Wireless Sensor Networks and Ubiquitous Mobile Sensing for Water Quality Monitoring and Control within Lake Victoria...

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1 author:

Anthony Sambaiga Faustine
The Nelson Mandela African Institute of Science and Technology
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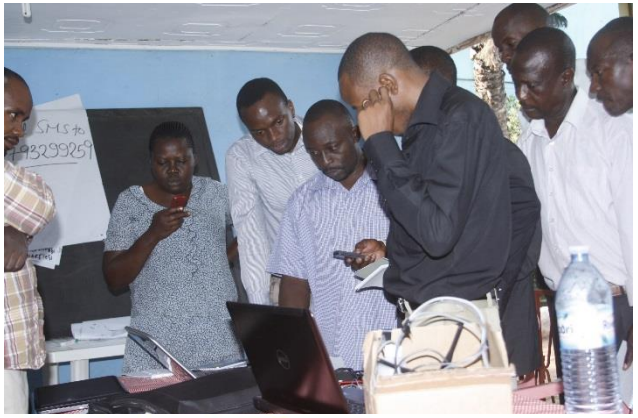
Wireless Sensor Networks and Ubiquitous Mobile Sensing for Water Quality Monitoring and Control within Lake Victoria Basin: Prototype Development



Anthony Faustine Sambaiga (AL, UDOM)

Research Interest: WSAN, M2M, Smart grid, Communications and ICT4D.

Outline

- ✓Introduction
- ✓Motivation
- ✓WSN
- ✓WQR
- ✓Results
- ✓Conclusion

Introduction

- Lake Victoria:

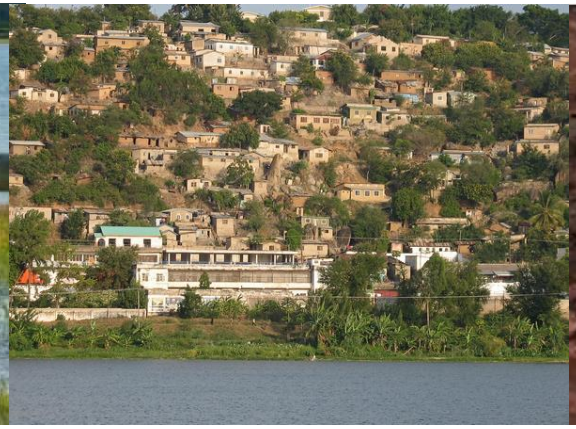
The world's second largest fresh water lake by area and the largest inAfrica with a surface area of 68,800km2.

Very important resource for the five riparian countries: Uganda, Kenya, Tanzania, Rwanda and Burundi

Introduction

- However it affected by

Population growth, Urbanization, Industrialization, Increasing commercial activities, Inadequate provision of sanitation services, etc


This result in speeding–up of contamination and damage to the water resources

Introduction

Introduction

- Thus water quality monitoring and evaluation:

Is essential in order to characterize water and identify changes or trends in water quality over time

Is very critical for water resources management programs around LVB

Motivation

- In most developing countries like Tanzania water quality monitoring and evaluation is entirely manual process.

Based on sampling and subsequent analyses in water laboratories.

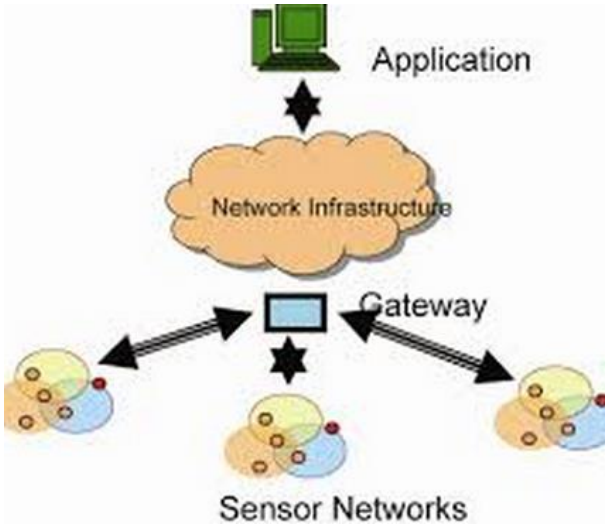
This approach is time-consuming, expensive and not appropriate for certain biological and chemical processes eg ORP

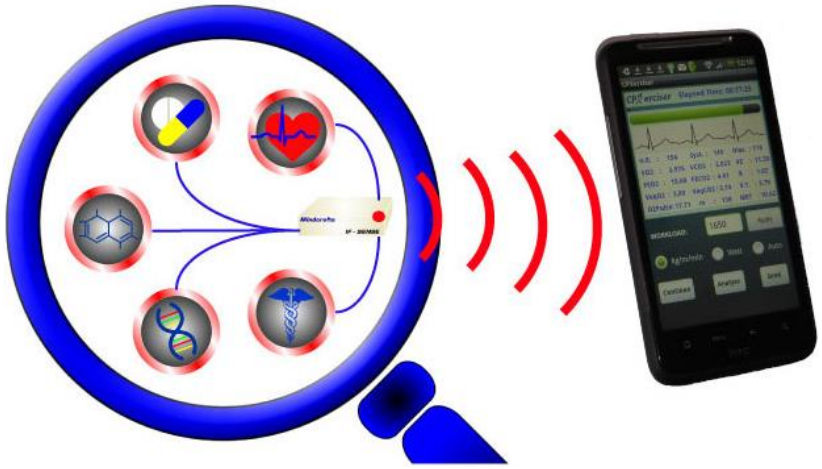
Motivation

- Emerging ICTs can be used to provide relatively inexpensive, and coordinated water quality monitoring networksprocess

Allowing a well-coordinated and continuous monitoring of water quality

Wireless Sensor Networks (WSN) and Mobile sensing as one of the emerging technologies has inspired many environmental monitoring applications.

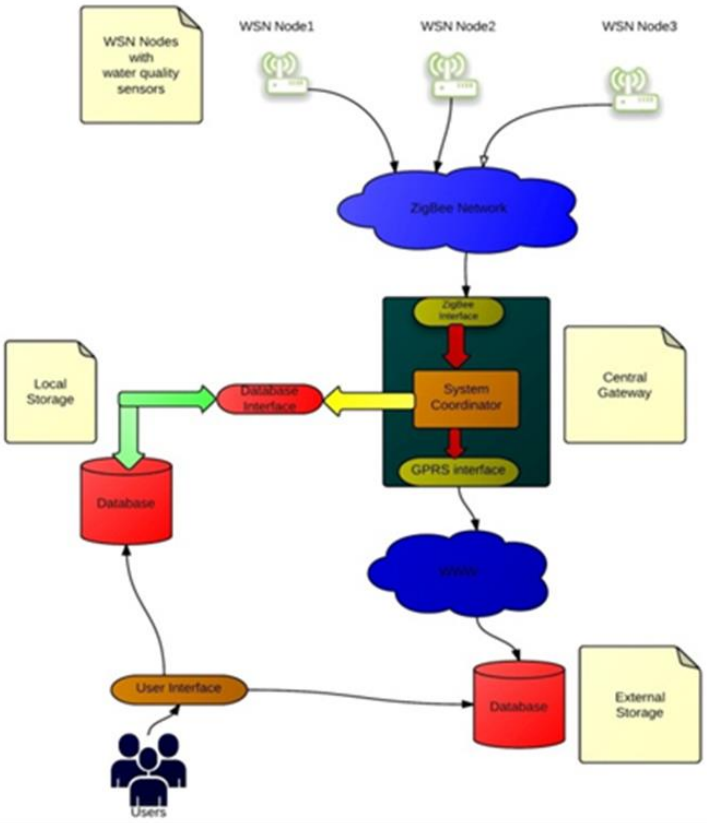




WSN

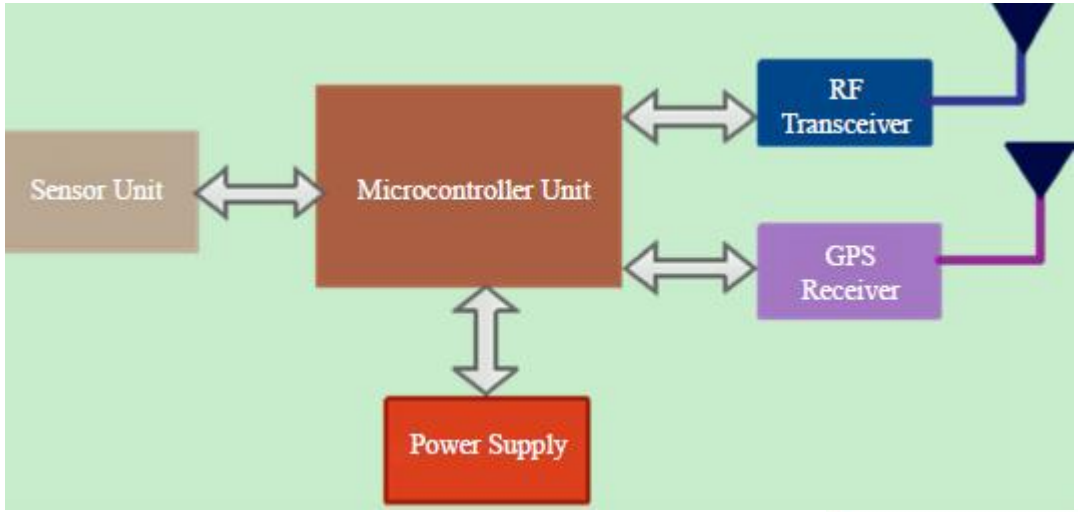
- WSN

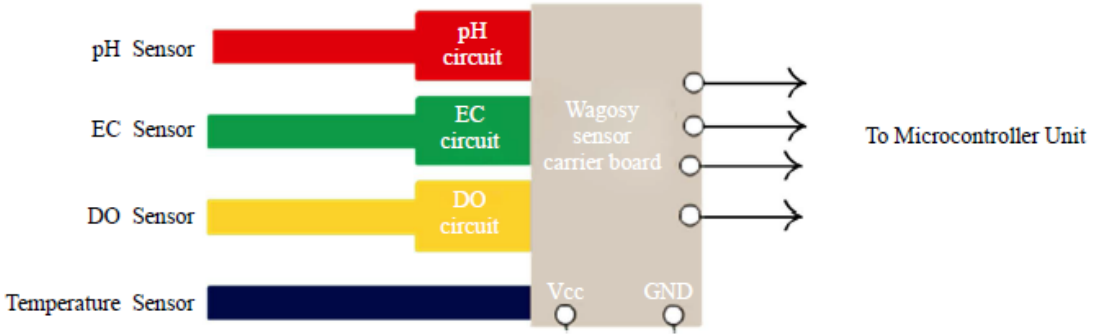
Anetwork of devices (sensor nodes) which sense water quality parameters and communicate the information through a wireless link

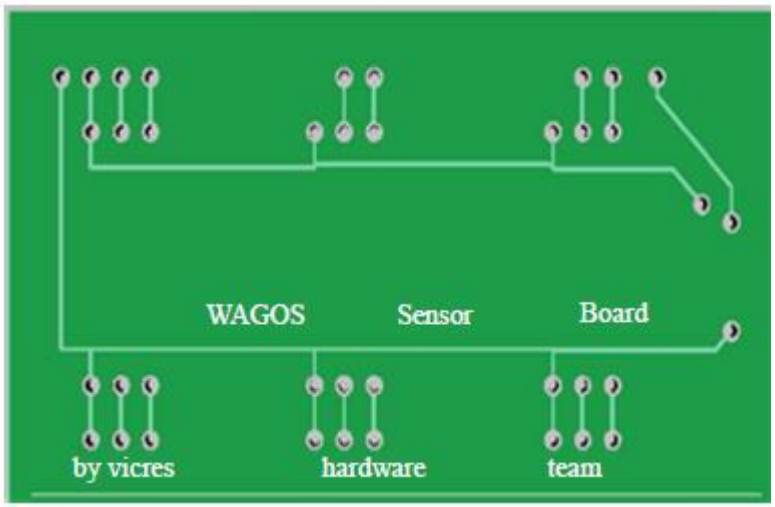


WSN Sensor Node

- It is equipped with sensor unit, Arduino MCU,GPS receiver, Power supply and Zigbee transceiver







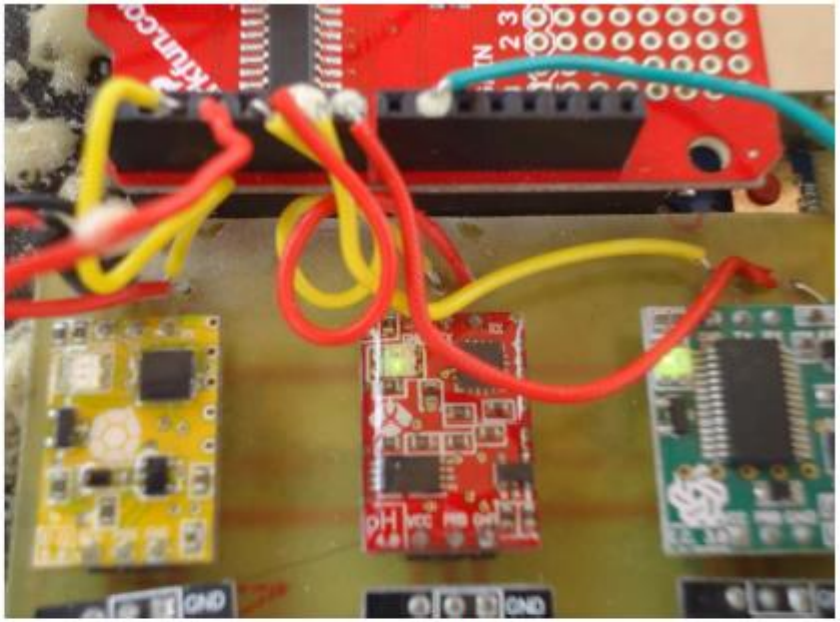
WSN Sensor Node

- The sensors were calibrated to ensure correct operation and accuracy in the resulting water quality parameter values.

The calibration was done at the Lake Victoria water quality laboratory in Mwanza with the assistance from water quality laboratory technician.

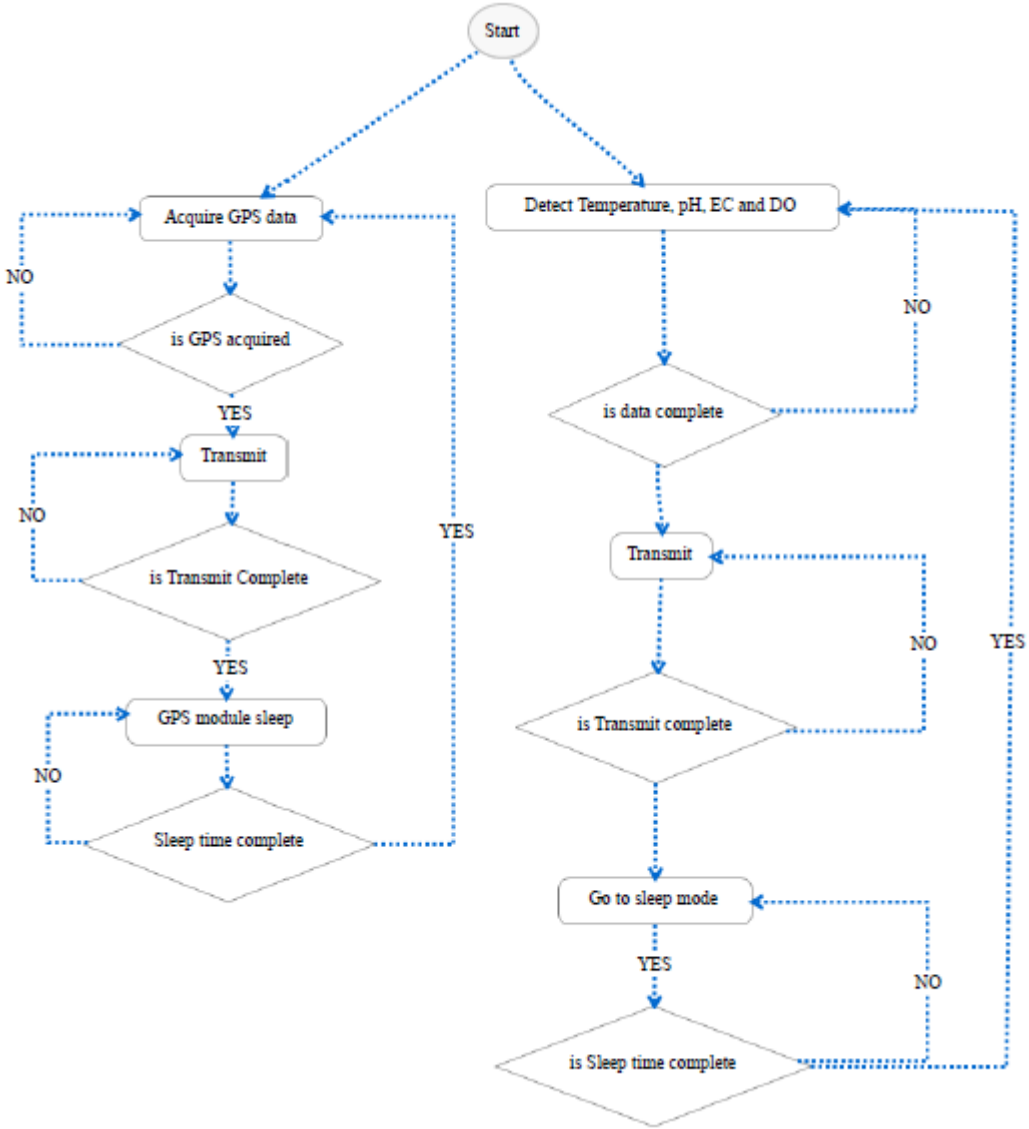
WSN Sensor Node

(a)



(b)

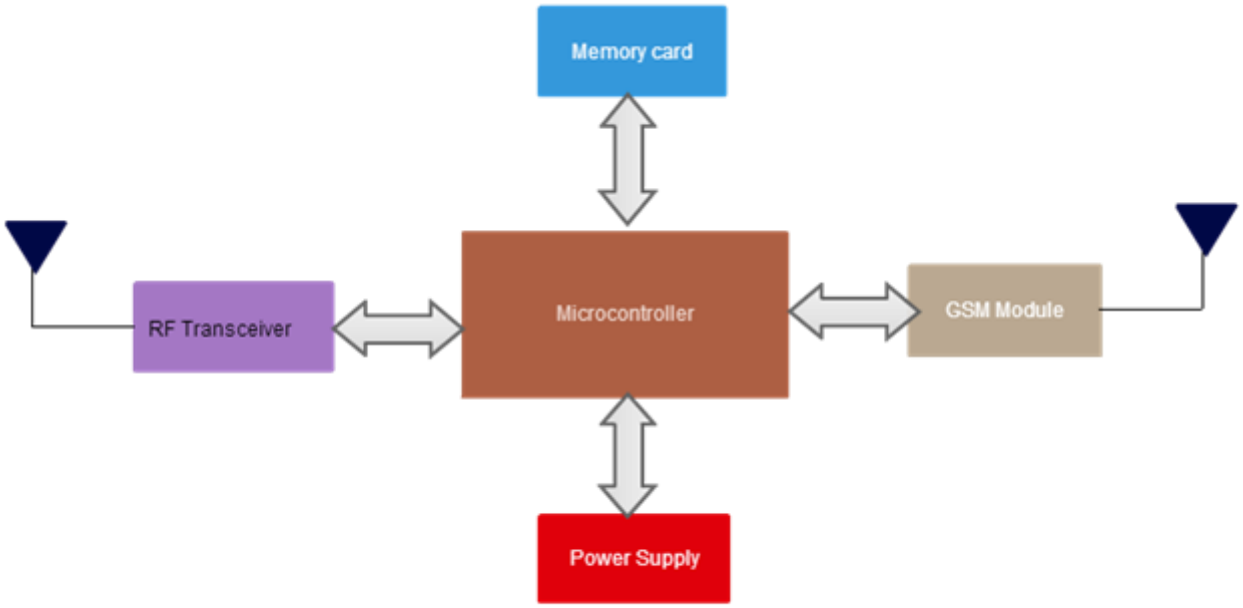
WSN Sensor Node



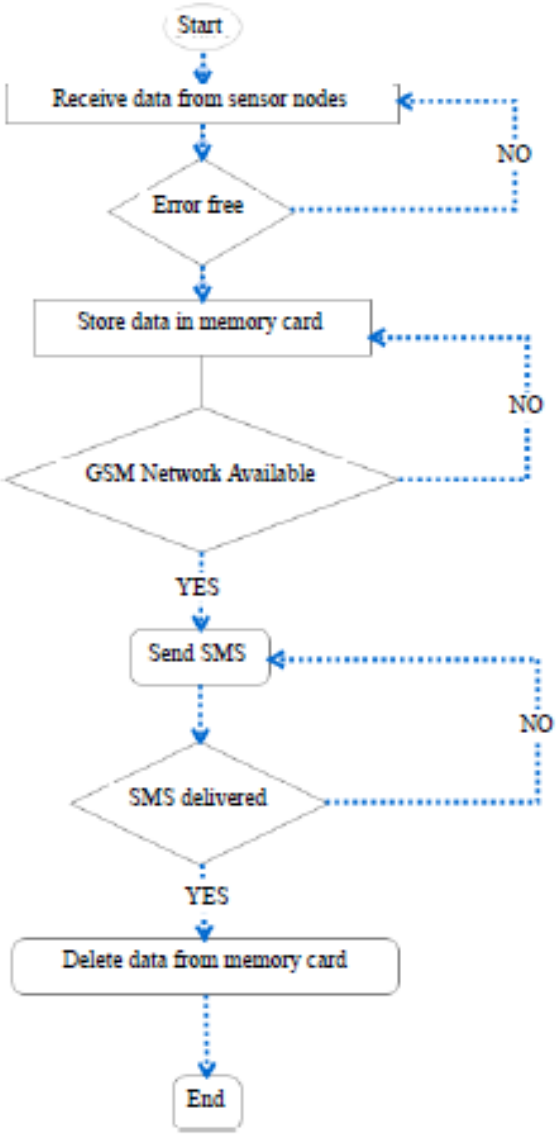
WSN gateway

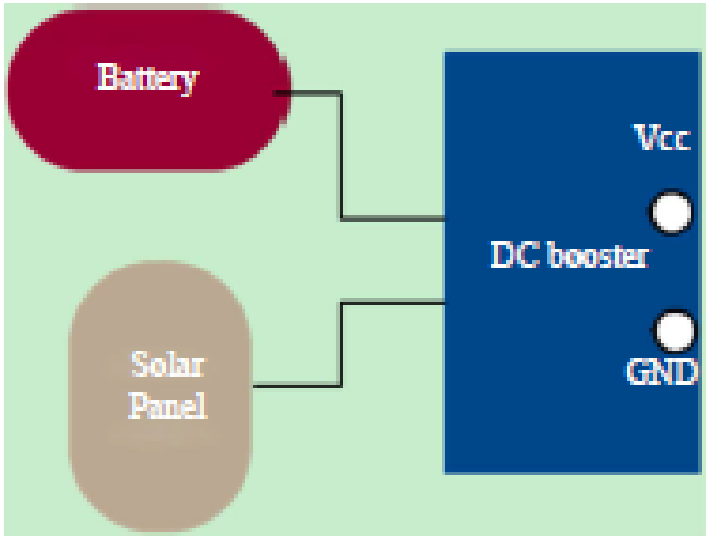
- The gateway collects all the information received from multiple sensor nodes and send to the Wagosy database

The developed gateway is equipped with MCU GSM/GPRS module, RF transceiver, memory card and power supply.



WSN gateway


Start
Receive data from sensor nodes
NO
Error free
Store data in memory card
NO
GSM Network Available
YES
Send SMS
NO
SMS delivered
YES
Delete data from memory card
End


Battery
Vcc
DC booster
GND
Solar
Panel

WSN application

- Includes the WaGoSy system which provides:

  - ✓ Database to store the received data.
  - ✓ visualization modules which enables stakeholders to visualize, map and compare water quality parameters and locations in graphical representation
  - ✓ Web portal that allows stakeholders with access to the Internet to communicate, create and share information.

Mobile Sensing

- The rapid spread in mobile phone use in developing countries has increased the application of mobile data management.

In this project we extends the use of ubiquitous mobile sensing technologies in water resource management

By designing and developing mobile data capture and reporting applications that leverage external sensing devices

Mobile Sensing: WQR

- WQR system consists of four main components:

1. Ubiquitous Sensing Device (USD)

Which consists ofArduino microcontroller and sensor unit

2. Communication module.

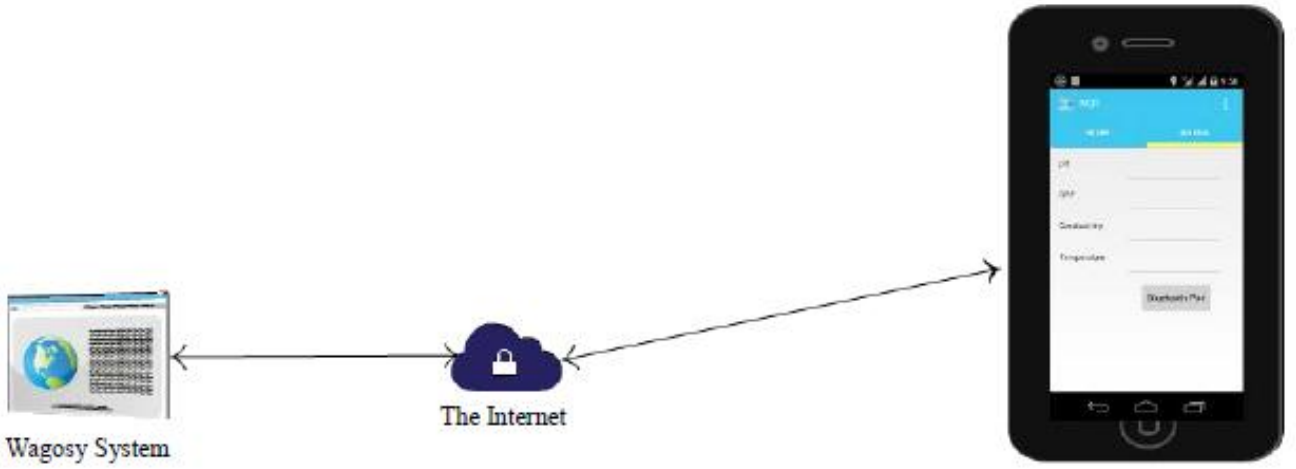
Which connect the sensing device and the Android mobile phone.

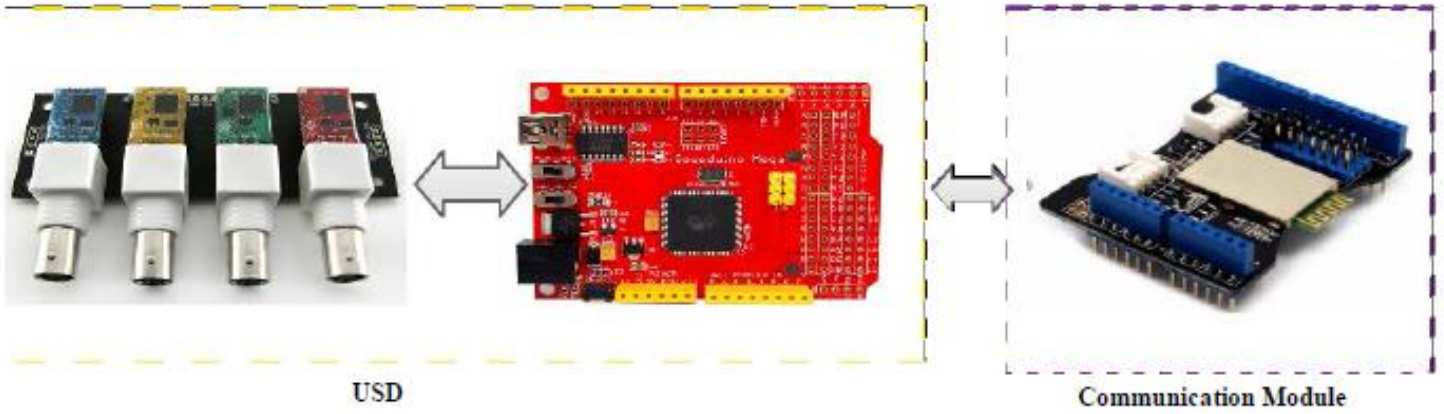
3. The mobile application

Developed using theAndroid platform and

4. The WaGoSy web server

System Architecture





Ubiquitous Sensing Device (USD)

- The ubiquitous sensing device (USD) consists of Arduino microcontroller, sensor unit and power supply

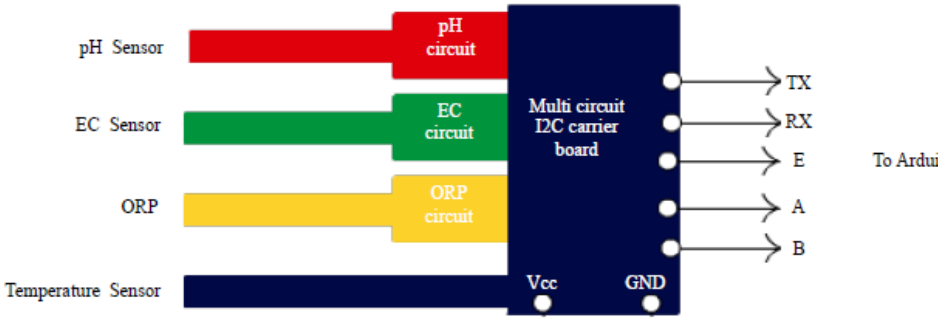
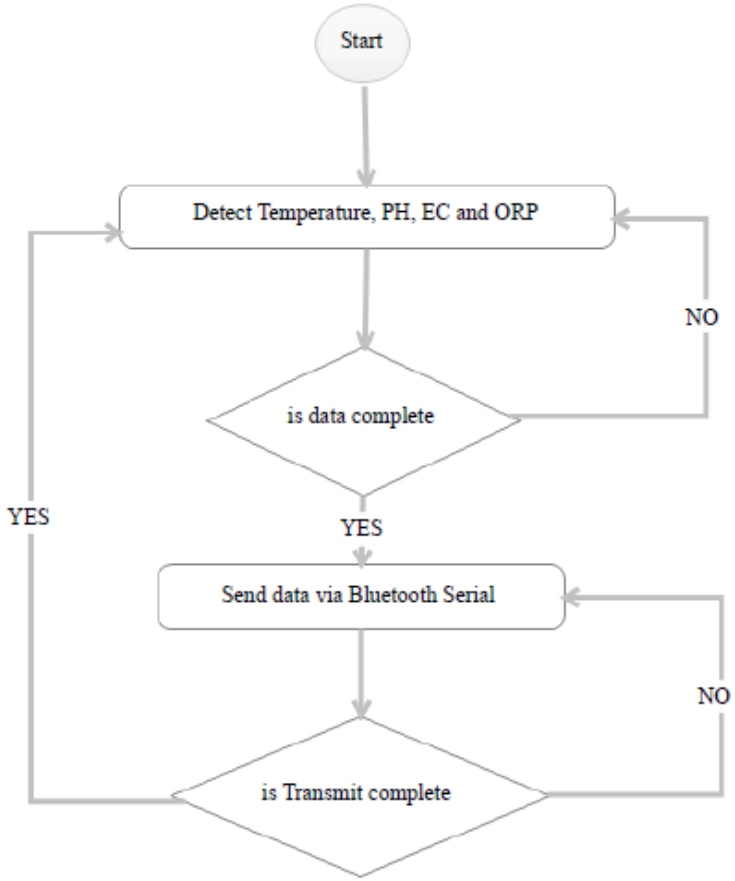


Figure 4. Sensor unit.

Table 1. Sensor specification.

Sensor	Manufacture	Model	Range
pH	Atlas Scientific	ENV-40-pH	0 - 14 (Na^+ error at >12.3 pH)
EC	Atlas Scientific	ENV-40-EC-K0.1	(K = 0.1) 0.1 - 0.5 µs/cm to 50,000 µs/cm
ORP	Atlas Scientific	ENV-40-ORP	+/− 2000 mV
Temperature	Maxim Integrated	DS18B20	−55°C to +125°C



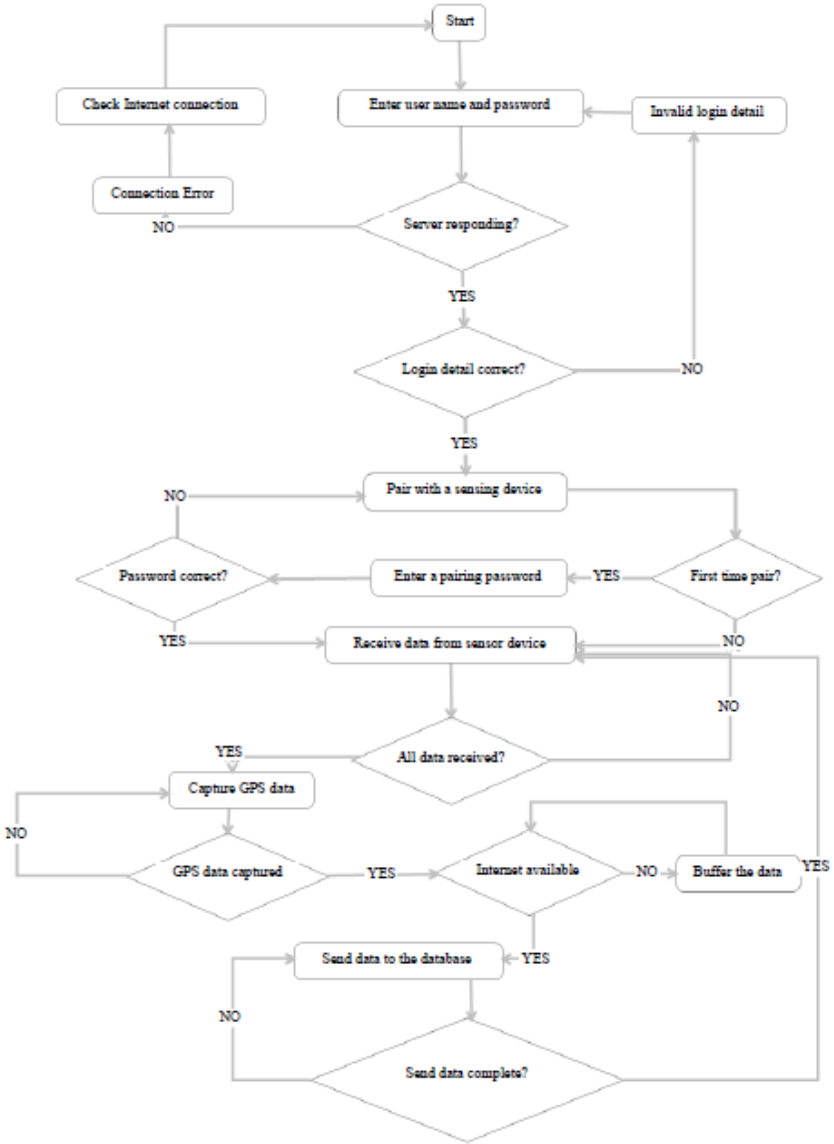
The mobile application

- The designed mobile app provides

User authentication, serial Bluetooth connection to the USD, remote connection (via internet) to the WaGoSy web server and history of the data reported.

The mobile application

- General processing of the proposed mobile app



Communication Module

- Three options can be used to allow external sensors (Arduino) to interact with anAndroid-powered device

1. UsingAndroid OpenAccessory Protocol (AAP)

   Need to implement USB Host stack on the Arduino board which is complicated.

2. Using USB androidAPI

   Simple but works only with Android devices that have an USB Host port

3. Using Wireless androidAPI (Bluetooth, Wi-Fi or NFC)

   Allow Android devices to connect to an even wider variety of external sensors.

Communication Module

- In this work, a serial Bluetooth module is used to provide communication between USD and the WQR mobile app.
  - This is because

Bluetooth is a popular method of communication between devices

Many smart phones today have the capability to communicate using Bluetooth.

It is easy to get cheap Bluetooth transceiver

Results

- WSN and WQR system was fully developed and tested to demonstrate its feasibility and effectiveness.
  - It has all the necessary feature for mobile data monitoring and reporting in water quality management applications

It allows decentralized actors to submit water source monitoring data remotely

Provides visualization functionality which enable administrator to visualize the datasets

It can be configured to send SMS and or email alerts to managers when data reveal problems

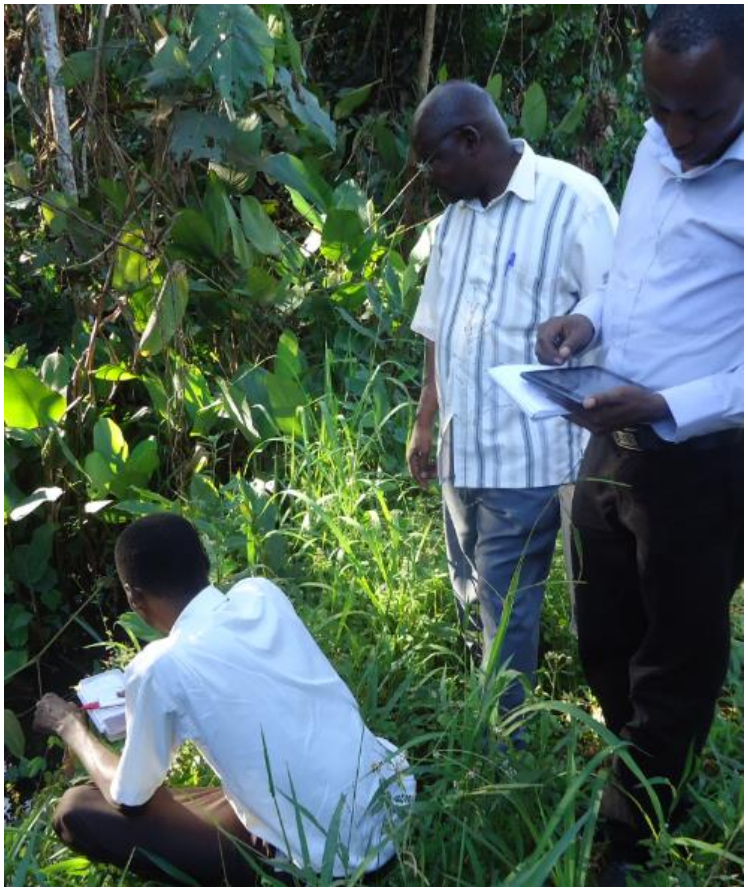
Results

- Field testing of the system was conducted in Nkokonjero, Uganda and Mwanza.
  - Verified the functionalities of the system and its practical application in actual environment.





Results



Most stakeholders find the WQR system easy to use and require little training.

Administrators and government authority managers were excited to see this system in place.

Results

- The WSN system cost, including sensors nodes and gateway stands at US $1250.
  - And the WQR system total cost including sensing device, mobile phones and the Bluetooth module stands at $750.

This is in stark contrast to commercial water quality monitoring systems US $3400 which is a threefold reduction in cost

Results

- Three publication.

Wireless Sensor Networks for Water Quality Monitoring and Control within Lake Victoria Basin: Prototype Development. AFaustine etal (2014), Wireless Sensor Network 6 (12), 281

Ubiquitous Mobile Sensing for Water Quality Monitoring and Reporting within Lake Victoria Basin
AFaustine etal,(2014) Wireless Sensor Network 6 (12), 257

Design and Simulation of Wireless Sensor Network for Water Quality MonitoringAround Lake Victoria,AFaustine, (2012)
JIVE, 37

Conclusion

- The system has been successfully designed and prototyped.

The system has capability to continuously measure water quality parameters and transmit them to a database in real–time.

This capability has potential to enhance accountability, transparency, and participation which are attributes for good governance of water resources.

sambaiga@gmail.com