UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electrical and Electronic Engineering Technology

DEVELOPMENT OF IoT BASED FLOOD MONITORING SYSTEM USING ESP32 AND NODE-RED FOR PREVENTIVE OF NATURAL DISASTER

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Bachelor of Electronics Engineering Technology (Telecommunications) with Honours

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A project report submitted
in partial fulfillment of the requirements for the degree of
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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

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Supervisor Name : TS. MOHD FAIZAL BIN ZULKIFLI

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ABSTRACT

Natural disasters such as floods have major impacts such as loss of life and economic losses that cannot be avoided, but proper planning can decrease the terrible aftermath. A flood warning system generally incorporates data on telemetric precipitation and water level estimated at several locations around the local region. It is challenging to provide information regarding river conditions, flood kinds, and so on based on these observations. In the absence of a real-time monitoring system, it is impossible to warn authorities and provide protective measures in the event of a major incident. As a result, an enhanced flood forecasting system must be installed and developed. It is necessary to implement an end-to-end flood forecasting, warning, and response system capable of preparing for an emergency evacuation. It is suggested to construct a new flood monitoring and warning system that is simple, cost-effective, uses little electricity, and is simple to deploy and operate. To address such issues, a IoT based system which include Ultrasonic Sensor, Node-Red and ESP32 is presented.

ABSTRAK

Bencana alam seperti banjir memberi impak besar seperti kehilangan nyawa dan kerugian ekonomi yang tidak dapat dielakkan, tetapi perancangan yang betul boleh mengurangkan kesan buruk. Sistem amaran banjir secara amnya menggabungkan data tentang kerpasan telemetrik dan paras air yang dianggarkan di beberapa lokasi di sekitar wilayah tempatan. Adalah mencabar untuk memberikan maklumat mengenai keadaan sungai, jenis banjir, dan sebagainya berdasarkan pemerhatian ini. Sekiranya tiada sistem pemantauan masa nyata, adalah mustahil untuk memberi amaran kepada pihak berkuasa dan menyediakan langkah perlindungan sekiranya berlaku insiden besar. Akibatnya, sistem ramalan banjir yang dipertingkatkan mesti dipasang dan dibangunkan. Adalah perlu untuk melaksanakan sistem ramalan, amaran dan tindak balas banjir hujung ke hujung yang mampu menyediakan untuk pemindahan kecemasan. Adalah dicadangkan untuk membina sistem pemantauan dan amaran banjir baharu yang mudah, menjimatkan kos, menggunakan sedikit tenaga elektrik, dan mudah untuk digunakan dan dikendalikan. Untuk menangani isu tersebut, sistem berasaskan IoT untuk menjangka kejadian akan datang dan memberi amaran tepat pada masanya dibentangkan.

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1.	V	Volt
2.	cm	Centimetre
3.	m	Metre
4.	€	Pound (Europe currency)
5.	Hz	Hertz
6.	mA	milli Ampere

LIST OF ABBREVIATIONS

1.	API	Application Programming Interface
2.	PVC	Centimetre
3.	API	polyvinyl chloride
4.	TRIG	Trigger on HC-SR04 Ultrasonic Sensor Pinout
5.	ECHO	Echo on HC-SR04 Ultrasonic Sensor Pinout
6.	VCC	Voltage Common Collector
7.	GND	Ground
8.	GPIO	General-Purpose Input/Output
9.	ESP32	Espressif Systems
10.	SMS	Short Messaging Service
11.	WiFi	Wireless Fidelity
12.	Tx	Transmitter
13.	Rx	Receiver
14.	GSM	Global System for Mobile
15.	IDE	Integrated Development Environment
16	DC	Direct Current
17.	C/C++	Programming Language C/C++
18.	JSON	JavaScript Object Notation
19	IoT	Internet of Things
20.	IBM	International Business Machines
21.	PWM	Pulse Width Modulation
22.	MCU	MicroController Unit
23.	PC	Personal Computer
24.	LCD	Liquid Crystal Display
25.	LED	Light-Emitting Diode
26.	GPS	Global Positioning System
27.	UI	User Interface
28.	USB	Universal Serial Bus
29.	CSV	Comma Separated Values

CHAPTER 1
INTRODUCTION

1.1 Background of Study

According to research that was published in 2018 by the Emergency Events Database (EM-DAT), Malaysia has been hit by at least 51 natural disasters over the course of the last 20 years. This nation is regularly struck by a variety of natural disasters, including earthquakes, tsunamis, floods, haze, and landslides. One of the most common types of natural disasters that strike a wide range of areas and populations throughout the nation on an annual basis is flood. It poses a direct risk to individuals, as well as to natural resources, the environment, and the economy, and it also causes harm. Figure 1.1 provides an overview of the significant disasters that have struck Malaysia between the years 1965 and 2016, broken down by the total number of persons impacted. (*"Dam Pre-Release as an Important Operation Strategy in Reducing Flood Impact in Malaysia,"* 2018).

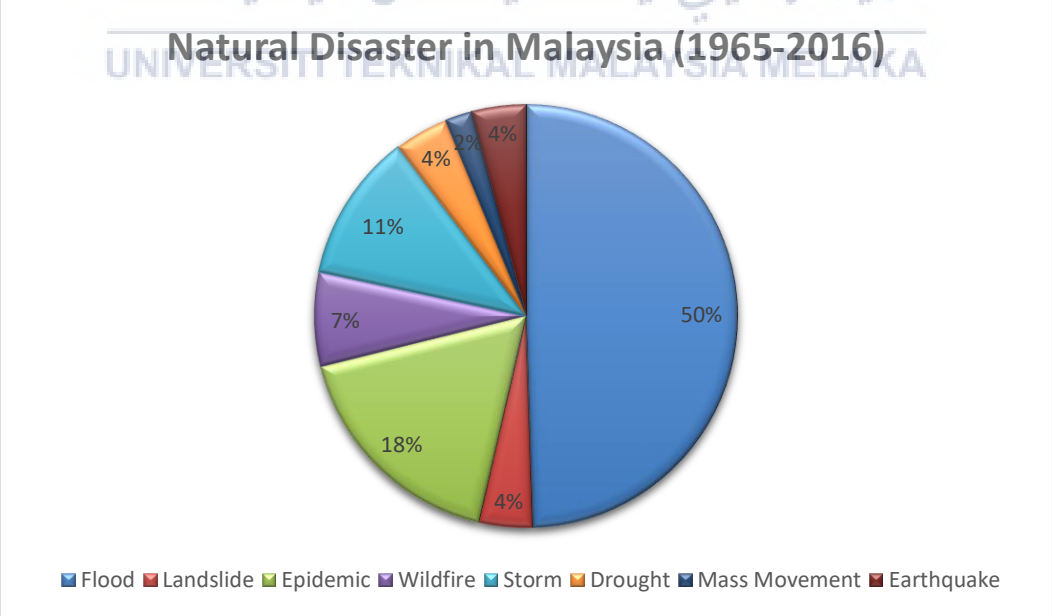

Figure 1.1: Natural Disaster in Malaysia (1965-2016)

In Malaysia, there are two types of floods which is flash floods and monsoonal floods. The fast river rises with shallow waters that exceed the bank of the river cause flash floods. It is most likely to happen near the river. It can sometimes happen even when no rain has occurred, such as when levees or dams fail or when debris causes a sudden discharge of water. Flash floods are widespread in desert locations with poor drainage systems.

While, monsoonal floods usually occur in the Northeast Monsoon Season. Monsoons are mainly caused by changes in temperature between land and water caused by radiation from the sun heating. The monsoon season happens in between of November and March, bringing heavy rains to the east coast states of Peninsular Malaysia and west of Sarawak. Monsoonal flood threatens people, natural resources, as well as creates economic damage. Sadly, this flooding claims more lives in Malaysia each year compared to other natural disasters which is why flood is a heavy concern of the country.

One of the technologies that can be utilised to reduce the number of fatalities caused by floods is the installation of flood monitoring and warning systems. These systems are particularly useful in the states along the east coast of Malaysia, such as Terengganu, Kelantan, and Pahang, as well as west of Sarawak. It is possible to connect the alarm system to the system so that it will inform both the local inhabitants and the higher authorities. An Internet of Things-based flood monitoring system is the name given to this kind of apparatus. The purpose of this system is to keep track of how high the water level is in the river and notify the user if it reaches a level that is considered to be dangerous. It is anticipated that national rescue teams such as PDRM, JPAM, and BOMBA would make use of this technology.

1.2 Problem Statement

The vast majority of flood monitoring systems are based on telemetry systems, which need data to be sent to a central terminal through transmitters, repeaters, and other associated hardware. When the equipment in a portion of the detected zone fails to perform properly, this approach is both expensive and unreliable. Other methods are unreliable because they depend on the communication infrastructure provided by other vendors. As a consequence of all this, a system that is trustworthy and reasonable in cost that is based on a wireless sensor network is needed.

1.3 Project Objective

This project's major objective is to develop an effective flood monitoring and warning system with IoT-based applications and built-in major flood mitigation. The following below are the specific objectives:

1. To study the flood monitoring and warning alert system.
2. To develop a Malaysian model of IoT based Flood Monitoring System using ESP32 and Node-RED for Preventive Natural Disaster.
3. To analyze a prototype for the proposed project.

1.4 Scope of Project

To eliminate any doubt regarding the project's scope caused by numerous limitations and constraints, the hardware of this project will be focusing more on in-house testing in which only indoor components and devices will be utilized. Besides that, a mock measurement for the threshold will be used in the wireless water level detection sensor system before triggering the warning system devices. This project is a system to monitor the

water level and to give an alert to local netizens about the flood status so then, they could evacuate before the flood hit them. Equipped with ultrasonic sensors and ESP32, the water level may be able to detect and Node-Red's Dashboard will be used to display the result of the water level and the status of the danger of the water level. If the water level passed the Danger level, the Node-Red then sends a warning to the local netizen.

1.5 Expected Result

This project will achieve the project's objectives which are to design an IoT-based flood monitoring system and able to give an alert to the authorities or local netizens to evacuate the place if the water level passed the danger threshold. This system is intended to give an early warning via the Node-Red platform. The ultrasonic sensor will connect to the ESP32 and wirelessly transport the gained data of the water level to the Node-Red before Node-Red could send an alert message to the local authorities.

1.6 Thesis Outlines

There are five chapters in this thesis including of introduction of the project, the literature review which is the works of the others related to this project, and lastly the method used to implement the knowledge into the project.

Chapter 1: In Chapter 1, briefing about general ideas of the project which are an introduction, problem statement, target of the project, scope of the project, project significant, and thesis outlines.

Chapter 2: In this project, basically study the literature review which is work that is related to the project. It is important in order to obtain some knowledge about the project.

Chapter 3: Discusses the methodology, which is consists flowchart of the whole project and the description of the component that will be used to solve the problem statement. Furthermore, this chapter includes some explanation about software and hardware development and also the main component of the project.

Chapter 4: Discusses in detail the outcome of the project in a logical way. The analysis of the outcome is also presented within this chapter.

Chapter 5: Summarizes the contribution of all studies to the project and provides concluding remarks. In addition, there are some recommendations for future works.

1.7 Summary of Chapter 1

In a conclusion, Malaysia was severely affected by the flood, especially during the monsoon season. As the natural phenomenon is untouchable, a flood monitoring and warning system are required to help the authorities and local netizens to evacuate sooner. With the display of the water level on the Node-Red Dashboard, the authorities will be able to do make an evacuation preparation.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

2.1.1 What is Flood ?

A flood is an outpouring of water that submerges normally dry ground. Floods are the most common form of natural disaster, and they are frequently caused by heavy rain, fast snowmelt, or storm surge from a tropical cyclone or tsunami that occurs in coastal regions. Floods can be divided into 3 categories. These are storm surges, dam failures, and flash floods. Storm surges are most likely caused due to the rapid rise in water levels along with the high speed of water flow. Besides that, dam failures are caused by the volume of the flood exceeding the capability of the dam could hold. Lastly, storm floods are caused due to the natural phenomenal contribution such as severe onshore winds that came along with low atmospheric pressure and high tides.

During the monsoon season in Malaysia, which runs from October to March every year, flooding is a typical occurrence, especially along the eastern coast of the nation. In most cases, it takes place in towns or metropolitan regions like Kuala Lumpur, Johor Bahru, and Pulau Pinang despite the fact that these locations have insufficient drainage systems that are unable to manage the excessive amount of precipitation. The year 2021 came to a close with a tropical storm making landfall on the eastern coast of Peninsular Malaysia. This event was responsible for three days' worth of intense rainfall over the peninsula. There were eight states on the peninsula that were affected as a direct consequence of the floods. Over the course of its most severe phase, it impacted a total of more than 125,000 people (Wikipedia Contributors, 2022) and resulted in the relocation of around 71,000 people at the same time.

It is the worst flood the nation has seen since the Malaysia floods of 2014–2015. Damage was widespread throughout the states of Selangor and Pahang, notably in the region of Hulu Langat and the city of Shah Alam. The rainfall levels reached all-time highs at the meteorological stations in Selangor and Kuala Lumpur. P. Prem Kumar, a reporter for Nikkei Asia, claims that the government of Malaysia has been criticised for its delayed reaction and disinterest in the wake of the tragedy.

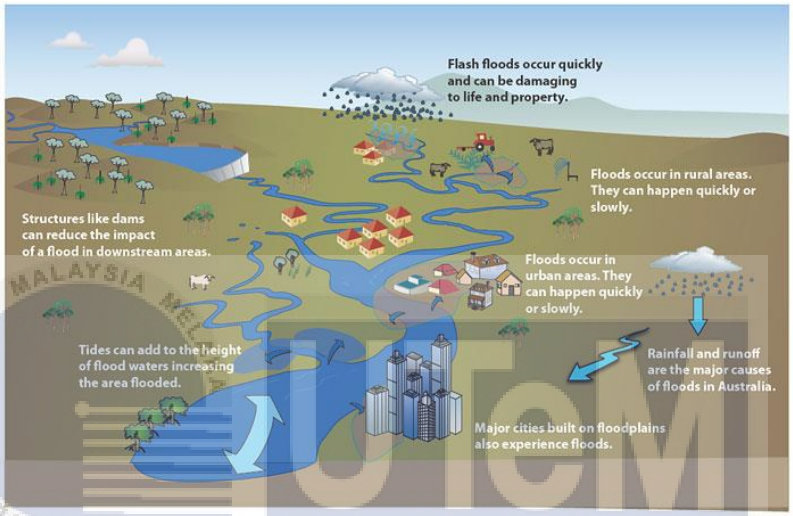

Figure 2.1: Flood Flow

Figure 2.1 illustrates the variables that lead to floods, one of which is the flow of water from a high point to a low point. This implies that low-lying regions may be drowned fast before reaching higher land (Ramizu, 2015). These factors differ across locations and dates, resulting in no two floods being the same.

2.1.2 Type of Flood That Occurs in Malaysia

According to the authors of "Performance Analysis of IoT-based Flood Monitoring Framework in Suburban" (2021), the disaster has been divided into two main categories by Malaysia's Department of Irrigation and Drainage (DID), which are flash floods and monsoon floods. Both of these types of floods are extremely dangerous. The length of time it takes for the water to return to its regular place is what allows meteorologists to

differentiate between monsoon floods and flash floods. For the sake of designing technologies that would prevent hasty mass evacuations, it is essential to have a solid understanding of the behaviour of the floods that occur in Malaysia.

A flash flood is a kind of flood that happens within six to seven hours following heavy rain, and it often happens during the first two hours of the heavy downpour. It is distinguished by a rapid increase in the river's level, with water depths that extend beyond the river's banks. Near the river is the most probable location for it to take place. There is a risk of flash flooding if thunderstorms hit the same location at the same time. On the other hand, the likelihood of sudden flooding is reduced when storms move at a faster pace since the rain is spread out over a larger region. It is possible for it to occur even when there has been no rain at all, such as when spillway or dams fail or when debris causes a rapid flow of water from a dam or reservoir.

In Malaysian cities, flash floods are the hydro-meteorological occurrence that occurs most often and causes the greatest damage. The nation's capital city is seeing an increase in the frequency of sudden floods compared to previous 10 years. Even while flash floods may not always take place during monsoon seasons, this is the period of year in the city when they are most likely to take place. Even though there are various ways to prepare for and adapt to flash floods, they continue to be a significant risk, especially in urban areas. Not only are flash floods hazardous and potentially disastrous due of the intensity of the water itself, but they may also be catastrophic because of the flying debris that can be swept up in the rush of the water.The illustration of the flash flood may be observed in Figure 3 below.