conduct serial data communication with Arduino as it is a small computer.

Fig.2 Arduino UNO

Fig.3 Raspberry Pi3

*4)Android Smartphone with MTP:* Any android smartphone with Media Transfer Protocol (MTP) can be used in this purpose. MTP permits media files to be exchanged atomically to and from portable devices.

*5) Dataplicity Service:* If Dataplicity Agent is installed on our device (Raspberry pi), it will sharply set up and keep up a secure HTTPS association with the Dataplicity IoT Router. We can access our Raspberry pi covered by Dataplicity anywhere as it has a viable internet connection. Fig.4 shows the total process [18].

Python programming language, Python Imaging Library(PIL), various Linux commands, HTML, CSS, PHP, MySQL database, Android apps etc. are also utilized

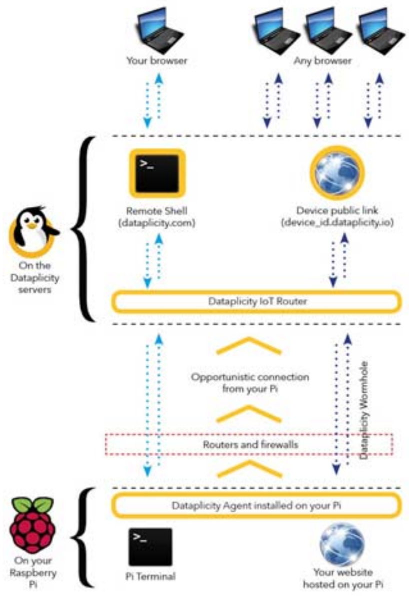



Fig.4 Working process between Raspberry pi and Dataplicity

## B. *System architecture*

Now we will describe the architecture of our proposed monitoring system. Fig.5 shows the general scheme of our monitoring system.

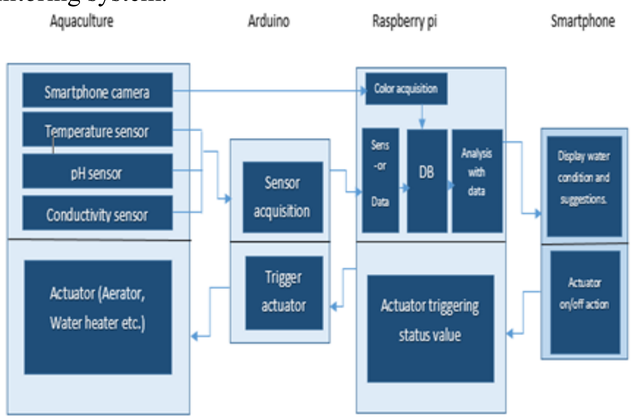



Fig.5 General scheme of the system

Temperature, pH and conductivity sensors are connected with Arduino and the Arduino is connected with Raspberry pi with A B USB cable to conduct serial communication. Sensor data acquisition is performed by Arduino program. The Arduino program prints the data in the serial line. There is a python program in the Raspberry pi which receives the sensor data form the serial line and stores the sensor data and time in the MySQL database installed in Raspberry pi.

An android smartphone with MTP activated is connected with Raspberry pi through USB cable. We have built an android camera app which is installed in the smartphone and continuously captures image of the water and save in the phone memory. Fig.8(a) shows the screenshot of the camera app. Raspberry pi copies the image from the phone to its own drive using a python program. Another python program extracts the RGB value of the total image using PIL library and saves the value in the database. From the RGB value we can assume the colour of water. Image capturing is very challenging here because water can exhibit colour variation due to gloomy weather, intense sunlight, shadow of the tree on bank of the pond etc. So we should capture image in a certain effective way. We can capture image at the midday when there is intense sunlight with special shading as Fig.6.

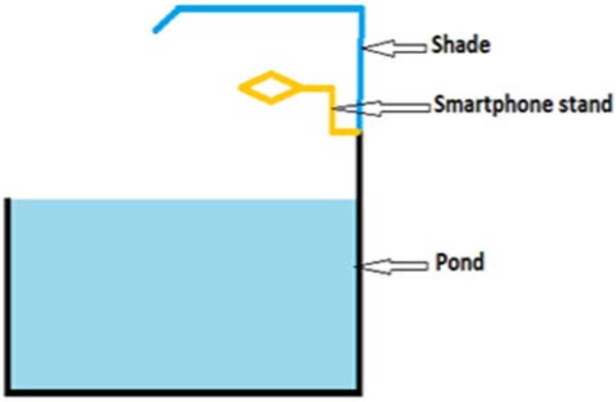



Fig.6 Image capturing system with shading

Then a webpage retrieves the data from the database using PHP and shows the values of all parameters are in the expected range or not. The webpage also gives suggestion about what actions should be taken according to the condition of the water. Suggestions giving program can be shown in the following flowchart in Fig.7.

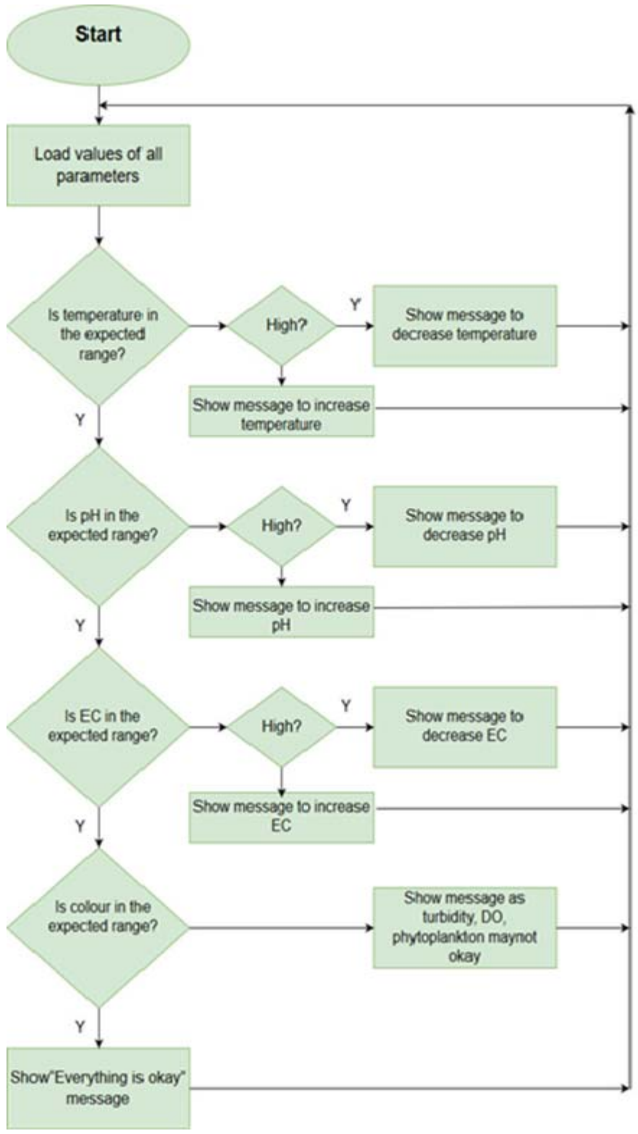
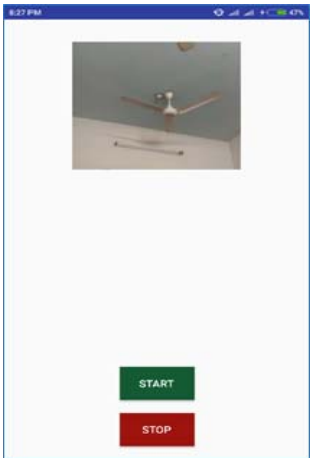



Fig.7 Flowchart of the suggestion giving program

Then we have created an android app named as FCM (Fish Culture Monitoring) which loads the webpage. Clicking the app users will get a screen (shown in Fig.8(b)) where they can select Wi-Fi or Internet before viewing the webpage. Users can see the comparison of the parameter values through chart. We have created a demo aeration system which can be controlled through our FCM app. Some other screenshots of the FCM app are shown Fig.11.





(a) Camera app (b) FCM app's first screen

Fig.8 Some screenshots of the apps

## IV. IMPLEMENTATION & RESULT

We have selected a pond's water as with standard colour with the help of an aquaculture expert to test our colour detection system. We have captured image of the standard pond water as Fig.9(a) with our camera app. We get RGB values of that image as R=89, G=104, B=45 using our RGB extracting python program and these values makes the colour as Fig.9(b). Then we have set range 80-100 for R, 95-115 for G and 40-50 for B as expected range for convenience. We have also captured images of another two pond's water for testing which are shown in Fig.9(c) and Fig.9(e) and after extracting RGB values we get colour as Fig.9(d) (R=66, G=157, B=24) and Fig.9(f) (R=47, G=46, B=28) respectively.


(a) (b)


(c) (d)


(e) (f)

Fig.9 Colour detection

Fig.10 shows our hardware setup of our system.

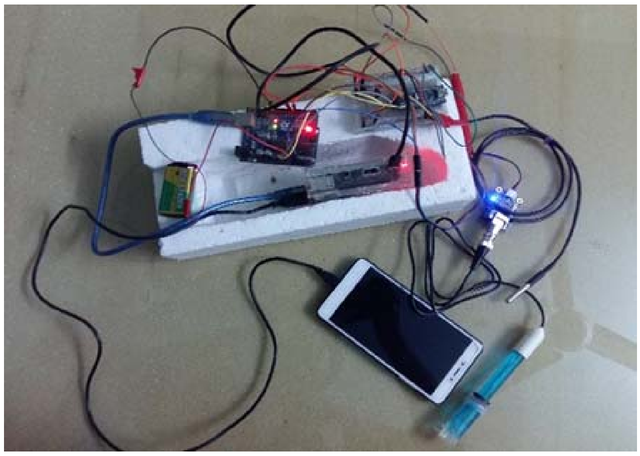


Fig.10 Hardware setup of the system

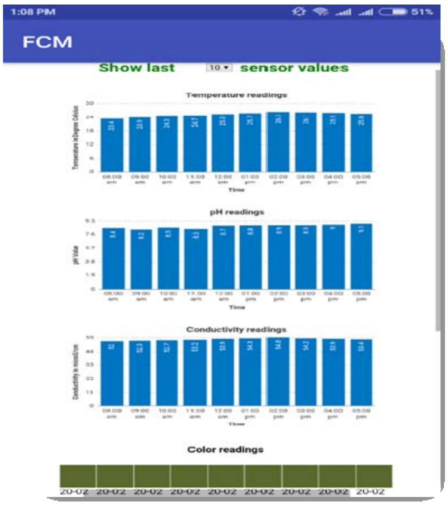
Our proposed system was implemented in our previously selected (as standard for colour) pond for some hours. Obtained values are shown in TABLE II.

TABLE II. OBTAINED VALUES OF IMPLEMENTATION

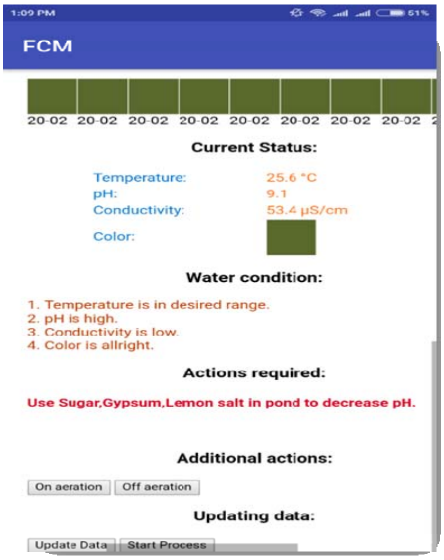
| Time | Temperature (˚C) | pH | EC (µS/cm) |
|---|---|---|---|
| 08:00 am | 23.4 | 8.4 | 52.0 |
| 09:00 am | 23.9 | 8.2 | 52.3 |
| 10:00 am | 24.3 | 8.5 | 52.7 |
| 11:00 am | 24.7 | 8.3 | 53.2 |
| 12:00 am | 25.3 | 8.7 | 53.9 |
| 01:00 pm | 25.7 | 8.8 | 54.3 |
| 02:00 pm | 26.3 | 8.9 | 54.8 |
| 03:00 pm | 26.1 | 8.9 | 54.2 |
| 04:00 pm | 25.9 | 9.0 | 53.9 |
| 05:00 pm | 25.6 | 9.1 | 53.4 |

Fig.11(a) shows the values in chart style in our FCM app. Colour readings are same because we captured image just one time as colour of the water does not change so frequently. Our app gives current status of the parameters and water condition (shown in Fig.11(b)). It also gives suggestion about required action according to the water condition. We see that conductivity is low but our app first suggests to decrease pH because pH is high and has precedence over conductivity.

Internet network is extremely unstable on rural African circumstance [19]. Most of the works need internet connection availability to get the result, but our system doesn't need this actually. And our app shows result in a well manner. So, we can say that our system is working effectively.




(a)




(b)

Fig.11 Screenshots of FCM app

## V. CONCLUSION & FUTURE WORK

This work designs and implements a unique aquaculture monitoring system based on IoT. Both Wi-Fi and Internet are combined in this system for convenience. This work finds a way to give better result with low cost than other available systems. Aqua farmers can avoid time consuming manual testing now. This will help the aqua farmers to produce more number of fishes which will help to fulfil the demand for fish.

Though we have created a system to control a demo aeration system, more actuators such as heating rods, fish feeder etc. will be integrated to this system. We will develop a better way to capture image and use better image processing techniques to provide better result.

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