1. Research Method

In this study, flood monitoring system using wireless sensor node is developed to observe the status of flood which could alert people who were in the area frequently affected by floods in Selangor state, Malaysia. The system consists of a sensor node which detects the water level and rain intensity using an Ultrasonic Distance Sensor (HC-SR04) and rain sensor respectively. When the water level and rain intensity reaches a certain level of hazards, the device will generate an alarm system with three different colours of LEDs indicating three levels of detection for flood level in order to notify people on incoming flood in that area that could endanger their life.

Numerous types of ultrasonic sensors with significant differences in frequency and power consumption are available. The high-frequency ultrasonic sensors will have a sharper beam width and may detect obstacles in a longer range. Some of the new sensors also have the same detection range as previous models but less power consumption. The ultrasonic sensors must be able to detect obstacles or objects between 2cm and 50cm in this project. Since the entire system supply is taken out of the supply, less current consumption is crucial and must be capable of operating at low voltage. HC-SR04 meets this project's criteria for detecting the level of flood water after long research between the HC-SR04 and other ultrasonic sensors.

NodeMCU based technology that acts as the microcontroller of this system that attached with ultrasonic and rain sensors to form a wireless sensor node and placed at a high prone area of flood. When the sensors were triggered, all the data will be sent to Blynk application to be viewed on user's smartphone via the wireless connection. The integrated IoT architecture with Blynk application as it illustrated in Figure 1 [18][19]. At the same time, the data is stored in a CSV database. This data can be converted into excel form through email which could alert the local authority for further action once the level reached warning and critical level.

Two sensors are used as inputs to the NodeMCU and power supply of 5V is used to power up the system to function well. The ultrasonic distance sensor is used to detect the flood level at a high prone area of flood (maximum is 3m away from it). In this project, 40cm of distance from the ultrasonic sensors and the water level will trigger the buzzer and LED. The rain module sensor detects the rain intensity and develops a notification alert when raining heavily started. The scope of this project is focusing at a high prone area of flood in Selangor. The Blynk application provides an interactive and easy to access platform for user or victim to get accurate information on the incoming floods by displaying current condition of flood water level and rain intensity in real-time condition.

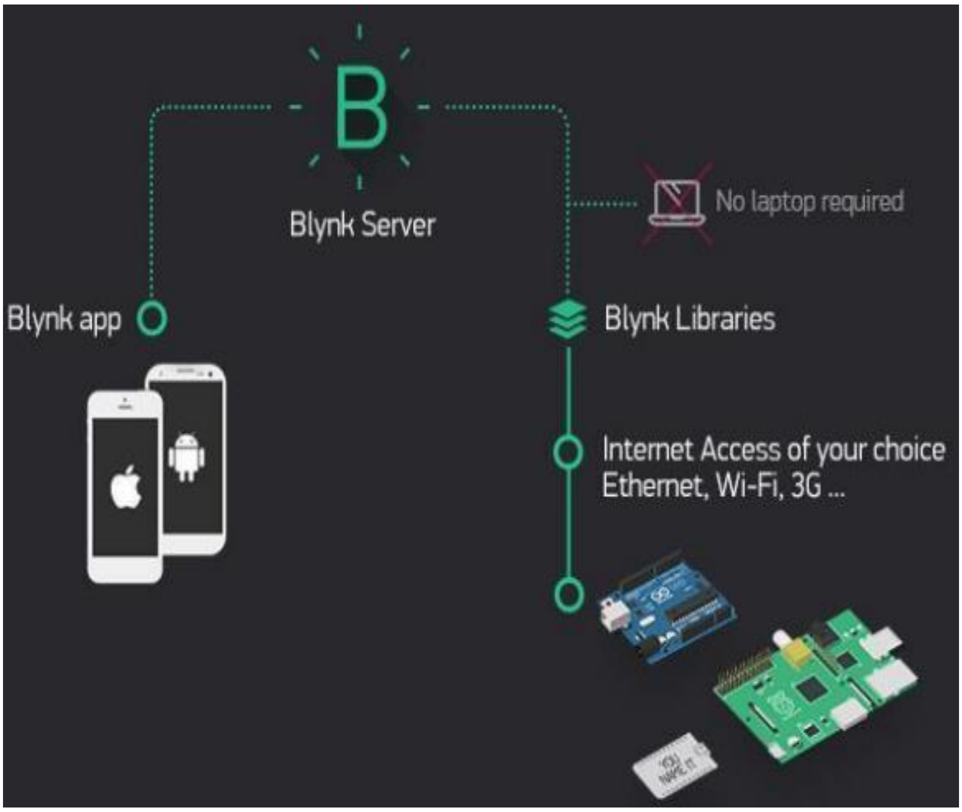


Figure 1. Blynk IoT-cloud Based Architecture [18] [19]

When there are changes in flood level, the graphs captured the data and change the measurements accordingly. So, when there is immediate change in the measurement, the buzzer and LEDs will turn on which act as alerting purposes. Blynk's alert notification also sent to the victims when the flood water level or rain intensity reached a certain point of hazard. From Figure 2, the flow chart explained the overall system and how it works. First, NodeMCU connected with the internet via Wifi connection. After the Blynk connection is established, ultrasonic sensors and rain sensor act as two different input of the system. When the water level rises, the system will continue to the next steps. Three processes when water level rises which are greater than 20%, greater than 40% and greater than 60% which trigger green, yellow and red LEDs respectively. Buzzer triggered with different frequency for every different process before sending the data to Blynk application. Besides, when the rain intensity rises, two processes occur which are greater than 60% and between 30% to 60%. All of these data are sent to Blynk application on user's smartphone. Finally, notifications via Blynk and email are sent to the user for alerting purposes.

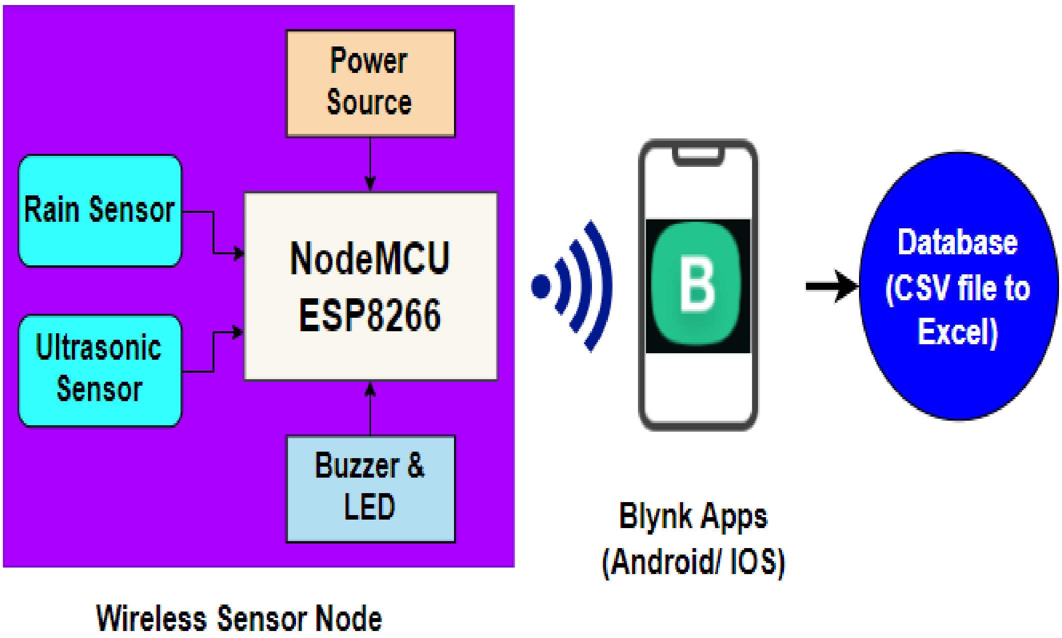
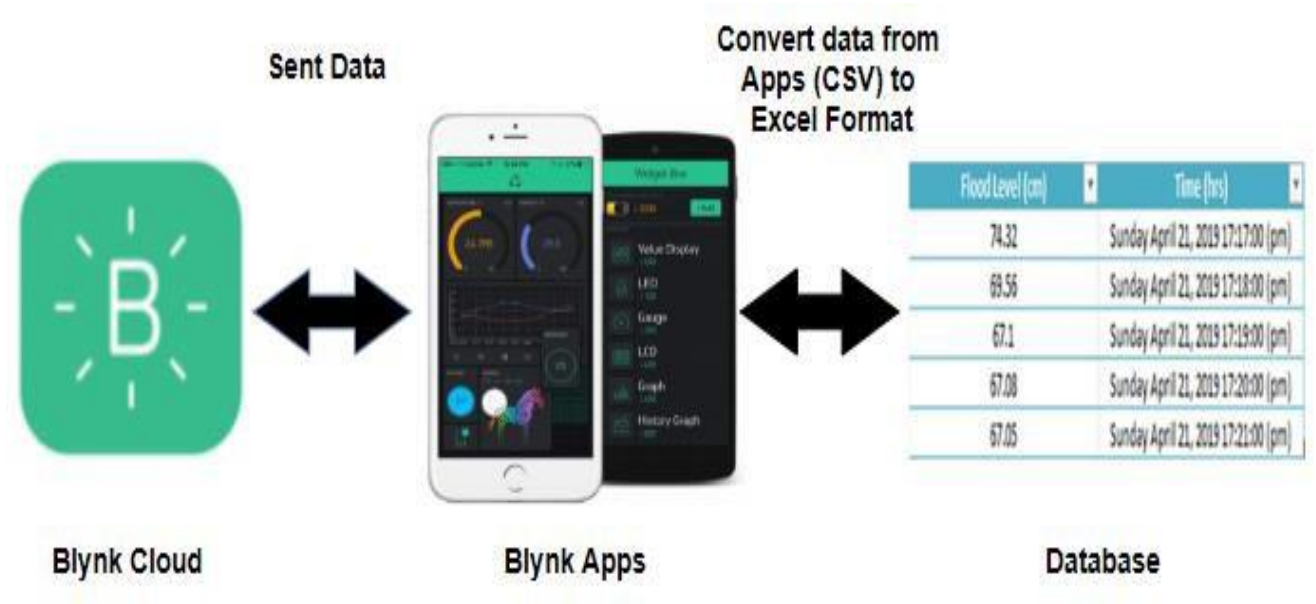


Figure 2. Schematic Diagram of the Proposed Flood Warning and Monitoring System

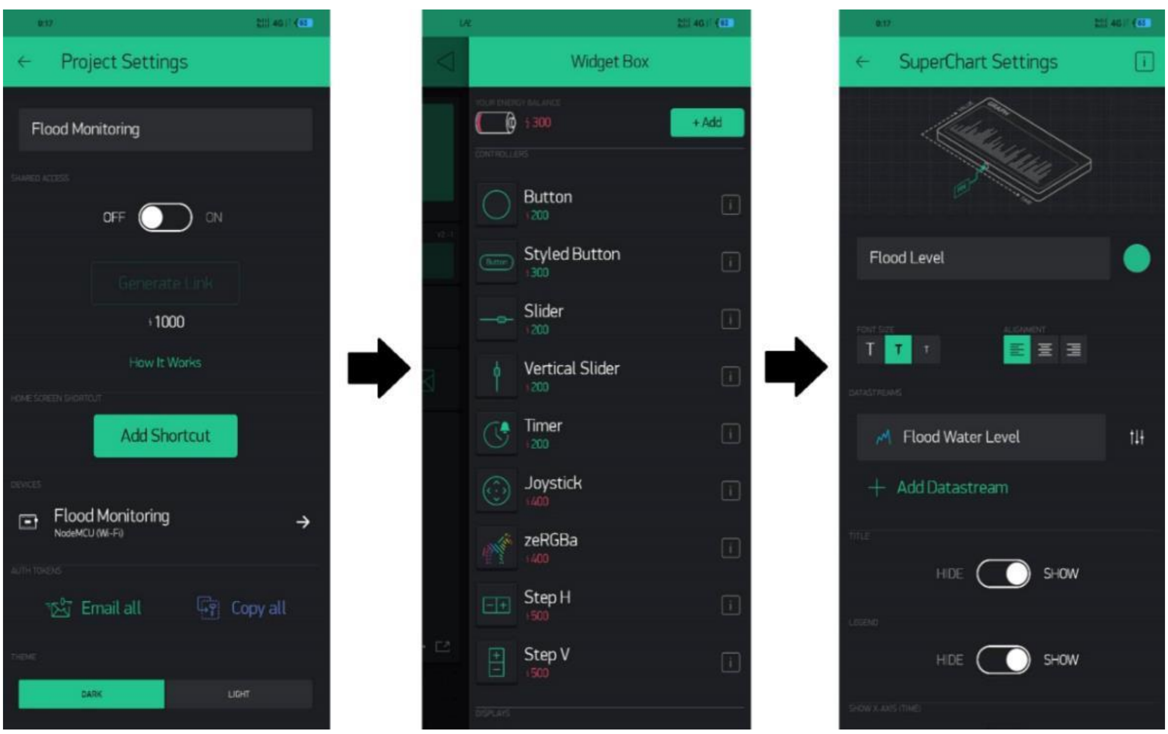
Blynk was designed to remotely controlled hardware where data can be displayed, data stored and data monitored. The Blynk platform consists of three main stages which are Blynk cloud, Blynk apps and Blynk database as shown in Figure 3.

Figure 3. The Flow Database Via Blynk Apps



In this work, Blynk was used to create a flood monitoring system application for monitoring data from NodeMCU which connected with ultrasonic and rain sensors over the internet by using a smartphone. There will be LCD to display the level indicator (safety, warning and critical level) inside the Blynk's interface. Next, the value display widget will display the flood's level sense by ultrasonic sensors. Besides that, different LEDs light up according to the current level to indicate the current status of flood. Lastly, the history graph widget could track the flood's level and save it into the database. Figure 4 shows the layout design of Blynk used in this work.

Figure 4. Schematic Diagram of Steps to Build Blynk Interface



In Figure 4, the step by step procedure for building the Blynk apps using a smartphone is illustrated. Users could install or download Blynk apps for android or iOS at Google plays store or app store. User needs to install Blynk library in the Arduino IDE library folder to interface with Arduino. The work for Arduino based application as it reported by the Authors [20]. Furthermore, open the apps on the smartphone after the installation is complete and create a new account to log in to a new project. The selected hardware is NodeMCU for this project and the type of communication is WiFi ESP8266. The authentication token must be obtained first to build a project. Once the authentication token is obtained by the user, the Blynk apps can be designed.

Figure 5. Completed System Blynk's Interface

Figure 5 shows the complete setup of Flood Monitoring System via Blynk application. An LCD display indicates flood detection on water level status which appear whether Safety level, Warning level or Critical level. Next, three LEDs that act as an indicator are displayed which triggered based on flood level status. Rain intensity level widget is added to display the rain intensity which acted as the first system's monitoring on rain before huge flood occurs. A flood level is displayed in cm unit and the system sends the alert notification and email to the victim continuously when the flood water level together with rain intensity reached certain level of hazard. For the user or victim that always used social media, this system was very useful as it can send the alert via Twitter so they will keep updating with the latest condition of flood at their place. At the lowest part of the interface shows a Super-chart widget which could display the graph of flood level in real time condition. All the widgets kept updating between each other that lead to the combination of very useful system to warn and monitor current flood condition at place with high prone of flood in Selangor State.

1. **Advanced Sensor Technologies**:

   IoT-based flood monitoring systems are incorporating more advanced sensors. For example, Doppler radar sensors, LiDAR (Light Detection and Ranging), and ultrasonic sensors provide more precise data on rainfall, water levels, and flow rates.

2. **Wireless Sensor Networks**:

   IoT-based flood monitoring systems are moving towards wireless sensor networks, reducing the need for physical connections and enabling more flexible deployment in remote or challenging terrains.

3. **Satellite and Remote Sensing Integration**:

   Integration with satellite technology and remote sensing allows for a broader, bird's-eye view of flood-prone areas. Satellite data can be used to monitor large regions and provide early warnings.

4. **Real-time Data Processing**:

   Improved data processing and analysis capabilities using edge computing and cloud-based solutions enable quicker and more accurate flood predictions. Machine learning algorithms can be applied to real-time data to refine predictions.

5. **Blockchain for Data Security**:

   The use of blockchain technology can enhance data security and integrity in flood monitoring systems. It ensures that the collected data remains tamper-proof and reliable.

6. **Integration with Weather Forecasting**:

   IoT-based flood monitoring systems are increasingly integrated with weather forecasting models. This allows for more accurate predictions and early warnings by factoring in meteorological conditions.

7. **Smart Infrastructure**:

   IoT-enabled flood monitoring can also be integrated with smart infrastructure, such as smart dams and flood barriers. These systems can automatically respond to flood warnings to mitigate damage.

8. **Predictive Analytics**:

   Advanced analytics, including predictive analytics, can anticipate potential flood events based on historical data, current conditions, and weather forecasts, providing even earlier warnings\
   .

9. **Public Engagement through Mobile Apps**:

   Innovative mobile applications can provide real-time alerts to the general public, allowing residents to stay informed and take appropriate action in response to flood warnings.

10. **Cross-Platform Integration**:

    Flood monitoring systems can integrate with other platforms like social media, emergency services, and transportation systems to improve preparedness and response coordination.

11. **Drone Technology**:

    Drones equipped with sensors and cameras can be deployed for aerial surveillance and data collection during floods, providing valuable information for decision-makers.

12. **Community-Based Monitoring**:

    Some systems engage local communities and volunteers to collect data and participate in flood monitoring, enhancing the coverage and accuracy of information.

13. **Low-Power IoT Devices**:

    Energy-efficient IoT devices ensure longer battery life, making it possible to deploy sensors in remote areas for extended periods.

These innovations in IoT-based flood monitoring and early warning systems not only help in early detection but also aid in better response coordination, reducing the impact of floods on communities and infrastructure.

The Development Process Of An Iot-Based Flood Monitoring System Involves Several Key Stages:

1. **Requirements Gathering and Planning**:

- Define the objectives and scope of the flood monitoring system.
- Identify the geographic areas to be covered.
- Determine the parameters to be monitored, such as water levels, rainfall, and weather conditions.
- Specify the desired communication methods and data transmission frequency.

2. **Sensor Selection and Deployment:**

- Choose appropriate IoT sensors capable of measuring the required parameters.
- Deploy these sensors strategically in flood-prone areas.
- Ensure sensors are weatherproof and have a reliable power source, often using solar panels or batteries.

3. **Data Collection and Transmission:**

- Configure sensors to collect data at regular intervals.
- Establish communication protocols, such as Wi-Fi, cellular, or LPWAN (Low Power Wide Area Network), for transmitting data to a central hub.

4. **Data Processing and Storage:**

- Set up a central data processing system to receive and store sensor data.
- Implement data validation and quality checks to ensure accuracy.
- Store historical data for trend analysis and modeling.

5. **Integration with IoT Platform:**

- Integrate the sensor data into an IoT platform that can manage and process the information.
- Implement security measures to protect data during transmission and storage.

6. **Data Analysis and Early Warning Systems:**

- Utilize machine learning algorithms and data analysis techniques to detect patterns and anomalies in the data.
- Implement early warning systems that trigger alerts based on predefined thresholds.

7. **Visualization and User Interface:**

- Develop a user-friendly interface to visualize real-time and historical flood data.
- Provide access to relevant stakeholders, such as emergency responders and the public, through web or mobile apps**.**

8. **Community Engagement:**

- Encourage community involvement by allowing the public to report local flooding incidents and contribute data.
- Establish channels for feedback and communication with local residents.

9. **Testing and Validation:**

- Conduct thorough testing of the entire system to ensure its reliability and accuracy.
- Validate the effectiveness of early warning systems and response mechanisms**.**

10. **Scalability and Maintenance:**

- Ensure the system can be scaled to cover larger areas or accommodate additional sensors.
- Establish a maintenance plan to regularly check and service sensors and data infrastructure.

11. **Collaboration with Authorities:**

- Collaborate with local authorities, disaster management agencies, and meteorological departments to improve response coordination.

12. **Continuous Improvement:**

- Continuously monitor the system's performance and gather feedback for ongoing improvements.

The development of an IoT-based flood monitoring system is an iterative process that requires careful planning, ongoing maintenance, and adaptability to changing environmental conditions. It plays a crucial role in enhancing flood management and disaster response efforts.