# Implementation of Flash Flood Monitoring System Based on Wireless Sensor Network in Bangladesh

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*Abstract*— **This research involved in the design & implementation of water monitoring system that provides a solution to remotely monitoring water levels, early warning of events, sending notifications when critical water levels are reached through mobile and accessing all information via a website. It enables people to obtain readings remotely instead of having to travel to each monitoring stations to collect data and gives protection of the safety of monitoring personnel under certain dangerous circumstances. The system consists of the field sensor, Arduino Ethernet-shield, data collection software module, web console module, Mobile based monitoring module and distributed servers. The field sensor acquires the real-time data as water-level information from river stations. The data is then stored to distributed web servers and represented to website so that everyone gets the status of water levels. The proposed monitoring system presents useful characteristics as large network capacity, sensor hardware compatibility, long-range communication, low power consumption, and capable of taking challenge to natural environment threats like weather conditions and various type of water mixed up with others materials.**

***Keywords: Wireless Sensor Network, Remote Monitoring System, Water Monitoring in Bangladesh***

## I. INTRODUCTION

Floods are responsible for the loss of precious lives and destruction of large amounts of property every year, especially in the poor and developing countries like Bangladesh, where people are at the mercy of natural elements. In flash flood, water level rises and falls quite rapidly with little or no advance warning. Typically, flash floods [1] occur in areas where the upstream basin topography is relatively steep and the concentration time of the basin is relatively short. In Bangladesh flash floods generally occurs in the north-east, south-east and Chittagong region. A lot of effort has been put in developing systems [2], [3] which help to minimize the damage through early disaster predictions. Field monitoring by people is still used, but sensor monitoring is being adopted by more monitoring stations.

Flooding is a natural phenomenon, which cannot be prevented. Complete flood control is not in the interest of most Bangladeshi farmers. Currently there is no automated system for monitoring of floods in Bangladesh. In addition, implementation of an improved real- time flood and warnings system can reduce the damage caused by floods [4].

## II. RELATED WORKS

In recent years, the flood forecasting systems are implemented mostly based on wireless sensor network. Because centralized and Non-WSN based telemetric systems fail to ensure fast or reliable warning system.

Reference [1] is based on Micro controller developed for Automated Water Level sensing and controlling. They tried to overcome some problems and implemented an automated water level monitoring and controlling system. But it was not suitable for high range and huge nodes of distributed system.

References [5] and [6] handle issues in parameter data management and system design and comparison of various distributed models. Reference [9] discusses forecasting in general. It provides an exhaustive analysis of the various types of forecasting models, simple and complicated.

Jiang, Xia and He present a water level monitoring system based on wireless sensor networks which has been successfully applied in Poyanghu Lake,China [2].

References [7] and [8] handle issues in parameter data management and system design and comparison of various distributed models. Reference [9] discusses forecasting in general. It provides an exhaustive analysis of the various types of forecasting models, simple and complicated.

Sunkpho and Ootamakorn (2011) present a real-time flood monitoring and warning system for a selected area of the southern part of Thailand. [3]

## III. SYSTEM DESIGN AND IMPLEMENTATION

The overall system consists of a hardware module, a data collection software module and a web monitoring console module. The data collecting software are used in network server programs. This program runs on different node of the river stations simultaneously and collects water level data from the respective river station nodes. The web monitoring system enables to gather sensor information from remote sensors and supports data analysis and decision-making. To administrate the monitoring system, a complete end-user interface carries out historical data queries and warning

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messages for river station status. Figure 1 shows the system architecture of remote monitoring system.

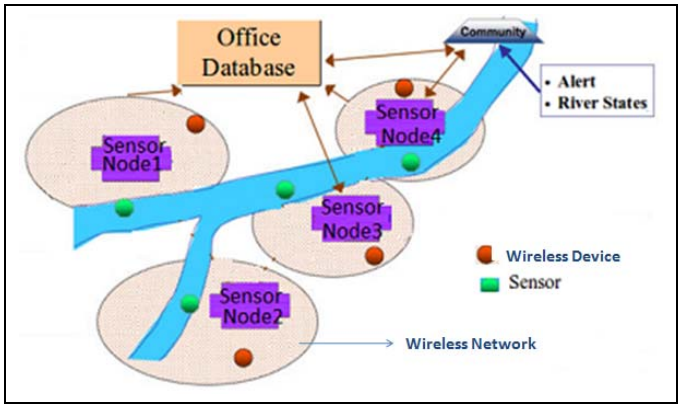


Figure 1: Computation Model for Distributed River System

*A. Hardware System*

The hardware module consists of wireless transceiver, fluid sensors [10], Micro controller Module, Ethernet communication Module, and power module and on board safety circuits. The field sensor module acquires the real-time data of the water-level and wireless transceiver sends the converted data to the base station. The base station module controls the field sensor module and transfers the data to the data center module by Ethernet/Internet. The data center module receives and stores data from the Ethernet/Internet module and then transfers the data to the WEB releasing module where the data will be published. Now we will discuss some important components of hardware system.

1. Wireless Sensor Module

In our work, LL Series Liquid Level Sensor from Honeywell is used. The LL series Liquid Level Sensor uses an opto-schmitt trigger which provides a digital output that indicates the presence or absence of liquid. These components require user supplied external circuit protection.

Figure 3: Honeywell LL103101 water sensor

2. Wireless transceiver

We use XBee [10] as wireless transceiver which is manufactured by Digi International [11]. The XBee uses a fully implemented protocol for data communications that provides features needed for robust network communications in a wireless sensor network. It has many features such as addressing; acknowledgements and retries help ensure safe delivery of data to the intended node.

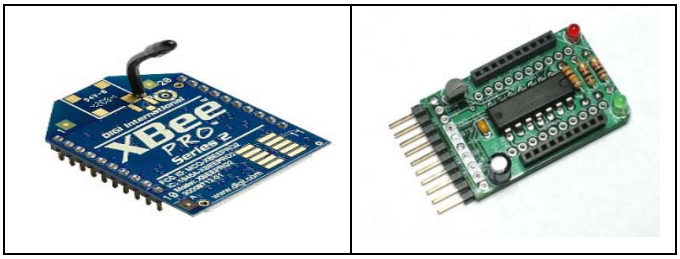


Figure 2: X-Bee adapter with X-Bee module.

2. Mash Networking Concept

We have chosen mesh network techniques for X-Bee. The core concept is a coordinator and router node. Each router node can broadcast information and also can repeat information from another to another router or to the coordinator. The coordinator manages the whole network and can also act like a router. In this network each device can see each ones data. Various end devices can get connected to router or coordinator. There are two styles of mesh networking Protocol available: ZigBee[11] and DigiMesh. Devices can be programmed with either protocol in API (Application Programming Interface) Mode [12].

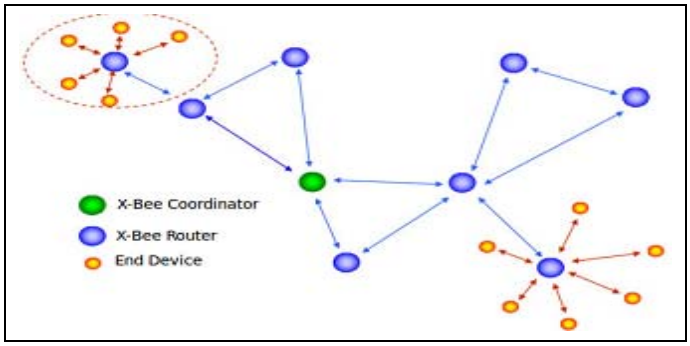


Figure 4: Zig-Bee Mesh network.

3. Integrated System

Finally, all modules are combined into a single system for monitoring water level of distributed measurement stations. A power supply unit is integrated with the system which is rechargeable by a charging port. Three water sensors are used to detect three level of water, the upper sensor notifies critical level alarm, middle sensor detect warning level water

information and the sensor in the bottom detects the normal level water information. After the testing of prototype, the final hardware was designed having its own dedicated PCB capable of having six water sensors, improved power options and regulations with reduced spacing. . Figure 5 shows the integrated Water Level Monitoring Hardware Components where RF module, Sensor Modules, Alarm, Power module is combined into a board.

| | |
|---|---|
| Size of the System | : 16x12x10 Inch |
| Weight | : 2KG |
| Wall | : Protected by heavy thin glass. |

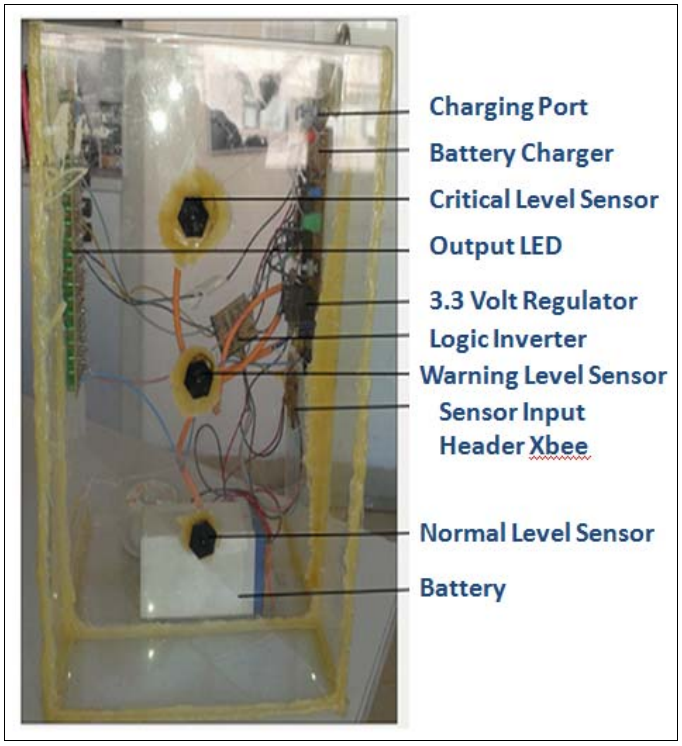


Figure 5: Water-level monitoring Hardware system

B. *Data Collection Software Development*

Software development has come a long way in the last decade, and modeling tools form an important component of today's development environment. Demands on the industry have increased many times over, particularly in the areas of robustness, portability and re usability, and by harnessing the power of Java and PHP. Here is some technologies and tools which are used in both data collection software and web monitoring module.

| | |
|---|---|
| Programming Language | : Java |
| Web Tools | : PHP, MySQL, Apache |
| Framework | : Netbeans |
| Others Technologies | : HTML, Javascript & CSS |

The program creates a new thread every time a connection request is received. The main program simply creates the thread and hands the connection to the thread. The run() method of the thread handles the connection in exactly the same way that it would be handled by the original program. On the server side, a thread unrelated to the original one receives the method invocation, executes the requested method and returns the result over the network. From a bird's eye view, the control flow moves during the remote call from one virtual machine to another and returns to the original machine when the method returns. This program runs on different node of the river stations simultaneously and collect water level data from the respective river station nodes. ChatServer.java file is shown below.

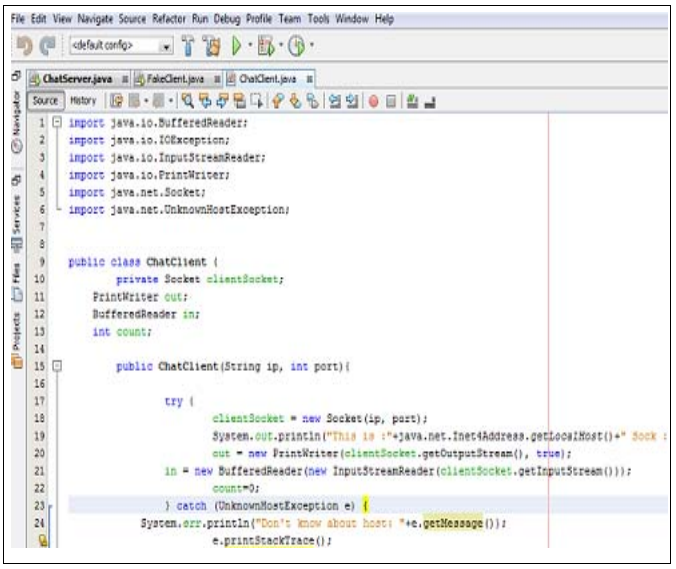


Figure 6: ChatServer.java thread for distributed servers

C. *Web Monitoring Module*

The website presents data from a sensor networks as river water levels. Website users can easily see current river levels, compared to monitor stage and warning stage levels. The website also has the capability to provide graphs showing data from October 2002 to the present.

The website provides:

- Real-time water level information.
- Current water levels in some rivers with monitor and flood levels.
- Historical data for Bangladesh Water Development Board.
- Graphing and tabular data downloading functions for selectable time periods between October 2012 and the present.
- Mobile based SMS alert system.

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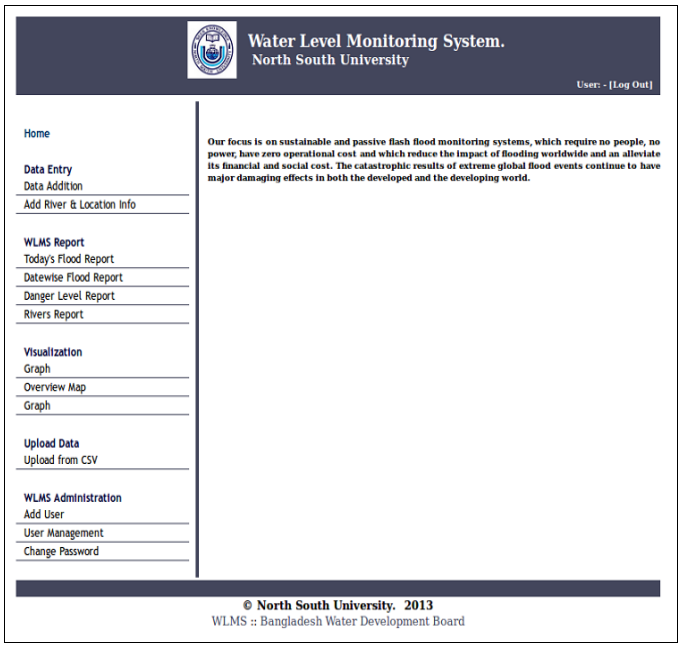


Figure 7: WLMS Web Implementation Overview

The web monitoring framework consists of an application server and a data server. The application server is implemented using PHP and the Apache web server. The data server is based on a MySQL database management system. The idea is that the base station establishes a connection directly with the server and requests the insertion of the data collected by the sensors. Then the server authenticates the request and decides whether or not to allow the aggregation to the database. The aggregated data are readily available to any requests from clients via web services.

The database was initially populated with basic data regarding the water development board data which included data such as the boundaries of the watersheds, the contours, and the location of the river sources, among others. The danger level and warning level information of river stations are collected from the Flood Forecasting and Warning Center of Bangladesh water development board.

## III. RESULT AND EVALUATION

The monitoring system will allow remote administration of the sensor networks by the web interface. The objective goes toward zero human presence for maintenance and administration during the monitoring period. For this reason, the application server will provide a web interface that enables the access to the sensor network directly from the Internet using a standard web browser. Using the web interface, end-users will be able to perform administration tasks, such as configuration changes, software updates, and health-status control. For example the frequency for sensor readings and transmissions may be set remotely. We have deployment our system one of the authorized location of Bangladesh water development board. It was Kurigram of TEESTA [13] river on Brahmaputra base station. The data collected and stored into database by the software we development.

| Base Station | River | Location | Water Level | Danger Level | Creation Date | Status |
|---|---|---|---|---|---|---|
| BHAHMAPUTRA | TEESTA | KURIGRAM | 13 | 15.1 | 2013-01-01 06:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 13.1 | 15.1 | 2013-01-01 07:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 13.3 | 15.1 | 2013-01-01 08:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 13.6 | 15.1 | 2013-01-01 09:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 13.5 | 15.1 | 2013-01-01 10:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 13.7 | 15.1 | 2013-01-01 11:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 13.4 | 15.1 | 2013-01-01 12:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 13.5 | 15.1 | 2013-01-01 13:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 13.8 | 15.1 | 2013-01-01 14:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 14.0 | 15.1 | 2013-01-01 15:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 14.5 | 15.1 | 2013-01-01 16:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 14.8 | 15.1 | 2013-01-01 17:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 15.0 | 15.1 | 2013-01-01 18:00:00 | Normal |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 15.2 | 15.1 | 2013-01-01 19:00:00 | Critical |
| BHAHMAPUTRA | TEESTA | KURIGRAM | 15.0 | 15.1 | 2013-01-01 20:00:00 | Normal |

Table 1: One Hour Interval water-level information of Kurigram river station.

### 1. Graphical Representation

The real-time information presented on this website is received via wireless sensors from different stations. These data are normally posted (in graphical form) within four hours of observation. Information presented graphically on this web site is considered public easiest way to know the status of observed stations. During floods, timely and detailed situation reports are required by the disaster management authorities to locate and identify the affected areas and to implement the corresponding damage mitigation; this is the most delicate management category since it involves rescue operations and the safety of people and property.

The water-level variation dynamic chart of the designated site can be drawn in WLMS through choosing the site and the time period. The user can follow the water-level trend by appointing the last time as the collection time of the last piece of data.

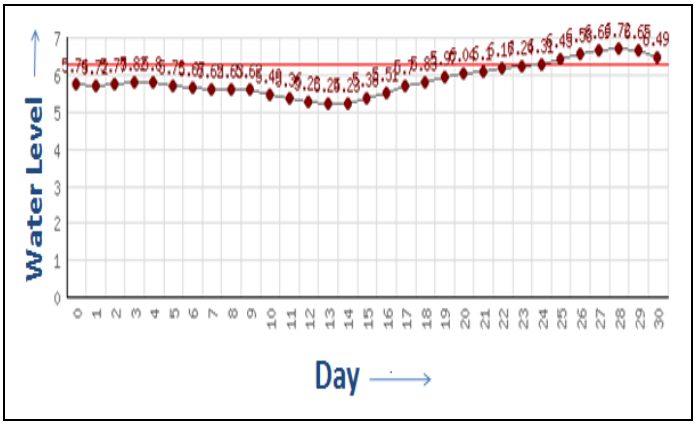


Figure 9: Graph showing reconstructed Kurigram River's flow for January 2014 with danger level.

2. Map Representation

The Web map is introduced in the WLMS to show the detailed locations, descriptions, and the current water-level by adding the labels in the map. The map of Bangladesh will be the default map, but the map can be customized through revising the scale and the sites in the background configuration file. Finally, we have developed all river station's water level overview and showed the status of normal level river stations and danger level water stations. Normal level water stations are showing green color on the specific area of the map and critical or danger level area are showing read color in the specific are of the map.

To plot a location on our map, the location needs to have a map coordinate allocated to it. For all examples we used a longitude and latitude coordinate in our PHP programming. Real-time data streams from all sensors can be reviewed, as well as alert notifications. Abnormal events are detected in the data stream of each sensor node and are grouped together and used to estimate the location of the abnormal event.

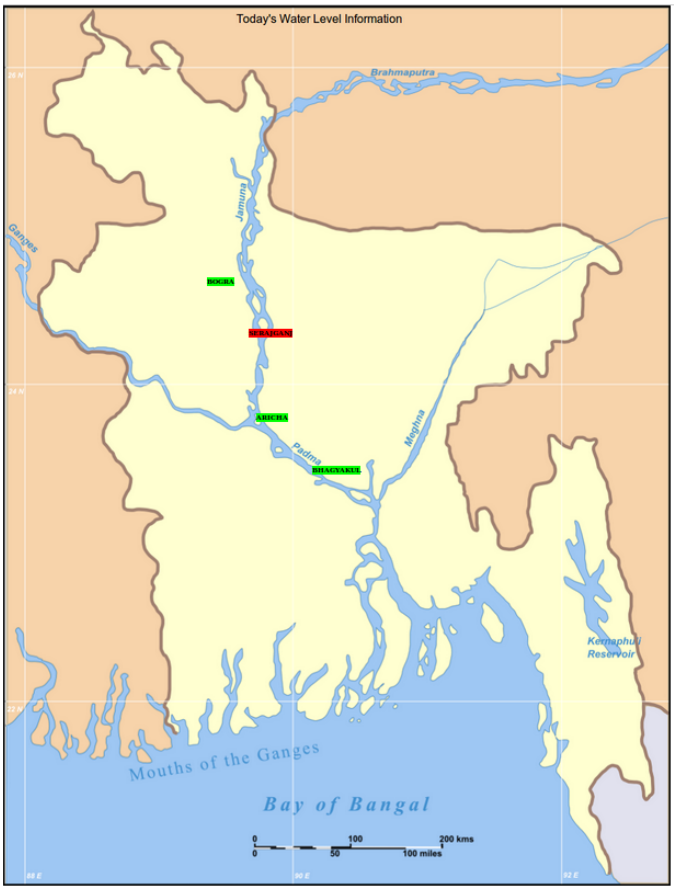


Figure 10: Shows graphical water-level information (Green indicates the station is normal state and red indicates the station is danger state) for the different stations on the website.

*D. Mobile SMS Based Monitoring*

This section describes the design process & implementation of a Flood Level Monitoring system through mobile. The objective of the proposed system is to be able to read the water level at every hour, display it to the supervisor and alert the relevant authorities by means of an alarm and short message system (SMS) when the level of water surpasses a user defined threshold.

To send SMS messages from our website, we used Ozeki NG SMS Gateway [14], GSM Mobile/Modem with data cable and PHP script. We developed the system such that PHP and MySQL will synchronize with Ozeki NG gateway database when there will have any insertion a row into the MySQL database regarding sending messages.

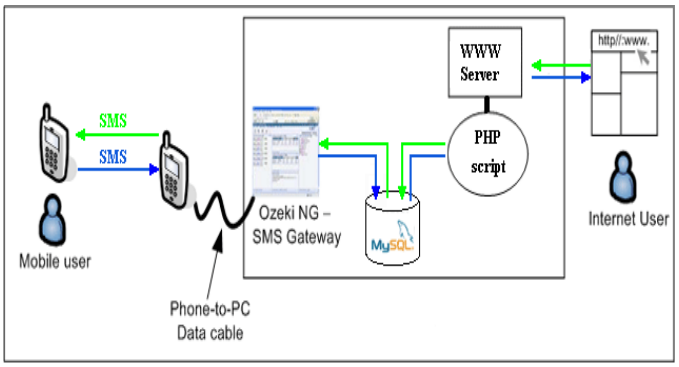


Figure 11: System Architecture for sending alert SMS to mobile.

The following components are needed to add SMS functionality to our MySQL enabled PHP website.
Major Components:

- PHP/MySQL Database
- Ozeki NG - SMS Gateway
- Mobile phone/Modem
- MySQL ODBC 3.51 Driver[15]

The PHP scripts find out the critical and warning river stations and sends SMS to the respective person.

| Username | Mobile | E-mail |
|---|---|---|
| asraf | +8801710127205 | asrafulkuet@gmail.com |
| nova | +8801755501325 | nova@nus.edu |
| tanvir | +8801689969484 | asraful_kuet@yahoo.com |
| theraps | 01710127205 | tanvir_portal@yahoo.com |

Confirm Sent to SMS? Clear

Figure 12: Sending SMS to the respective persons of alert monitoring stations

This warning system is deemed to be a faster method of alerting the relevant authorities and the vulnerable residence. Mobile Phones have become one of the most popular communication devices amongst the people all over the world and we want to take the advantage in flood monitoring system.

## V. THREATS AND CHALLEGENCES

Basically, a sensor network comprises a set of nodes, where each node includes a processor, a wireless radio module, a power supply, and is equipped with sensor hardware to capture environmental data. Each node performs the tasks of data gathering, physical parameter processing, and wireless data transmission to the control server. Specifically, for real time monitoring applications, sensor nodes must also fulfill a number of additional requirements:

- Power lifetime: Power sources are often not available at the locations of hydrological interest. Moreover, these locations are usually unprotected, and if renewable energy devices are used, there are prone to vandalism or theft. Thus, sensor nodes must have low-consumption.
- Long-range communication: Remote locations are commonly sparse over large areas, and far away from the control center. Sensor nodes must have a peer-to-peer connection with the control center.
- Weather Condition: Weather conditions are often an integral element in designing water-level sensors, integrated environmental monitoring and control system. Weather parameters are frequently used in understanding and modeling environmental applications that are dependent on water resources. So it's a big challenge whether the sensors work in any condition.
- Variation of Water Condition: In general, river water contains lot of elements or components such as dust, soil and dirty materials which make different kind of waters. So it's also a thread to give accurate result in all type of water.

## VI. CONCLUSION AND FUTURE WORK

In Bangladesh, Flash Flood as well as Floods is responsible for the loss of precious lives and destruction of large amounts of property. A lot of effort and control are required to be put in developing systems which help to minimize the damage through quick information broadcasting. A complete real-time flood monitoring system has been designed and Implemented in this paper which uses wireless sensor network to monitor water conditions: water level. The developed monitoring system presents useful characteristics as large network capacity, sensor hardware compatibility, long-range communication, and minor impact on the natural environment. The software and the hardware are researched and developed independently. They can not only tremendously ensure a stable, expansible and reliable system, but also reduce the expenses. We think it will open great opportunity for disaster management in Bangladesh.

Our Future work involves more powerful hardware implementation of the monitoring system and performing field tests to observe the communication process between the nodes and finding out correlation of neighbors node which causes increase or decrease of water level. The system can be further improved on the following aspects: (1) Combination of more nodes. Users can obtain the data in large-scale by placing the nodes orderly and optimizing the structure of the sensor network. (2) Intelligent power management. The current system uses storage batteries to provide power, but this method has its limitations in inaccessible places. The self-developed embedded intelligent power management is based on a low-temperature rechargeable battery, solar energy and wind power generation**.**

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