# Development of a Fog Computing Based Data Analysis Platform for Real-Time Monitoring of Water Quality

**Piyali Ganguly [1a], Anirban Bose [2b], Amlan Chakrabarti [3a], Anjan Kr. Dasgupta [4b]**

piyaliganguly1992@gmail.com[1], anirban2128@gmail.com[2], acakcs@caluniv.ac.in[3], adgcal@gmail.com[4]

A. K. Choudhury School of Information Technology, University of Calcutta [a]

Department of Biochemistry, University of Calcutta [b]

## Introduction

Water quality depends on various climatic factors and variation of water quality can be observed due to season change. Water parameters such as pH, dissolved oxygen, temperature are the basic water features and those features need to be monitored in real – time for various water applications such as agriculture, fishery and aquaculture based water applications [1,2,3]. Water quality monitoring is an essential need for the human being. Fog computing is a part of an IoT based system framework and the goal of this fog computing is to generate a notification in real-time. Fog enabled IoT platform can analyse sensor generated data in real-time and user can get a notification about the condition of the water system [5]. Water quality monitoring comprises of several case studies and based on those applications sensing of various water parameters may vary. Here, we have highlighted two specific case studies such as drinking water quality monitoring and fishery based water quality analysis under fog computing environment. Fog computing comprises the computation and decision generation using smart fog devices. Fog device is a concept of an intelligent computation platform, where sensed data can be computed and based on data computation notifications can be generated.

## IoT Based System Architecture

Figure 1 describes the fog computing based IoT framework for water quality monitoring. The fog computing framework consists of three layers such as sensing layer, computation layer and cloud layer [4].

## Sensing Layer

Sensing layer consists of several sensor nodes and each sensor node is composed of several sensors, data acquisition unit and communication module.

## Fog Layer

Fog layer is composed of several gateway devices. Each gateway device performs data acquisition from sensor nodes and performs data analysis inside each gateway device.

## Cloud Layer

Cloud layer performs data analysis and generates decision report for each of the individual sensor nodes. Cloud layer is the upper layer of the computation platform and cloud maintains a large sensor based database for performing trend analysis on those acquired features.

## The Need for Real-Time Water Quality Analysis for Drinking Water and Fish Water

Water quality depends on various water parameters such as temperature, dissolved oxygen, pH value and conductivity of a water body. The main challenge in agriculture and pisciculture system is that to identify a proper usage of a particular water body and which is suitable for a particular crop farming and pisciculture breeding respectively.

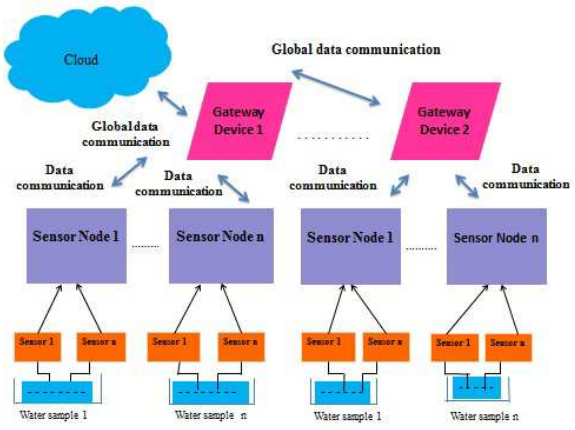



*Figure 1: Fog Computing based System Framework*

Another main challenge of water quality monitoring is that, if unwanted solid compounds get dissolved at a particular region of a water body, there is a possibility of water pollution due to those elements. If pollution occurs at a particular position of a water body, it can spread over the large area of the water body and this can affect the life cycle of aquatic organisms. In rural areas due to water pollution drinking water resources get polluted and this pollution can't be identified by human beings. Real-time fog device based notification generation can detect water pollution and save the life of aquatic organisms.

IoT nodes can perform data acquisition from different positions of the water body and collect various features such as temperature, humidity, pH, dissolved oxygen and conductivity. The collected data in real-time is sent to the fog device for monitoring the water system's condition. Each fog device is connected to a cloud platform and sends data of a particular region of the water body to the cloud platform for performing data analysis. Cloud platform can generate a seasonal trend of water quality, based on data analysis. This seasonal trend will help to predict the condition of the water system and to take a right decision based on seasonal changes. In contrast to cloud based analysis the real-time monitoring of the water system using the handheld fog device helps the authority to take a decision in real-time.

Fog inspired IoT system has various application areas such as agriculture based applications, health IoT based applications, smart farming based applications etc. Here, we are concentrating about fog inspired water quality monitoring for drinking water quality analysis and fishery based water quality analysis.

### The Data Processing and Analytics in Fog and Cloud End

Generated sensor data from different sensor nodes is processed inside the fog device and inside the cloud platform to generate a decision. Fog device performs real-time data analysis and cloud performs trend analysis based on stored dataset.

### Fog Based Data Analysis

To incorporate the intelligence inside a fog device a learning model is built within the fog device. The device learning is performed in two steps such as learning model building and the verification of that model using several unknown test cases. The performance metrics such as test case accuracy is noted for each of the verification phases. Based on those noted accuracy the modification and tuning of various learning parameters are performed. Here, we have described the concept of handheld fog devices for drinking water quality monitoring and for fishery based applications respectively. The device verification phase can be performed by a group of expertise people of that particular field. Based on the consent of the expertise group the learning model can be modified.

### Cloud Based Data Analysis

Cloud based data analysis is also known as global data analysis. Global data analysis is performed inside the cloud platform, where data from different fog nodes are stored and analysed for report generation. Figure 4 describes cloud based sensor database which contains IoT node ID, Sensor ID, fog node ID, Local Timestamp, Global Timestamp and Latitude and Longitude of the deployed IoT node. Cloud based data analysis is required for the field of monitoring of a large water body. Inside the cloud platform as data from different fog nodes can be gathered and cloud end data analysis model can generate a decision report for each of the IoT nodes based on their locations with respect to a particular fog node. From cloud end data analysis user can get a view of the water system for each of the locations of the water body.

### Applications in Daily life

Fog computing based system can be used in various applications such as fruit quality monitoring, water quality monitoring, smart farming based applications etc.

### Drinking Water Quality Monitoring Based Application

Drinking water is an essential element in our daily life and monitoring of drinking water quality is also an important aspect in our daily life.

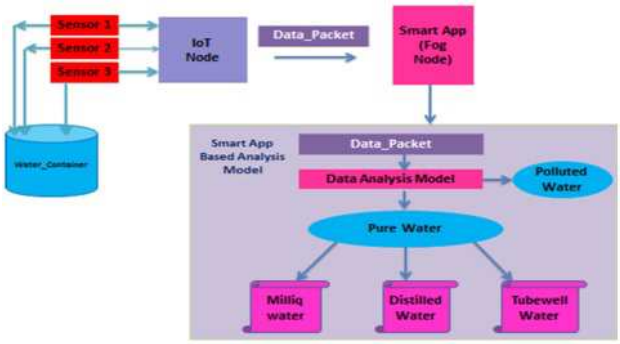



*Figure 2: Fog Computing Based Drinking Water Application*

We have proposed an IoT based intelligent system, which can predict the probable usage of a water sample and can predict whether that water sample can be used in drinking purpose or not. Figure 2 describes the concept of handheld device for drinking water quality analysis. The handheld device is intelligent enough to decide whether a particular water sample can be used as drinking water purpose or not.

### Fishery Based Applications

Water quality monitoring is an essential thing for agro based communities. In pisciculture water quality monitoring is the most essential need. We have devised an IoT based intelligent system which can decide the kind of fish farming suited for a given water body. Here, we have proposed a concept of open hardware based handheld device, which can perform data analysis in real–time. With the help of the handheld device, shown in Figure 3, user can decide whether the water body is suitable for a specific type of fish breeding or not. Various fishery based applications such as carp breeding and prawn breeding depend on the quality of a water sample and our fog device can help on such decisions.

### Quality Monitoring of Fruits

Gas sensing based fruit quality monitoring can be performed using a handheld fog device. Fruit quality monitoring can help to detect the quality of a food and how much it is perishable. This real-time fruit quality detection can reduce the wastage of fruits.

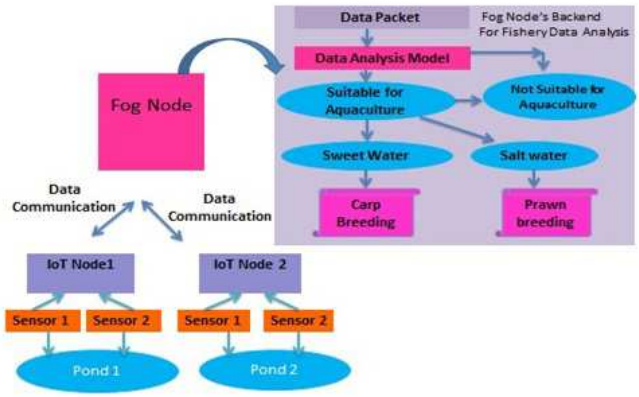



*Figure 3: Fog Computing Based fishery Application*

### IoT Based End to End Security Model

IoT based system is composed of several IoT nodes and fog nodes and each node performs data communication between them. IoT based End to End security comprises device authentication, end to end data encryption using lightweight data encryption and data integrity based model design. To perform data communication between each of the IoT nodes and a specific fog node, each IoT node must be authenticated to the fog node. The legitimate IoT node and fog node can perform data communication between them. To authenticate each of the IoT nodes and fog node lightweight device authentication approach can be used. The data packets generated by each of the IoT nodes are encrypted using data encryption technique and is sent to the fog node. The concept behind the data encryption is that only legitimate fog nodes can decrypt the data packet and that data packet is saved inside the fog nodes for performing data analysis. Inside the fog nodes the integrity of that data packet is maintained.

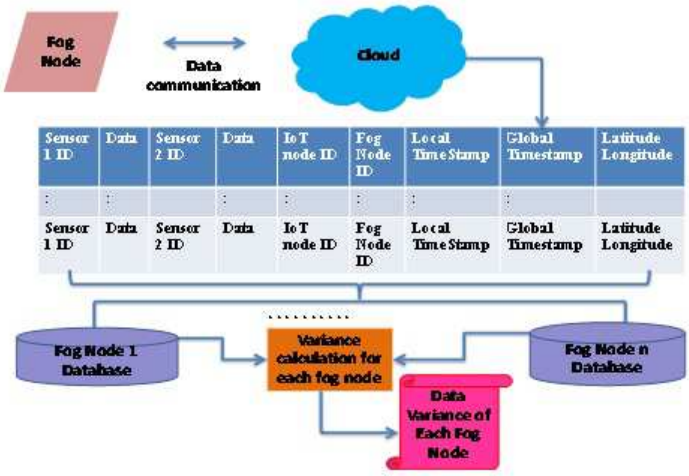



*Figure 4: Cloud Based Data Analysis*

## Conclusion

Our objective is to incorporate big data based computation inside a small fog device. Here, we have described the concept of a fog device for two applications such as drinking water quality analysis and fishery based applications. In future our plan is to build cloud based trend analysis model using large datasets. The cloud based data analysis model will also generate seasonal trends of a system for various IoT based applications.


## Acknowledgement

This work has been carried out through the project funding of MeitY, Govt of India, Reference : Administrative approval No. 13(10)/2016-CC&BT dated 18.07.2017


## References


[1] Paul B. Bokingkito Jr., Orven E. Llantos, *Design and Implementation of Real-Time Mobile-based Water Temperature Monitoring System*, 4th Information Systems International Conference 2017, ISICO 2017, 6-8 November 2017, Bali, Indonesia.

[2] Cesar Encinas, Erica Ruiz, Joaquin Cortez, Adolfo Espinoza, *Design and implementation of a distributed IoT system for the monitoring of water quality in aquaculture*, 2017 Wireless Telecommunications Symposium (WTS).

[3] K.Raghu Sita Rama Raju, G.Harish kumar Varma, *Knowledge Based Real Time Monitoring System for Aquaculture Using IoT*, 2017 IEEE 7th International Advance Computing Conference.

[4] Farshad Firouzi, Amir M. Rahmani, K. Mankodiya, M.Badaroglu, G.V. Merrett, P. Wong, Bahar Farahani, Internet-of-Things and big data for smarter healthcare: From device to architecture, applications and analytics, Future Generation Computer Systems 78 (2018) 583586.

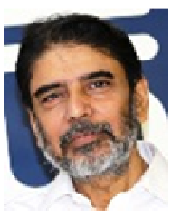
[5] Piyali Ganguly, Anirban Bose, Kaushik Chakraborty, Amlan Chakrabarti, and Anjan Kr Dasgupta, *Development of a Multi-Fog Based Water Quality Monitoring System Using Bio-Sensing Platform*, 2018 IEEE International Symposium on Smart Electronic Systems (iSES) (Formerly iNiS).


**About the authors**

Piyali Ganguly is Senior Research Fellow of the MeiTY sanctioned project Open Hardware Based Communicable Digital Biosensing Platform at The A.K.Choudhury School of Information Technology of University of Calcutta. Prior this she has completed her M.Tech from university of Calcutta in 2017.

Anirban Bose is Senior Research Fellow of the MeiTY sanctioned project Open Hardware Based Communicable Digital Biosensing Platform at The A.K.Choudhury School of Information Technology and pursuing his Ph.D. at Department of Biochemistry, University of Calcutta. He completed his M.Sc Biochemistry in the year 2012 from the University of Calcutta. He has some teaching experience as a Guest lecturer at Microbiology Department, St. Xavier's College, Kolkata. His research interest lies in the area of photobiology, photochemistry, and biosensing. He has one co-authored one publication and has also filed one US patent and two Indian patents.

Amlan Chakrabarti is presently Professor and Director of AKCSIT, University of Calcutta. Prior to this, he completed his post doctoral research in Princeton University after completing his PhD from University of Calcutta in association with ISI, Kolkata. He is the recipient of DST BOYSCAST fellowship award in Engineering Science in 2011, Indian National Science Academy (INSA) Visiting Faculty Fellowship in 2014, JSPS Invitation Research Award in 2016, Erasmus Mundus Leaders Award from EU in 2017 and Hamied Visiting Fellowship from Cambridge University in 2018. He is a Senior Member of IEEE and ACM, Secretary of IEEE CEDA India Chapter and Vice President of Society for Data Science. His present research interests include VLSI Design, Quantum Computing and Embedded System Design.



Anjan Kr. Dasgupta retired as a UGC open post Professor from the Department of Biochemistry, the University of Calcutta in the year 2017. He is presently an ICMR(PI), DBT(PI) and MeiTY(Co-PI) in the same University. He passed M.Sc Physics from IIT Madras in the year 1978 and then obtained his Ph.D. from the University of Calcutta in the year 1983. He has proven track record of initiating new courses and projects, in both the Universities he was associated with (University of Kalyani and University of Calcutta) contributing in a major way towards teaching research and inventions.