Flood Monitoring and Alert System Using Wireless Sensor Network

By

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15873

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CERTIFICATION OF APPROVAL

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Approval by,

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(DR AZRINA BT ABD AZIZ)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JANUARY 2016

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MUHAMMAD FAKHRUDDIN BIN SAMUJI

ABSTRACT

Flood monitoring and alert system using wireless sensor network is a project to collect flood data in Perak Tengah Region. The project will develop a system that uses a wireless sensor network which consists of a sensor, transceiver to transmit data, and computational device to monitor and predict the flood. Water level, Temperature, and Water velocity data are vital in order to predict the flood disaster. The working principle for this mechanism begin with sensors collecting flood parameters at a specific location, follows by the transmission of these parameters from nodes to the base station. The system will automatically compare the measured parameter with the threshold value that we set for the probability of flood disaster. If the measured values exceed the threshold values that are set, an alert message will be triggered through the use of a Global System for Mobile (GSM).

ACKNOWLEDGEMENT

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CHAPTER 1
INTRODUCTION

1.1. Background study

Flood is a natural disaster that regularly happens in Malaysia as the occurrence of flood happens each and every year [3]. A flood is an event where the accumulated water flows out from the river and submerges the land that is usually dry. There are many types of flood which are flash flood, tidal flood and monsoon flood [1].

Flood disaster can be in large scale and powerful enough to carry big destruction to certain areas. The loss is significant in causing lost in life of resident, the damage of property and food supply, and destruction to government infrastructure [2, 4].

The existing technology used to monitor and alert flood can be categorized into two categories, remote sensing data and local sensing data. Remote sensing data usually use Satellite to record the image of the cloud and predict the rain formation. Local sensing data will measure the flood parameters in the area of study which is at the river by installing sensor nodes along the river.

Even though prediction or tracking the cloud can be made precisely [5], there will be a need for the autonomous checking of the water velocity, the water level in the river and the temperature of certain areas to provide information whether there will be a flood and the condition level due to the cloud formation easily change from time to time depends on the wind blow

This project will design a flood monitoring system for Perak Tengah Region that will use local sensing data via microcontroller system for monitoring and the system can also measure various flood parameters such as water velocity, water level and temperature. These parameters will be transmitted to the user located in an office for display. An alert will be sent to the user when the reading of the parameters exceeds the threshold values indicating dangerous flood condition.

1.2. Problem Statement

According to National Security Council, one of the worst flood disasters happened at Perak in 2014 affecting Kampung Gajah, Lenggong, Kerian, Bota, Parit, Kuala Kangsar and Sungai Siput. The victims of this disaster involved around 1900 families and they were relocated to the nearest shelter.

Most of victims are not aware of the upcoming flood disaster, as there is no specific flood monitoring and alert system installed in Perak Tengah region. Some cases, the victims have already been warned by the authority on the flood disaster, but due to lack of detailed information on the flood scenarios, the time flood begin and fully flooded, the resident ignore the information.

There was a study for flood monitoring and alert system conducted by previous University Technology of PETRONAS student, but the system design did not consider of various flood parameters instead only the water level reading [6].

Flood monitoring system in Malaysia uses a telemetry system that measures the water level values and upload the data at a specific web page. This method requires an Internet connection to upload the values and it is not suitable for developing country like Malaysia due to the excessive cost to build and implement the system throughout the country.

This project will design a flood monitoring and alert system that is low cost and is able to measure various flood parameters such as the water level, water velocity and temperature in real time. In addition, this system will predict the flood disaster and send an alert to the end user.

1.3. Objectives

The main objectives of this project are:

I. To develop a low cost wireless sensor network (WSN) prototype which consists of sensors, transceiver and computational device.

II. To test and validate the working of the built system

III. To measure the flooding parameters such as rainfall, temperature and water level in the field test at Perak River.

1.4. Scope of Study

This project focuses on the Perak Tengah region, which is susceptible to flood disaster due to rise of water levels at Perak river. This project is a collaboration within University Technology of PETRONAS and Department of Irrigation and Drainage (JPS) Perak Tengah, the system will be tested and installed at Rumah Pam Sungai Perak.

CHAPTER 2

LITERATURE REVIEW

2.1. Increasing Flood Risk in Malaysia

In Malaysia, flood happens when the monsoon wind blows and most of cases happen during northeast monsoon season (November to March) [5, 7] and the affected area is the East Coast of Peninsular Malaysia [8]. The other monsoon wind such as Southwest also can cause flood disaster, but due to Indonesia and Thailand covering the other side of the Peninsular Malaysia, the percentage of having flood disaster is low [9, 10].

Malaysian population among the nation has increased day by day [11, 12]. It has been stated that the total number of the population in Malaysia is about 3.5 million roughly. As the population grows, the basic necessities such as provision and shelter will also increase in demand. The human progress, such as the deforestation will make the flood disaster even worse if the forest is not maintained [13].

There were some causes which result to serious flood disasters such as the monsoon wind which comes with heavy rain, the high composition of sediment in the river, man action to the forest and flat topography of the river coast [14]. The other factor of flood disaster is the melting of ice in the north and the South Pole of the world and this phenomenon will increase the water level of the sea and the water level of the river [15].

2.2. Flood Monitoring and Alert System Past Technology

There were many research journals regarding the flood monitoring and alerting system. Most of the system used either remote or local sensing data to monitor and predict the flood.

2.2.1. Remote Sensing Data

One way to detect an upcoming flood is via satellite remote sensing technology [16, 17]. A satellite is an object that moves around the globe and can monitor the change in condition or shape of the earth’s surface at certain area several times in a day as shown in Figure 2.1 [18, 19].

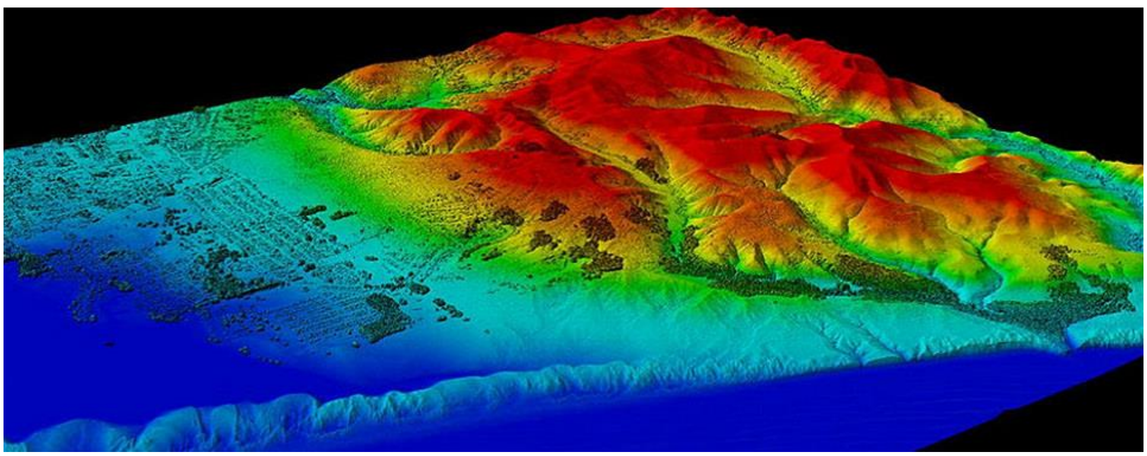

Figure 2.1 Satellite scanning the Earth's surface

The parameters which the satellite remote sensor monitor are based on the soil wetness, surface water body variation and rainfall information [20] [21]. To increase the flood prediction, they also add weather monitoring, wide range imaging, and high spatial and temporal resolution as shown in Figure 2.2.

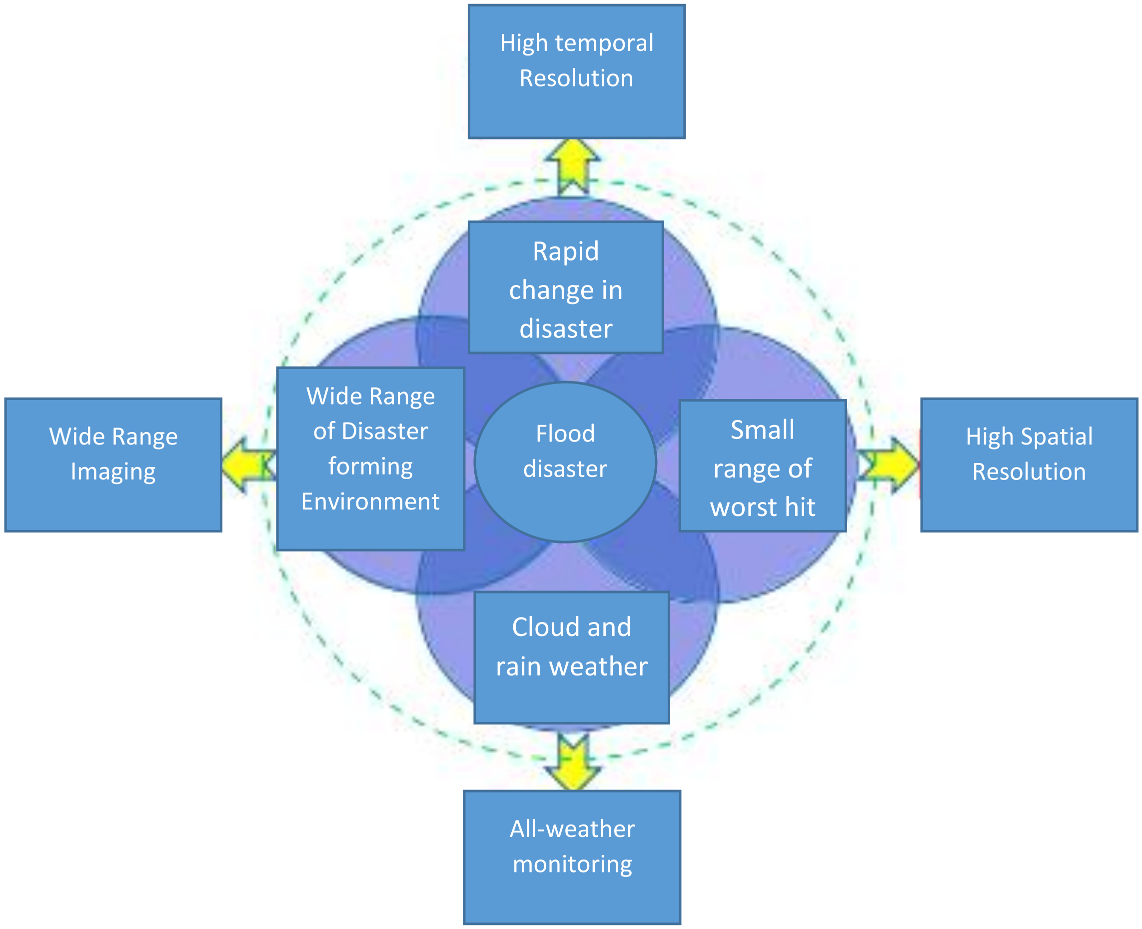

Figure 2.2 Satellite remote sensor for flash flood alerting

Satellite remote sensing data will predict flood by comparing the real-time data image with the normalized image. The accuracy of this method depends on the satellite system parameters such as the incident angle, polarization effects, spatial resolution and the wavelength [22].

The flood monitoring system is crucial for residents who are exposed to the flood disaster. The data and information need to be transferred or delivered quickly and accurately to the person who are being entrusted with this system. The person will analyze the output of the system and spread the predicted information to the resident [21, 23].

2.2.2. Local Sensing Data or Telemetry

Local sensing data or Telemetry system will use embedded system technology to implement the mechanism in the environment. Embedded system nowadays has become a hot issue in the electronic world. The rapid growth and the vast usage around the world are making the embedded system popular all over the globe.

Local sensing data or Telemetry system consists of three major parts as shown in Figure 2.3:

1. Sensing
2. Data processing and transmission
3. Application

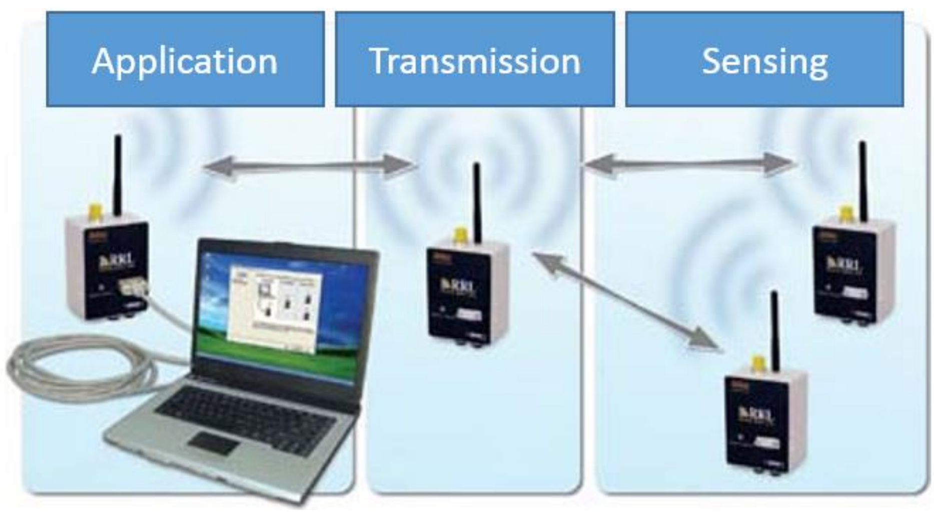

Figure 2.3 Three major part of Telemetry system

2.2.2.1. Sensor Network

Sensor is one of the Wireless Sensor Networking (WSN) components that senses the environment. The selection of sensor is important to a system to ensure the output is accurate. There are some parameters which needed to be monitored for flood monitoring and alert. The parameters are:

- Hydrological: The sensor used for the hydrological is to check the water level and the velocity or flow of the river water. The sensor is installed along the river side [1, 24].
- Metrological: Sensor used for the metrological is to check the intensity of the light, temperature of the surrounding, humidity of surrounding, the barometric pressure, wind direction and the speed of the wind [2].
- Landslide: sensor used to check the soil moisture and the geophone. This type of sensor is installed on the mountain around the river.

The sensors must be located at a strategic place to retrieve accurate data analysis. In addition, the sensors or the system which are planted at the river must be weather proof for whatever monsoon in that area. In some cases, exposed material with a coating and moisture proofing is used to prevent the system from failing [25].

The challenge of this method is to do data collection at the river. Furthermore, the river is lack of electric supply and communication infrastructure. This factor will make the flood monitoring and alert system difficult to implement in practice.

Environmental sensor network needs a complex system to be accurate and it must meet the minimum requirement of the system prediction such as functioning in a long term and support all of the sensors of the parameter to detect the occurrence of flood phenomenon [26]. There were some cases reported due to the destruction of the mechanism caused by the flood and the mechanism need to be reinstall [27].

2.2.2.2. Processing and Transmission

The processing and transmission are important to deliver data from a node installed at a remote location to the end user. The communication technology used in the flood monitoring and alert system is via Wireless Sensor Networking (WSN).WSN is widely used in the flood area due to the low cost and also for the fast and accurate data transfer [28] [29]. Wireless sensor network also becomes a popular usage in human life and the entire world. With this technology, all human activities can be monitored within the stipulated time. There are many types of WSN (communication standard) such as 3G, Bluetooth, GSM, ZigBee, Wi-Fi as shown in Table 2.1.

Table 2.1 Comparison between wireless technology used in the world [30]

Wireless Technology	Range	Data rate	Benefits	Media
3G	Limited	2 megabits per second	1. Online service 2. Proper for download or receive large files	Too much memory needed
Bluetooth	100 meters	700 kilobits per second	1. Wireless 2. Low energy consumption	One to one connection
GSM	All over the world	9.6 kilobits per second	1. Availability 2. Wireless	Low cost
ZigBee	100 meters	250 kilobit per second	1. Wireless 2. No internet needed 3. Low cost	Wireless mesh network
Wi-Fi	Internet	2.4 gigahertz	1. Wireless 2. Database	High cost

The Range of ZigBee module to make sure the node communicating in such a good manner depends on the module series itself. Most ZigBee modules can communicate within the 100 meters. The data transfer rate to deliver the information is around 250 kilobits per second. There are many benefits of using ZigBee module compared to the other such as it works wirelessly, there also will be no internet connection needed to communicate between nodes. It is also low cost to purchase the module and the unique part is it can form wireless mesh network. The disadvantage of this system is it needs to be paired with another device to cope with the communication world and to easily alert the end user such as the GSM module. The ZigBee system is being used in the project as a medium to transfer data from one node to other node.

Mesh network system

A wireless mesh network as shown in Figure 4 is a famous technique that easily connect the entire city using inexpensive technology and effectively sends data wirelessly. Mesh nodes are small radio transmitter that have the same operation as a wireless router. The nodes are programmed to interact with other nodes and support dynamic routing which allow data to be transfer through shortest path [30], less cost, convenient to use when there is no Ethernet wall connection and self-configuring ability. An example of mesh network system using ZigBee is shown in Figure 2.4.

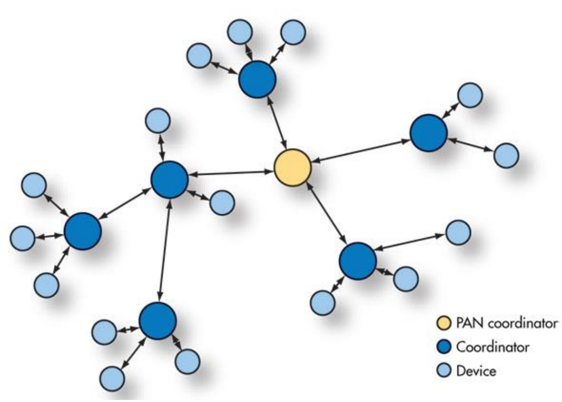

Figure 2.4 Mesh network system

2.2.2.3. Application

Finally, the result is displayed either through application or on the web server. The built system must be efficient in decision making and is able to detect or predict the disaster correctly and reliable.

The overview of most of the local data sensing or Telemetry start with the system measuring the parameters and processing them using the microcontroller to produce a digital data. The nodes will communicate using a communication system between the area of installation and control room. In the control room, the data will be analyzed and if the parameter exceeds some value, it will trigger an alert to the user[12]. The overall system is being illustrated in Figure 2.5.

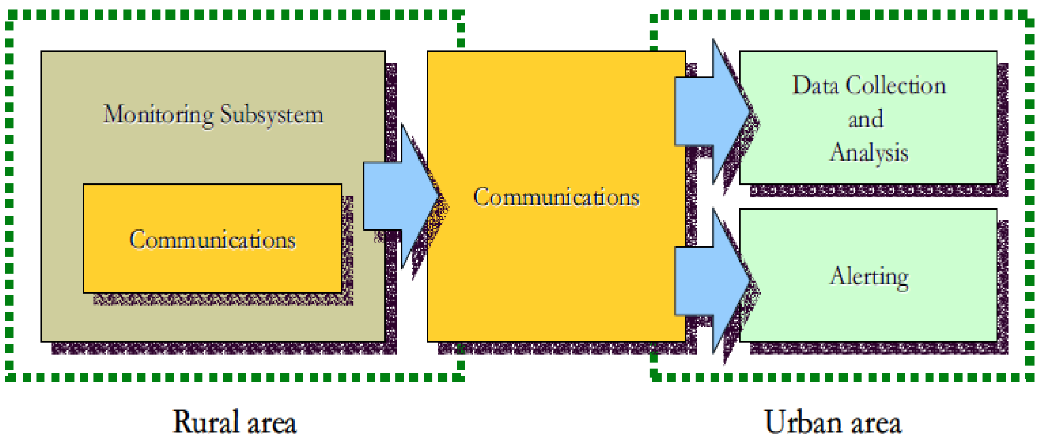

Figure 2.5 Flood monitoring and alert using local data sensing or Telemetry [12]

2.2.3. Combination of local and remote sensing data

This system will use both local and remote sensing data to monitor and alert flood disaster. This system uses the local sensing data to give the real time monitoring and display the data to the user. The remote sensing data is used to compute the data and analyze it to produce an optimum and high quality data thus will lead to producing an accurate prediction. The drawback of this system is that it combines both the disadvantage of the local sensing data and remote sensing data [31].

2.3. Comparison between all methods

Local sensing data, remote sensing data and both combination have their pro and cons (refer Table 2.2).

Table 2.2 Comparison among three methods

	Local sensing data or Telemetry system	**Remote sensing data**	**Combination local and remote sensing data**
Cost	Depends on sensor nodes	High cost	High cost
Parameters	Hydrological, metrological, landslide	soil wetness, surface water body variation and rainfall information	Hydrological, metrological, landslide, soil wetness, surface water body variation and rainfall information
Scale	Depends on sensor nodes	High	High
durability	Low durability (can be upgraded)	High durability	moderate
Accuracy	Moderate	Moderate	High
Maintenance	Low	High	High

2.4. Malaysia Flood Telemetry system

In Malaysia, telemetry system is used to monitor and predict the upcoming flood disaster. The current system only measures two flood parameters that are water level and rain level. The remote sensor is installed at certain places and each of the sensor is equipped with the Internet shield. The data then been uploaded to a certain database and can be seen through a website.

The website shows the map of Malaysia and each of the remote sensor is shown on it. User can click to which part of the remote sensor they want and observe the parameter as shown in Figure 2.6 [32].

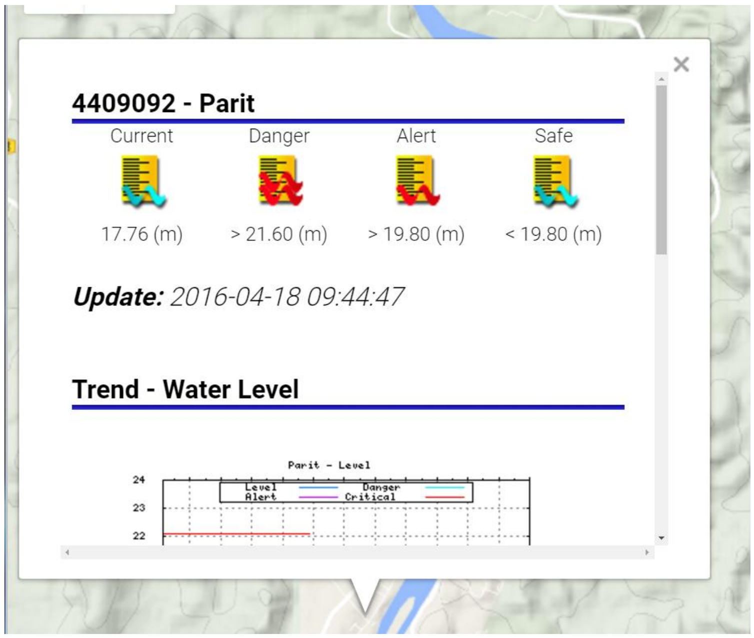

Figure 2.6 Website of Flood Monitoring and Alert system by JPS.

The current telemetry system used in Malaysia is said costly to each remote sensor need to be supplied with the Internet shield and also the cost of website rent. Furthermore, the remote sensors only measure water level and rain level, even though there are many important parameters in determining the flood disaster.

This project aims to minimize the cost by using the ZigBee communication due to zero need for Internet shield and this project will introduce multiple flood parameters in order to make the flood monitoring and prediction even precise

CHAPTER 3

METHODOLOGY

3.1. Project Flow Chart

Final Year Project (FYP) consists of two semesters, which are FYP 1 and FYP 2. The project distribution is divided into four main parts. Literature review and Experimental design are completed during FYP 1. The two remaining parts are design implementation and data acquisition which will be achieved during FYP 2. The project distribution is elaborated in detailed in Figure 3.1.

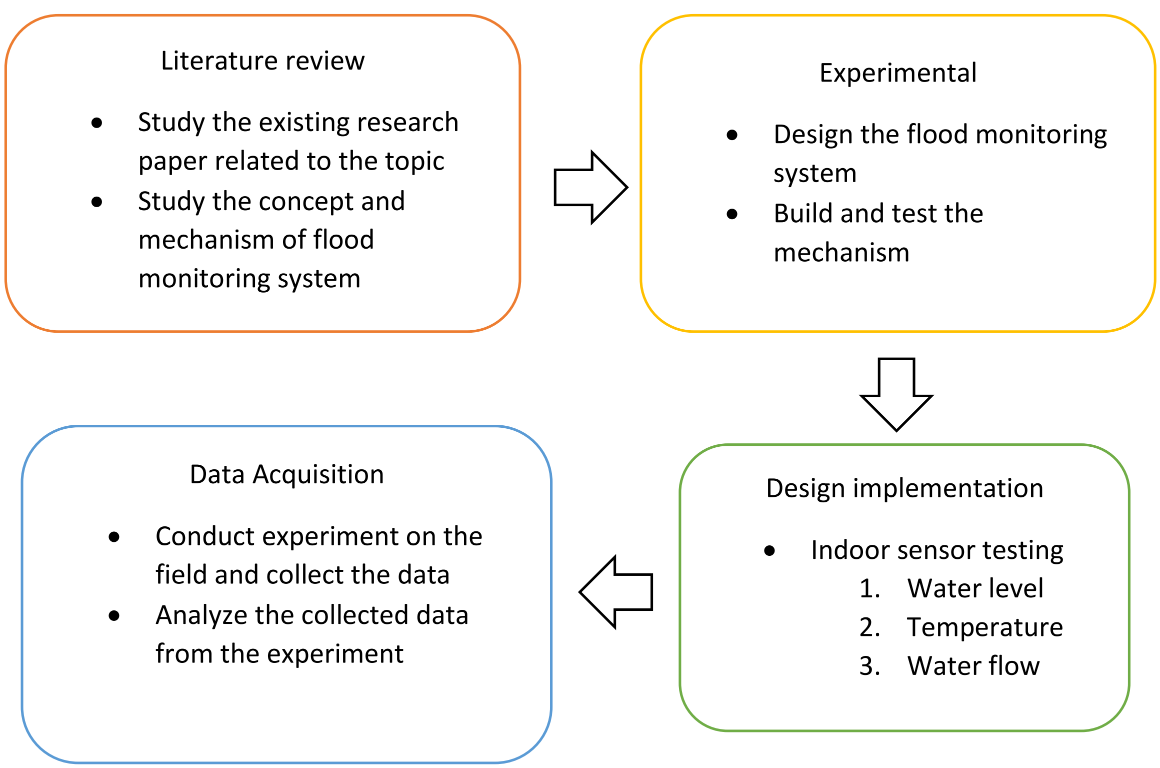

Figure 3.1 Project flow chart

3.2. System architecture

Flood monitoring and alert system using WSN is designed and built for monitoring, predicting and alerting of the flood disaster in the Perak Tengah Region. The system can be divided into three parts (refer Figure 3.2):

3.2.1. Sensor node 1

Part 1 consists of the transceiver, microcontroller, water flow sensor and water level sensor. These two sensors will be installed at the riverside to measure the parameter. The data will be transmitted to sensor node 2 through the ZigBee module.

3.2.2. Sensor node 2

Part 2 consists of a transceiver, a microcontroller, and temperature sensor. The receiver will retrieve the information transferred by the transceiver in sensor node 1. Temperature sensor will record the values and the microcontroller will compare the values with the threshold value. All of the data will be transferred to sensor node 3.

3.2.3. Sensor node 3

Part 3 consists of a transceiver, a microcontroller, a GSM module, a phone and the Personal Computer to monitor the data. The staff can monitor all the parameters via the computer. The phone will receive the alert signal if the measured value exceeds the threshold value.

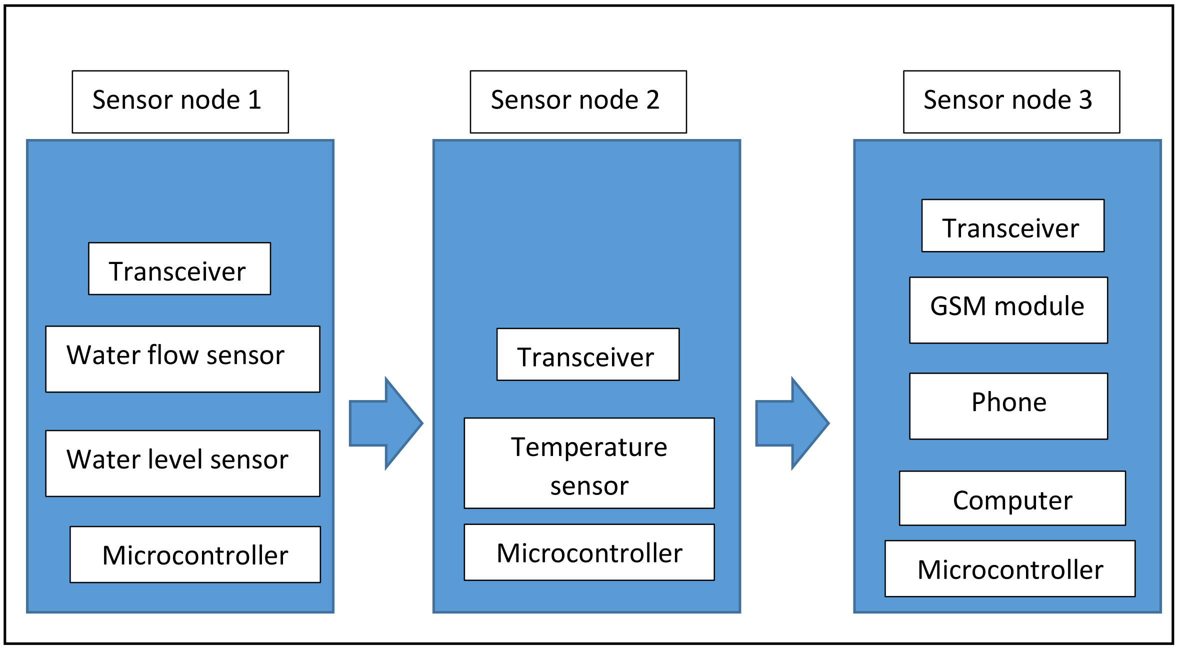

Figure 3.2 Network architecture

All nodes will be installed at the Perak River area as presented in Figure 3.3.

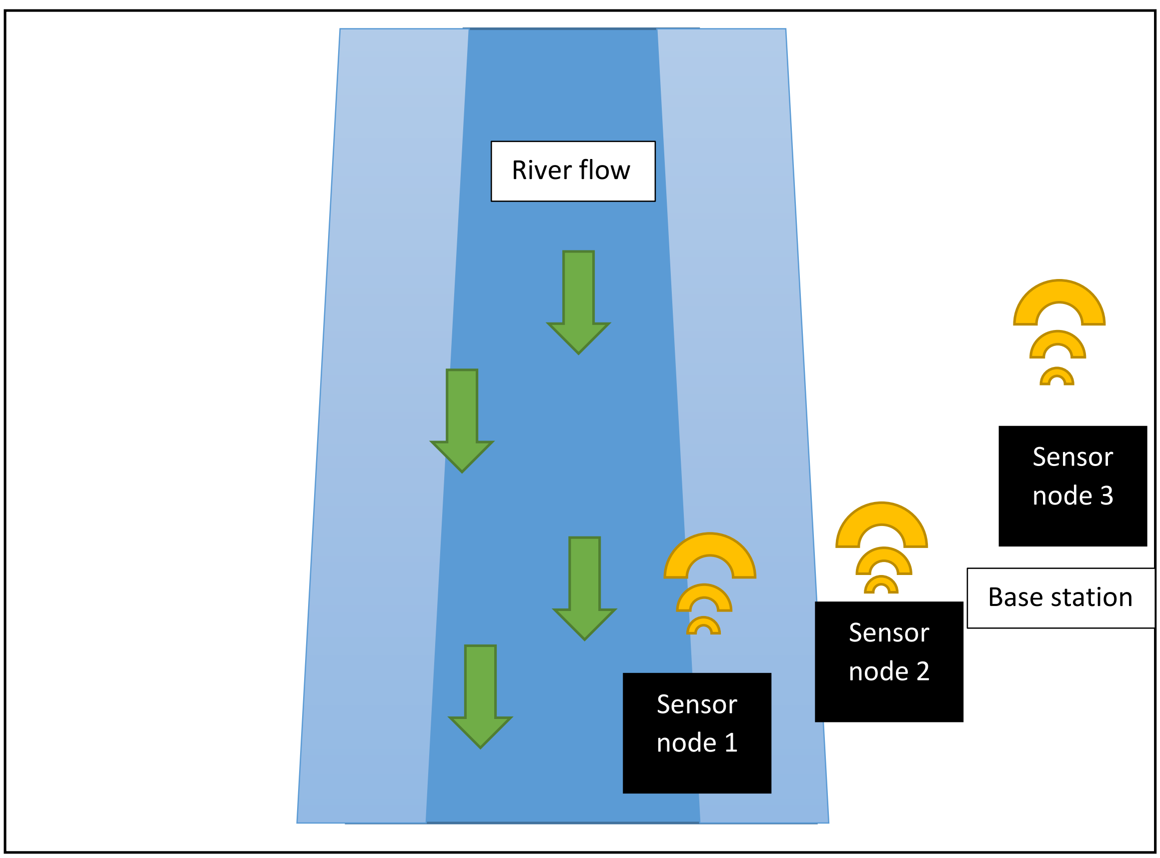

Figure 3.3 Sensor node installation location in Perak River

3.3. Materials and Apparatus

The apparatus for flood monitoring and alert system using wireless system are selected by some factors which are low in cost, able to measure various flood parameters such as the water level, water velocity and temperature in real time. The function of each apparatus are described in Table 3, page 28.

3.3.1. Microcontroller

A microcontroller is a compound of microchip which are able to do read – write, store information by having the memory and can take input to synthesize or produce output and all of these parts are in one board which is the Arduino as shown in Figure 3.4. It can even drive motor or read information through the sensor, but the specification of the item must meet the basic need of an Arduino [33].

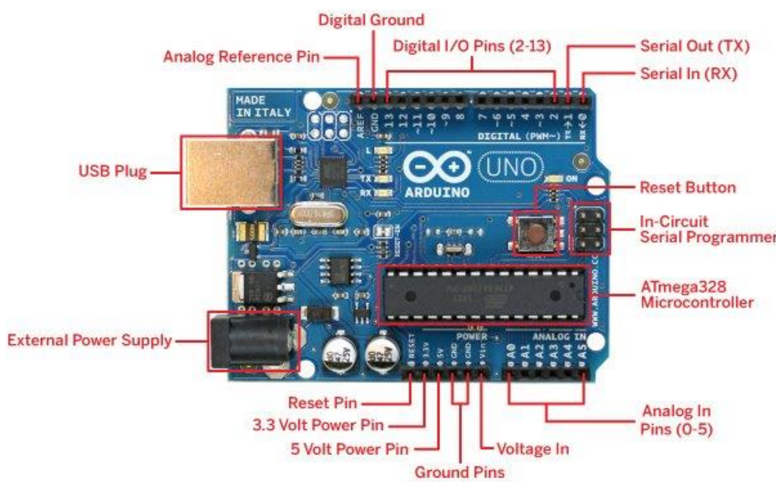

Figure 3.4 Arduino Uno

3.3.2. Sensors

Sensors are crucial in measuring the flood parameter. In this paper, the parameters are the water level, temperature level and velocity or water flows. The sensor used are Ultrasonic sensor, temperature sensor and water flow sensor.

Figure 3.5 Ultrasonic sensor

For this project, the sensor used to measure water level is Ultrasonic sensor as shown in Figure 3.5. This sensor measures the distance from the sensor to the object. It works like a simple communication and have both transmitter and receiver. The working principle of ultrasonic sensor starts with the transmitter emitting an ultrasound with the frequency of 40 kHz with the timer simultaneously on. When emitted ultrasound bounces back to the receiver the timer will stop. The distance can be calculated using:

$$Distance = time\ x\ velocity \qquad (1)$$

The range which the sensor can detect are starting from 2cm to 400 cm and the accuracy can reach to 3mm.

Figure 3.6 Water flow sensor

The sensor chosen to measure the velocity or water flow rate of water is the YF-S201 Hall effect Water Flow Sensor as depicted by Figure 3.6. The sensor has a pinwheel sensor that rotates when the liquid moves through it and will measure how much liquid has passed through. It uses an integrated magnetic hall effect that produces an electric pulse when it is rotating. The generated electric pulse is a simple square wave and it can be converted into liters per minute by:

$$Flow\ rate, L/min = \frac{Pulse\ frequency(Hz)}{7.5} \tag{2}$$

Figure 3.7 Temperature sensor

As given in Figure 3.7, the selected sensor for measuring temperature is DHT 11. This sensor consists of resistive type humidity measurement and humidity sensing technology, which can measure both temperature and humidity. The measurement range for humidity is 20% to 90% while temperature range is 0 to 50 degrees Celsius. The humidity accuracy can reach to 5% and temperature accuracy can reach to 2 degrees Celsius.

3.3.3. Wireless data transfer

Data need to be transferred quickly and wirelessly. In this project the wireless system used are ZigBee module and GSM module**.**

Figure 3.8 GSM module

The aim of this project is to alert the community toward the upcoming flood disaster. SIM900 is the selected mechanism that will be used in this project. The system will alert the end user in real time. The GSM module as in Figure 3.8 will send an alert via SMS when the measured values of parameters exceed the threshold values set.

Figure 3.9 ZigBee module

The system uses ZigBee module as in Figure 3.9 is the medium to transfer the data from one node to another. These modules use simple communication between the microcontroller, computer. The system can be set up whether to use it point to point or multi point networks. The power consumption for this module is around 0.15 Watt and the transfer rate is 250 kbps from a node to another node. The maximum range between two modules is 120 m and if the range is more than 120 m it will have disruption or no data is transmitted.

3.3.4. Alert system

The system will alert the subjected person via SMS received through the phone and the real time data is displayed on the computer at the base station. Table 3.1 summing the equipment used.

Table 3.1 Equipment and their functionality

Equipment	**Function**
Ultrasonic sensor	To measure water level
Temperature sensor	To measure the temperature
Water flow sensor	To measure the water flows
Arduino UNO	As microcontroller to set the condition
ZigBee module	Transfer data via wireless network
GSM module	Alert by sending SMS
Computer	Base station and display data
Phone	To receive alert sent from GSM module

For Parit region, the only available information is water level where the previous flood parameter is shown in Table 3.2. For temperature, the average value is 27.4 ℃ and the lowest is 21.8℃ and the highest is 33℃ [34]. Therefore, water flow parameters require more analysis to provide specific prediction to the system especially before the occurrence of flood disaster.

Table 3.2 Danger level, alert level and safe level parameters for Parit region

	Level 1	Level 2	Level 3
Water level (m)	Danger (>21.6)	Alert (>19.8)	Safe (<19.8)
Temperature (℃)	Danger (21.8)	Alert (27.4)	Safe (33)
Water flow (L/hour)	Danger	Alert	Safe

3.4. Program flowchart

Program flowchart as shown in Figure 3.10 is the overall flow of how the flood monitoring and alert system works using the architecture shown previously in Figure 8. The program starts with the activation of all nodes. All of the sensors will measure the parameters which are water velocity, water level and temperature. The data in sensor nodes 1 and 2 will be transferred to sensor node 3. The data is then analyzed and the values will be compared with the flood parameter threshold value. All of the values will be displayed on the computer at the base station. If the value of measured parameters exceeds the threshold value, GSM module will trigger and send an alert to the phone. If the value does not exceed the threshold value, the sensor will start measuring the new data.

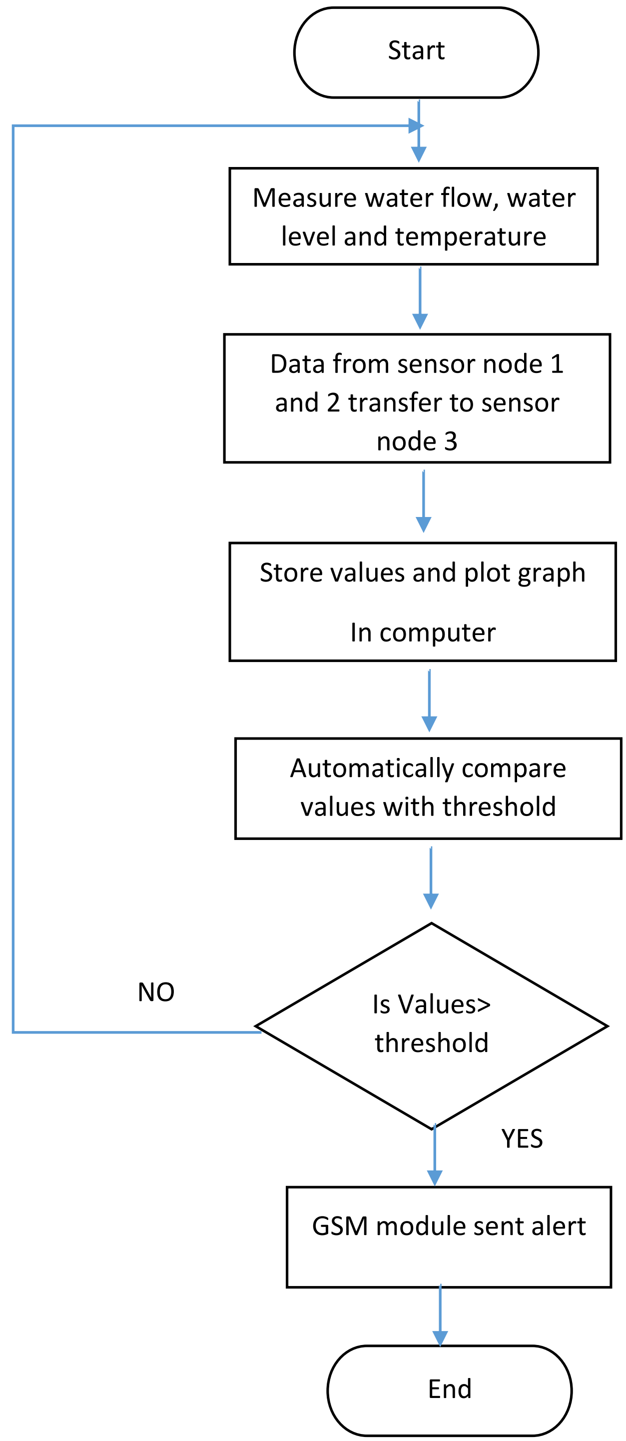

Figure 3.10 Program flowchart

3.5. Gantt Chart and Key milestones

Gantt chart and key milestone for Final Year Project 1 is summarized as shown in Table 3.3.

Table 3.3 Gantt Chart and Key milestones (FYP 1)

No	Detailed Work	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project Selection														
2	Literature Review														
3	Extended proposal submission														
4	Material Purchasing														
5	Proposal Defense														
6	Coding														
7	Testing temperature sensor														
8	Testing ultrasonic sensor														
9	Testing water flows sensor														
10	Integration														
11	Interim draft report submission														
12	Interim report submission														

Process

Suggested Milestone

Gantt chart and key milestone for Final Year Project 2 is summarized as shown in Table 3.4.

Table 3.4 Gantt Chart and Key milestones (FYP 2)

No	Detailed Work	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Testing GSM & ZigBee module														
2	Coding & Integration of material														
3	Build prototype														
4	Progress Report														
5	Testing prototype (Field)														
6	Verification of result														
7	Final Report														

Process

Suggested Milestone

CHAPTER 4

RESULT AND DISCUSSION

This chapter provides the results of the experiments. Three experiments were conducted. First experiment was done in indoor environment. Second experiment studies the system implementation in outdoor to observe the behavior of these sensors. The purpose of third experiment is to integrate all the sensors and produce flood monitoring system using wired connection.

4.1. Indoor Sensors testing

In indoor experiment three experiment were done which are Ultrasonic sensor, Temperature sensor and Water flow sensor to test the functionality and accuracy of the sensors.

4.1.1. Water level via Ultrasonic Sensor

The purpose of the experiment is to check correction of the coding and test the operation of the sensor. Figure 4.1 shows the sensor is used to detect an object. The code operates well with the hardware and the output result is displayed on the serial monitor on the Arduino software as in Figure 4.2.

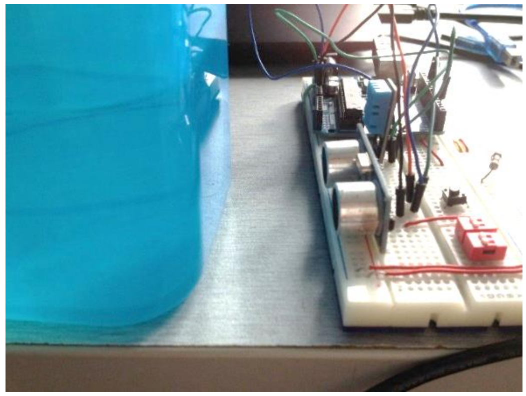

Figure 4.1 Ultra Sonic testing using an object

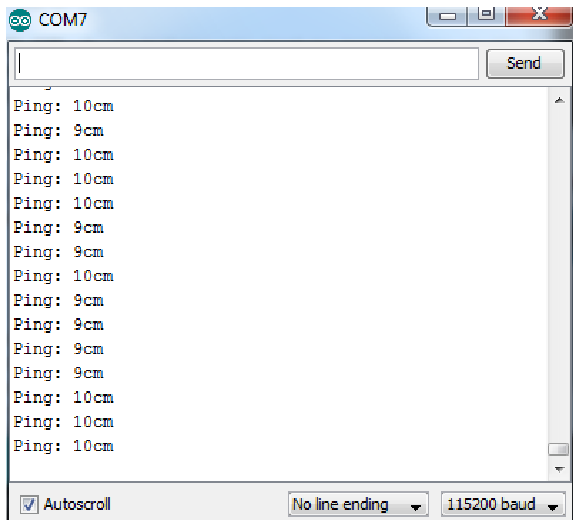

Figure 4.2 Result displayed at serial monitor

The Ultrasonic Sensor is then tested onto the surface of the water as shown in Figure 4.3. The experiment is done to show whether the sensor can be used to sense water level or not. The serial monitor can display the distance between the sensor to the water surface, proving that the Ultrasonic Sensor can be used to monitor the water level.

Figure 4.3 Ultrasonic sensor with water surface

The test is continued with different levels of water as in Figure 4.4.The same container is added with water to check the sensitivity of the Ultrasonic sensor with the water surface.

Figure 4.4 Different levels of water testing

4.1.1.1. Results and analysis

Two distinct water level were chosen which are 10 cm and 20 cm. The experiment was being repeated 4 times and the data is recorded in the Table 4.1 and Table 4.2. Measured value is the value recorded using the Ultrasonic sensor where Actual value is the value measured using ruler from the sensor to the water surface.

Table 4.1 Water level sensor testing for 10 cm

Water surface	Measured	Actual
Test 1	9cm	10cm
Test 2	10cm	10cm
Test 3	10cm	10cm
Test 4	9cm	10cm
Mean	9.5cm	10cm

Percentage error for 10 cm is 5 % and is calculated by:

$$Percentage\ Error = \frac{Mean\ measured\ value - actual}{actual} \times 100 \tag{3}$$

$$Percentage\ Error = \frac{9.5cm - 10cm}{10cm} \times 100 \tag{4}$$

$$Percentage\ Error = 5\ \%$$

Table 4.2 Water level sensor testing for 20 cm

Water surface	Measured	Actual
Test 1	21cm	20cm
Test 2	21cm	20cm
Test 3	20cm	20cm
Test 4	21cm	20cm
Mean	20.75cm	20cm

For water level of 20 cm, the error is 3.57% and is calculated by:

$$Percentage\ Error = \frac{20.75cm - 20cm}{20cm} \times 100 \tag{5}$$

$$Percentage\ Error = 3.57\%$$

Based on the small error calculated for 10 cm and 20 cm water level, the Ultrasonic sensor is reliable due to its percentage error below 10%.

4.1.2. Temperature via Temperature Sensor

The Temperature sensor as in Figure 4.5 was coded to produce an output. The experiment was performed to test whether the sensor is compatible with the code. The output was displayed as temperature on the Serial Monitor as shown in Figure 4.6. The measured values then were compared with the google forecast values to calculate the accuracy of the temperature sensor.

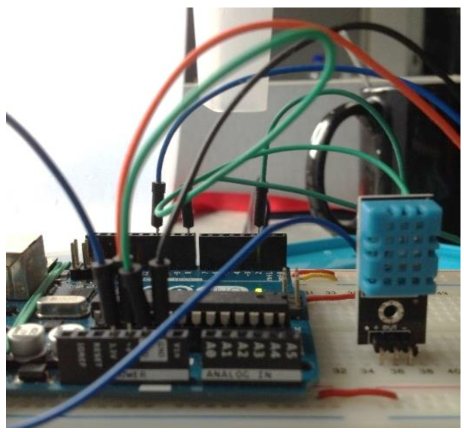

Figure 4.5 Temperature sensor testing

```
Humidity: 65.00 %      Temperature: 31.00 *C 87.80 *F
Humidity: 65.00 %      Temperature: 31.00 *C 87.80 *F
Humidity: 65.00 %      Temperature: 31.00 *C 87.80 *F
Humidity: 65.00 %      Temperature: 31.00 *C 87.80 *F
Humidity: 65.00 %      Temperature: 32.00 *C 89.60 *F
Humidity: 65.00 %      Temperature: 31.00 *C 87.80 *F
Humidity: 65.00 %      Temperature: 31.00 *C 87.80 *F
Humidity: 65.00 %      Temperature: 32.00 *C 89.60 *F
Humidity: 65.00 %      Temperature: 32.00 *C 89.60 *F
Humidity: 65.00 %      Temperature: 32.00 *C 89.60 *F
Humidity: 65.00 %      Temperature: 32.00 *C 89.60 *F
Humidity: 65.00 %      Temperature: 32.00 *C 89.60 *F
Humidity: 65.00 %      Temperature: 32.00 *C 89.60 *F
Humidity: 65.00 %      Temperature: 32.00 *C 89.60 *F
Humidity: 65.00 %      Temperature: 32.00 *C 89.60 *F
```

Figure 4.6 Result displayed at serial monitor

4.1.2.1. Result

The temperature data from the sensor were compared with the online source generated by google as shown in Figure 4.7 [23]. The experiment was conducted four times and the data is recorded in the Table 4.3.

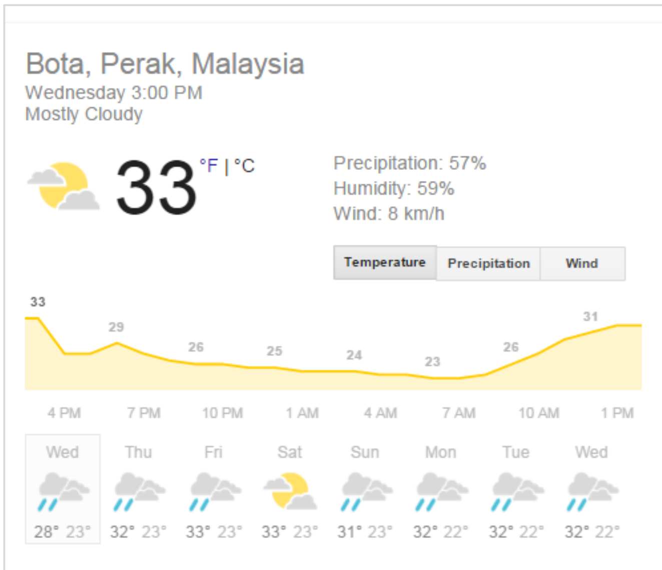

Figure 4.7 Weather forecast by google

Measured value is the value recorded using the Temperature sensor where Actual value is the value generated from wheather.com.

Table 4.3 Temperature sensor testing

Temperature	Measured (°C)	Actual (°C)
Test 1	32	33
Test 2	32	33
Test 3	32	33
Test 4	32	33
Mean	32	33

For temperature, the percentage error is 3.03% and is calculated by:

$$Percentage\ Error = \frac{32-33}{33} \times 100 \tag{6}$$

$$Percentage\ Error = 3.03\%$$

Based on the small error calculated for temperature, the temperature sensor is reliable due to its percentage error below 10%.

4.1.3. Water Flow Sensor testing

The water flow sensor in Figure 4.8 was operating and the water was passes through the sensor through the tube. The reading then being recorded and displayed on the Serial monitor as in Figure 4.9. The testing for water flow meter was still ongoing due to the need to conduct the experiment in the suitable lab to calculate the accuracy of the system with the actual value.

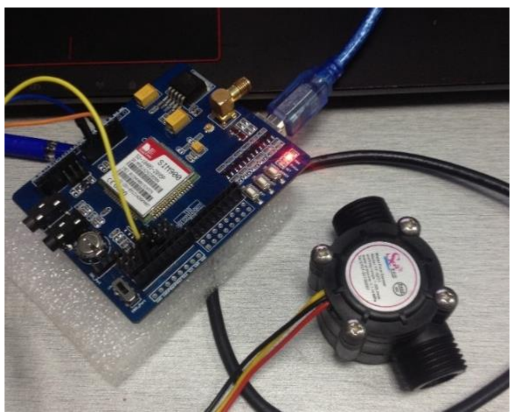

Figure 4.8 Water flow sensor testing

Figure 4.9 Result displayed at serial monitor

4.2. Outdoor sensors testing

The experiment is done in the real life situation to observe the behavior of the sensors. All sensors which are water flow sensor, temperature sensor and ultra-sonic sensor were tested and the result is recorded. The outdoor experiment has been done for 4 days and the data are tabulated in Table 4.4.

4.2.1. Water Flow sensor

Some additional part needs to be modified at the original Water Flow sensor to make sure the wire does not immerse in the water. Some material (polystyrene) is stacked to the Water Flow sensor to make sure only the turbine part of the sensor is immersed in the water as in Figure 4.10. The modified sensor is tested on the water surface and the data are recorded.

The data can be seen on the Serial monitor on the Arduino program on the computer. The outcome of the experiment shows that the system is able to deliver the data without damaging the sensor itself and the environment.

Figure 4.10 Water flow sensor outdoor test

4.2.2. Temperature sensor

The Temperature sensor can be used easily anywhere without any major modification to the sensor as long as the connection is correct and equipped with power supply as shown in Figure 4.11. Some protection is needed to protect the sensor from the water droplet because it may disrupt the sensor from sensing the temperature parameter.

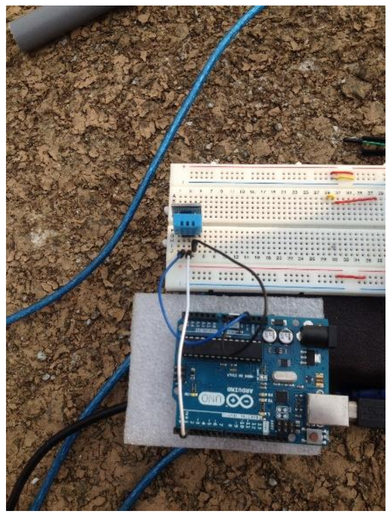

Figure 4.11 Temperature sensor outdoor test

4.2.3. Ultrasonic sensor

Ultrasonic sensor must be used on a dry place. It is because whenever the sensor made contact with the water or liquid in it will be malfunction. Thus, modification needs to be done to the sensor as shown in the Figure 4.12. A certain distance is kept between the sensor and the water surface and the transducer must be faced directly perpendicular towards the water surface. When flood happens, the water level can rise to 3 meters from the normal level of water. Thus the sensor and the water surface must be more that that range for the system to operate well.

Figure 4.12 Ultrasonic sensor outdoor test

The outdoor experiment has been done for 4 days and the data are tabulated in Table 9. The experiment was conducted for 3 hours each day with the delay of 15 minutes between the recorded data. The data shown in the Table 4.4 is the mean for each day. The data then displayed in graph as shown in Figure 4.13.

Table 4.4 Outdoor test result

	Water Flow sensor	Temperature sensor	Ultrasonic sensor
Day 1	56 L/hour	34(℃)	17.5 cm
Day 2	54 L/hour	33(℃)	16 cm
Day 3	59 L/hour	35(℃)	18 cm
Day 4	55 L/hour	34(℃)	17 cm

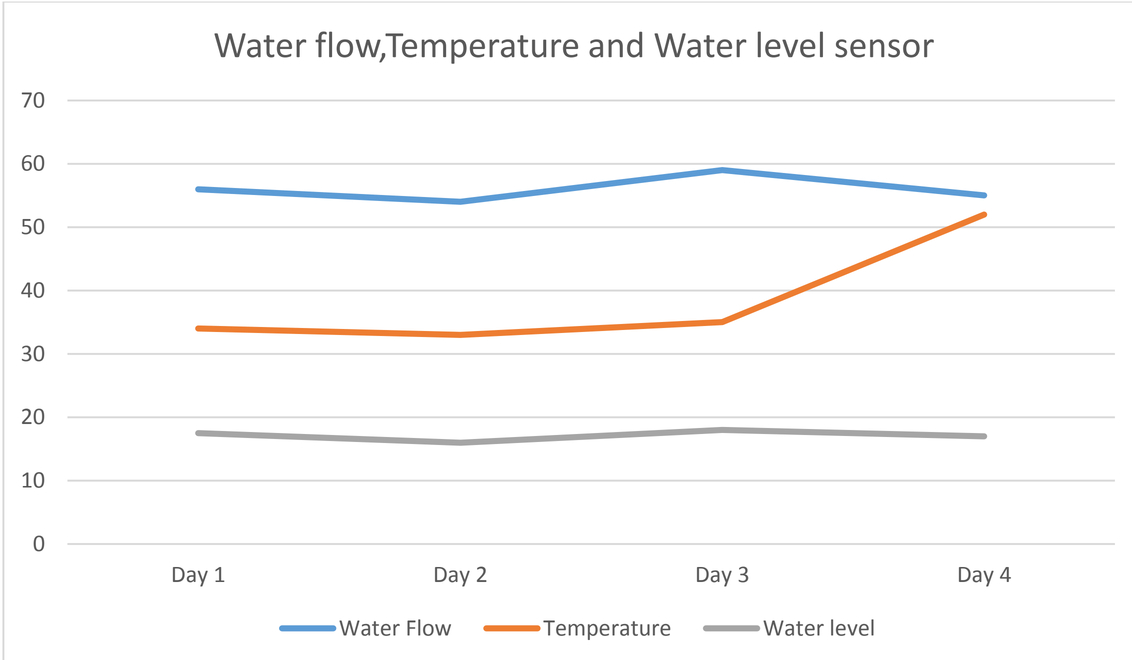

Figure 4.13 Graph of outdoor result

4.3. Subsystem Integration (wired)

The purpose of this experiment is to integrate all sensor data and produce a flood monitoring system using wired connection. All sensors are combined together into one Arduino board. The materials that used in the experiment are Ultrasonic sensor, Water flow sensor, Temperature sensor, an Arduino, a GSM module, a PC and a phone. A platform was made to implement all materials to fit in one system as shown in Figure 4.14. Two containers are combined together to enable all sensors to function at one time. The chronology of the system is to transfer water from container 1 to container 2. Ultrasonic sensor will be installed at the top of container 2 facing down the water surface to measure the water level as in Figure 4.15. The water flow sensor will be installed at the pipe between the container 1 and container 2 to measure the water flow as in Figure 4.16. Temperature sensor is stacked with the GSM module and the Arduino board as in Figure 4.17.

Figure 4.14 Subsystem integration (wired)

Figure 4.15 Ultrasonic sensor (wired)

Figure 4.16   Water flow sensor (wired)

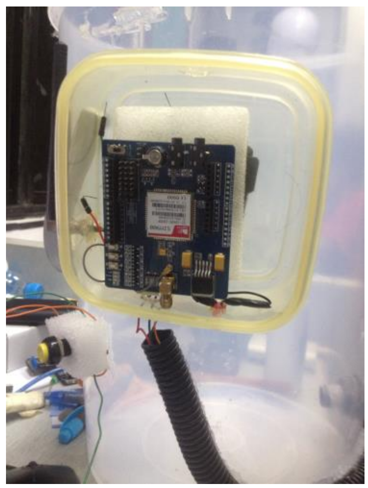

Figure 4.17   GSM module with Arduino (wired)

The observation is being made when the system operates and the result is recorded. All data are displayed on monitor through Serial monitor. The GSM has been set to trigger the message when it meets the selected condition. For this experiment, GSM module will send messages only when Water level is on level 1. Table 4.5 is the set of all water levels for the experiment. The water level is divided into three groups according to the JPS system which are Danger, alert and safe but the values in the Table 4.5 is adjusted according to the container.

Table 4.5 GSM module trigger mode

	Level 1	Level 2	Level 3
Water level (cm)	Danger (<12)	Alert (13-18)	Safe (19>)
Temperature (°C)	Danger (21.8)	Alert (27.4)	Safe (33)
Water flow (L/hour)	Danger (70>)	Alert (60-69)	Safe(<50)

Figure 4.18 Message received on phone

The GSM module will send an alert to a specified phone number as in Figure 4.18, when all parameters that are water level, temperature and water flow meet all the danger condition as shown in Table 4.6:

Table 4.6 Parameter that will trigger GSM module:

	Level 1
Water level (cm)	Danger (<12)
Temperature (°C)	Danger (21.8)
Water flow (L/hour)	Danger (70>)

4.4. Subsystem Integration (Wireless)

The purpose of this experiment is to integrate all sensor data and to produce a flood monitoring system using wireless connection. All sensors are combined together into one Arduino board. The materials that is used in the experiment are Ultrasonic sensor, Water flow sensor, Temperature sensor, an Arduino, a GSM module, a Personal Computer, a phone and a pair of ZigBee module. A platform was made to implement all materials to fit in one system as shown in Figure 4.19.

Figure 4.19 Subsystem integration (wireless)

The operation still same as the subsystem integration for wired which consist of two containers that are combined together to enable all sensors to function at one time. The difference is the transmission media which is by using wireless medium (ZigBee modules)

Due to the difficulties to with the ZigBee module hardware. The current system only can provide 2 nodes. A node called router as shown in Figure 4.20 will collect all three flood parameters and transmit the data wirelessly to another node called coordinator as shown in Figure 4.21.

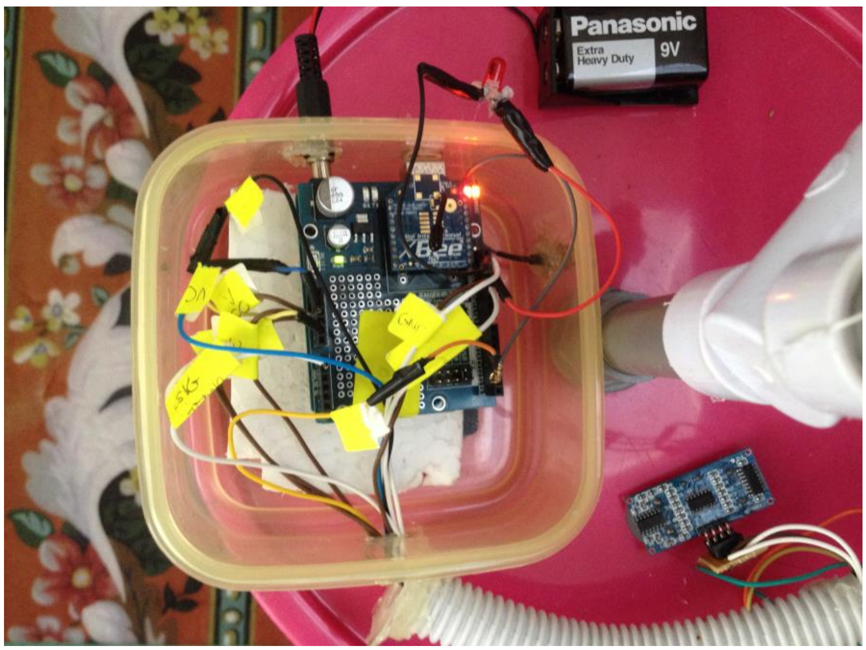

Figure 4.20 Router

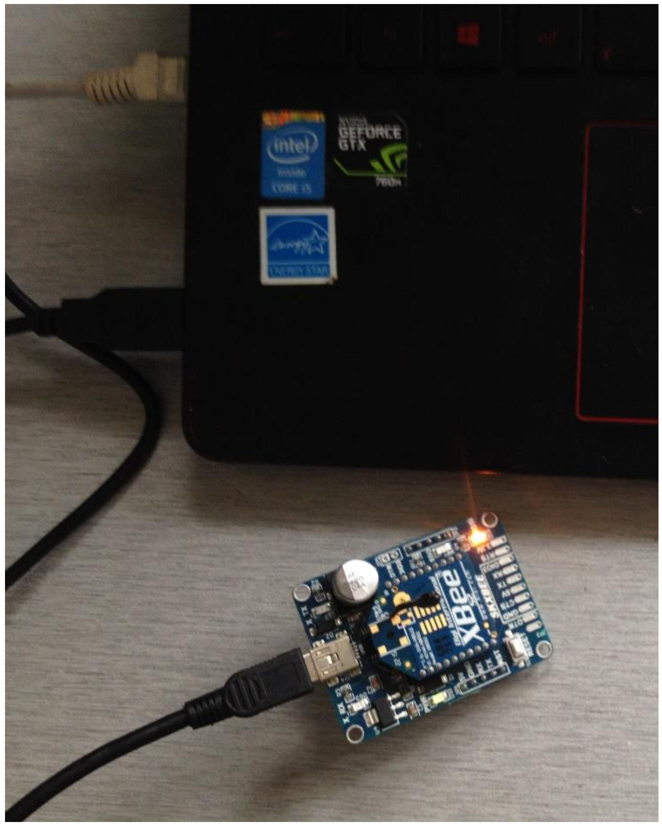

Figure 4.21 Coordinator

The GSM module cannot be integrated with the wireless system due to the complexity of the ZigBee module. The system will have such an interruption that will suddenly reset and stop the program. For the time being, the system will alert the user through the serial monitor showing “level 1” only when all parameters that are water level, temperature and water flow meet all the danger condition as shown in Table 4.7:

Table 4.7 Parameter that will trigger an alert

	Level 1
Water level (cm)	Danger (<12)
Temperature (℃)	Danger (21.8)
Water flow (L/hour)	Danger (70>)

4.5. Discussion

Indoor sensors testing, Outdoor sensor testing and subsystem integration (wired) has been tested and the code is working well with the hardware as shown in Table 4.8.

Table 4.8 Subsystem tested

Material	Tested	Remark
Ultrasonic sensor	✓	Object Water surface Outdoor
Temperature sensor	✓	Temperature Outdoor
Water flow sensor	✓	*Experiment in lab Outdoor
Arduino UNO	✓	Sensors
ZigBee module	✓	*2 ZigBee modules
GSM module	✓	*Sent Message
Computer	✓	*Display result
Phone	✓	Display Message from the GSM module

The integration of subsystem is the challenging part of the whole building process. The process will allocate more time due to programming part which need to be combined into one form of the system.

A problem occurs when the programming of the ZigBee module is hard to be completed. Furthermore, the ZigBee module also very sensitive and need to be handled carefully. More time will be needed to study the behavior and to code the ZigBee module to ensure data from every node is collected by the main node.

CHAPTER 5

CONCLUSION & RECOMMENDATION

Flood monitoring and alert system using wireless sensor network is important as it deals with flood disaster that happens every year in Malaysia especially in Perak. The flood monitoring and alerting system really make a huge difference in helping the residents to be aware of the upcoming disaster. The flood information would be obtained in real time without delay and the action can be planned earlier such as the relocation of the resident and their belongings.

This research is important and suitable for final year student to be done and completed with the help of a supervisor. The allocated time is enough and workable to complete the project research.

During the completion of this project, there are some recommendation to be made for a better accomplishment in the future. Future studies is required to make this project successful. The most problematic subsystem is the data transmission due to the ZigBee module is very sensitive and the bootloader easy to crash. Its compulsory to purchase ZigBee module from certified manufacturer and study the behavior on the communication system deeper. It is also being recommended to use system that have the same function as ZigBee module also use communication system that have higher communication range between the nodes. More flood parameter can be added to the existing flood monitoring and alert system to increase its accuracy and sensitivity such as barometric pressure, wind direction, speed of the wind and etc.

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