IOT System: Water Level Monitoring for Flood Management

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Abstract. The present of natural disaster such as flood cause loss of life, property, devastation of livestock and agriculture. Flood is known as yearly disaster in Malaysia because of the monsoonal rainfall. Therefore, a system that provide an informative flood notification system that give early warning need to be develop to reduce the losses and early notification to the community in the affected area. The notification system will involve GSM network due to the coverage of GSM network is widespread and mostly available in any places in Malaysia. The notification messages will be sent to user in that area, such as head of village, police station and nearest safety agencies. System architecture designed using Arduino UNO acts as microcontroller of system that will perform various actions such as to observe height of water, temperature and humidity and send SMS through GSM shield. In order to validate the accuracy of proposed system, experiment was conducted using small scale prototype to simulate the real flood conditions. The system will provide real time and reliable measurement of water height and send SMS notification.

1. Introduction
Floods are amongst the most common and devastating of all-natural hazards. The study location, Bandar Segamat is one of the famous area related flood, which is located at low area in Johor. The current flood warning system implemented in Johor is not widely use. The point of monitoring is focused on one location per river. Several areas still pending to receive early flood notification due to ineffective and unsuitable alert tools of communication channels. Moreover, existing warning system lacks the basic abilities to monitor water level. The proposed system focuses on designing system that overcomes the existing flood system based on comparison study on previous system [1]. The system is simulated to determine the accuracy and reduce system errors by using prototype of this system.

This research focused only for detection and early warning alert system via cell phone text messages that alerts local subscribers of potential flood events. This system is provided with the actual water level, temperature and humidity of the desired area location. An estimated time a particular river waterway will overflow is also included in the analysis. The hardware used in the design is split into several part namely: the water level detector, temperature and humidity detector, GSM module and micro-controller development board. Text messaging will set the notification to the registered customer when alarm signal is on. Block diagram of proposed system is shown Figure 1.
2. Flood Disaster in Malaysia

Flood is the most intense natural disaster experienced in Malaysia. Flash flood and Monsoon flood are two vital type of flood that occurred in this country. The monsoon flood occurs from Northeast monsoon which occurs from the month of October to March causing heavy rain to east coast state in peninsular, northern part Sabah and southern part of Sarawak [2]. Figure 2 shows the rainfall pattern in Malaysia and how it is influenced by two monsoon that are south east west and north east monsoon [3].

The location of Malaysia is near to the equator, and the most severe climatic related natural disasters are monsoonal flood [4]. It happens almost every year and causes a lot of damages, property loss, and not to mention the loss of life during the disaster. The world’s climate is changing drastically due to effect from human activities such as pollutions, cut countless trees, excessive gas emission etc.

Based on the history, one of the worst flood disasters was happened in this decade due to monsoon rain. The flood had affected the east state of Malaysia including Kelantan, Perak and Johor. This disaster started from November 2014 until early 2015. This worst flood involved 200,000 people and with 21 deaths. During this disaster, not only cause the loss of life but also a lot of damages building and public facilities such as school, train railway and hospital. Therefore, the communications also had a problem due to road was submerges by water. At certain places electricity had to be cut off to prevent electrical shock. The reported damages would cost state government over RM1 billion to recover all the facilities [5].
2.1. Communication Channels Used in Flood Warning System

Transmitting information (voice and data) are standards for mobile communication by using airwaves. In [6] from the comparing of two network models which is 4G and 3G, and the observed result it is concluded that 4G is more efficient than 3G. However, without network coverage, people cannot get online such as in rural area. Therefore, Global System for Mobile Communication (GSM) is the most fundamental way of communication with roaming facility and good network capability. GSM is virtually no requirement to build additional network [7,8].

Most common channel is use siren to notify of incoming flood or tsunami disaster. However, the system is not effective because of only surrounding people will be reached [9]. Radio and television also help in notify people but it will take time to broadcast the news. Internet is known for wide range of spreading information around the world but people must have Wi-Fi or internet data plan to receive the warning. Therefore, SMS is the most reliable methods to send information because of the widespread telecommunication system that can reach almost every places even rural village and mountain the signal can be reached [10,11].

2.2. Communication Channels Used in Flood Warning System

The alert system is very important to warn the upstream village immediately and then warn the downstream area in advance [12]. In order to design more effective system, the data from JPS Malaysia, is used as references in monitoring on study area. By using the data, sensor is programmed as to give warning base on each river attribute. Table 1 shows Segamat river level data.

Table 1. Segamat River Level Data.

| Station Name | River         | Above Mean Sea Level (MSL) m |
|--------------|---------------|------------------------------|
|              |               | Normal | Alert | Warning | Danger |
| Sg. Lenik    | Sg. Batu Pahat| 4.10   | 5.00  | 5.50    | 6.00   |
| Ladang Chaah | Sg. Juaseh    | 25.00  | 27.00 | 30.60   | 32.00  |
|              | Kemelah       |        |       |         |        |
| Sg. Muar     | Sg. Segamat   | 18.00  | 18.95 | 19.35   | 19.95  |
| Kg Awat      | Sg. Muar      | 7.30   | 7.92  | 8.53    | 9.14   |
|              | Buloh Kasap   |        |       |         |        |
| Sg. Muar     | Sg. Muar      | 5.00   | 7.92  | 8.53    | 9.14   |
| Buloh Kasap  | Sg. Segamat   |        |       |         |        |
| Bandar Segamat | Sg. Batu Pahat| 11.00  | 12.00 | 12.60   | 13.00  |
| Kangkar Chaah| Sg. Lenik     |        |       |         |        |

2.3. Communication Channels Used in Flood Warning System

Typically, water level detection operate by measuring the distance between the liquid level and a reference point at a sensor or transmitter near the top of the vessel [13]. In this system, only one sensor
is required to run the system compare to other method that required for different sensor for different height. The cost of development can be reduced when using ultrasonic sensor because it has more advantages compare to water level system in this system context. The flood notification system consists of three phases; data recording, data processing and data broadcasting.

2.3.1. Data Recording. The ultrasonic sensor measure water level and send the data to Arduino system. The sensor transmits high-frequency sound pulse and record how long it takes for the sound pulse to reflect back. The speed of sound transmitted is approximately 341 meters per second in the air. The sensor then used time difference between sending and receiving sound pulse to determine distance of object using the following mathematical Equation 1 [14]:

\[
\text{Distance} = \frac{\text{Time} \times \text{speed of sound}}{2}
\]

2.3.2. Data Processing. Data obtain from the ultrasonic sensor and DHT22 sensor sending to the micro-controller (Arduino UNO R3). The micro-controller will perform the calculation to determine the status of flood based on height of water with reference of past cases [11]. The system obtains two type of notification level: caution level and danger level. Each level has its own range height of water based on previous flood occurrence. As the system is conducted only in experiment, the system size is reduced to suitable scale but maintain the actual condition. In the system, the height of water is scaled down to 1cm: 10 cm ratio, with reference from water level of Sungai Segamat, Johor as shown in Figure 3.

![Figure 3. References level of flood in Sungai Segamat, Johor.](image)

2.3.3. Data Broadcasting. The processed data is then sent to Global system for GSM module in the form of SMS to be broadcast to all users registered in the system to inform regarding flood condition in the area. There are two type of warning design, first warning is named as Caution that ranged from 5.1-7.0 cm from ultrasonic sensor and second is Danger level ranged from 7.1-11 cm from ultrasonic sensor. Figure 4 illustrated the visual of the system.
3. System Design
Figure 5 shown the schematic design involve in the system which is Ultrasonic sensor (HC-SR04), Arduino UNO R3 and GSM shield (SIM900). These connections allow the system to communicate using serial library in the IDE software.
3.1. Sensor Calibration

In order to measure the height of the river, Ultrasonic sensor is used. Ultrasonic sensor will act as the references point for the system where the initial value is zero (0) and increase until the sensor reflect the signal from height of water to be stored in the system. DHT22 sensor is used to measure the temperature and humidity.

Figure 6 illustrate the sensitivity of the sensor for the prototype model. The value for average reading is close or similar with reading obtain for reading 1, reading 2 and reading 3. It shown that the ultrasonic sensor used in this system is reliable and quite precise. In this system, the reading is only taken at distance 2cm because ultrasonic sensor can only detect distance from 2cm to 400cm. 20 cm is the highest measurement because that distance reached the danger level condition in this system, where the normal water condition is about 1cm - 5cm from riverbed to the sensor.

![Sensor reading graph]

**Figure 6.** Graph of height measurement.

4. Time Taken to Transmit the Message from System to User

The GSM system used in this system to text the message by using network service provider in Malaysia region. The message that is send to receiver will be charged according to data rate applied by the service provider. In order to test the transmission time for the receiver to accept the message from the system, a few test messages will be sent to the receiver to measure the time taken for the message to arrive.

| Trial | 1    | 2    | 3    | 4    |
|-------|------|------|------|------|
|       |      |      |      |      |
| Transmission time (s) | 12.55 | 11.11 | 14.32 | 12.31 |
| Average Time (s)      | 12.58 |      |      |      |

Table 2 shows the message transmission time and significant as alarm system with faster. System stability is determined after considering the error that occurs from sensor used in the system. In order to ensure the system, provide precise and accurate message to user based on height of water, the system used time delay to compare or check a condition to ensure the system is performing the right task. When the system detects the height of water already reach the caution or danger level, the system will re-measure the height of the river again after 10 second of delay. If only the water level for the first and second measurement is in the same level then the system will send the messages.
Table 3. Content of messages

| Types of messages | Content of messages |
|-------------------|---------------------|
| Normal            | NORMAL – Water Level is normal |
| Caution           | CAUTION – Water Level = cm  
|                   | Caution Warning!  
|                   | Humidity = %  
|                   | Temperature = Celsius |
| Danger            | DANGER – Water Level = cm  
|                   | Caution Warning!  
|                   | Humidity = %  
|                   | Temperature = Celsius |

Table 3 shows the type of messages to be sent to user. The content of the message is very simple due to the character limit of messaging system that is 160 characters only and cannot be really interactive to be compared to other type of communication such as WhatsApp and messenger applications. The advantage of fast transmission and coverage area of GSM system is taken into consideration to support this system in rural or isolated area where there is no internet connection to perform other type of communication. The disadvantages of messaging are the pay rate applied for each number of messages to be sent to user, so to overcome that situation, messages only will be sent only one for normal and caution level and two for danger level. This method will be able to reduce the cost for the transmission of data to user. Figure 7 and Figure 8 shows the message received by user for conditions of flood notification system.

**Figure 7.** Caution and danger message for caution water level.
Figure 8. Data Collection via SMS.

5. Conclusion
Based on the result for flood management system, this project has been successfully developed. Each of part and module developed in the system are properly works. Ultrasonic sensor module works brilliantly to measure height of water and GSM module is also properly integrate with the Arduino UNO module to perform notification message. In addition, the system is able to prevent accidental input that may occur by providing the right coding to the system. This made the system reliable and produces trustable output for user. The second objective is to test the system by experimental setup are successfully develop where the result of the system is similar to the expected result to be achieved by the system. The third objective also achieved by provide the information with temperature, humidity to the registered customer.

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