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Flash Flood Management System Using IoT Technology

Alex Wai, Dr Mohd Fo'ad bin Rohani

Department of Computer Science, Faculty of Computing, Universiti Teknologi Malaysia, Skudai, Johor

alexwai@live.com, foad@utm.my

Abstract—Flash flood has been a common occurrence in Malaysia and many had suffered loss financially. Without proper flash flood disaster management, the impacts can be severe ranging from damaging properties to endangering lives. One of the main issues faced by the community is where they are not aware of flash flood happenings around them. A more efficient flash flood management system is proposed to better manage flash flood disasters. By leveraging the technology of Internet of Things, real-time updates and notifications for flash flood events can be delivered directly to the community. Early warnings can help mitigate potential disasters as well as assist involved authorities in managing such disasters.

Keywords - *component; flash flood; internet of things; real time*

1. INTRODUCTION

Technology has been a driving force in shaping the world. With the use of technology, we are able to achieve capabilities that exceeds our limits. Information technology, in particular, has benefited us in ways indescribable and brought us together. The Internet of Things (IoT) is a revolutionary technology that is capable of interconnecting the Internet with our everyday life objects. IoT has opened up endless possibilities in terms of facilitating our daily lives as it can be implemented in many areas, be it consumer or enterprise sectors.

Disaster management is important during a catastrophe outbreak in order to minimize casualties and impact of a disaster. For a country which is prone to heavy downpours throughout the year such as Malaysia, disaster management is crucial. Despite being geographically safe from major disasters such as volcanic eruptions and earthquakes, Malaysia had experienced devastating floods and the impact was severe [1]. In 2010, Malaysia was among the countries with the heaviest rainfall, averaging 2,500mm of rainfall throughout the country [2].

Over-development seems to be the main cause of floods as highly urbanized areas such as Kuala Lumpur and Georgetown are more likely to suffer from the mentioned disaster. This is often associated with high rainfall intensities, inadequate drainage systems and improper waste disposal [1]. Nowadays, desire and greed of humans has severely damaged the ecosystem as forests are being replaced by artificial development [3].

Recent flash flood sightings in Johor Bahru has alerted the public. Continuous heavy downpours are causing traffic congestion in major city areas. A system named Majlis Perbandaran Johor Bahru Tengah Flash Flood Management System was proposed to the Johor Bahru Tengah Municipal Council in order to facilitate them in flash flood disaster management. The public will be able to receive real-time alerts on flash flood happenings.

2. METHODS

2.1. Problem Background

Malaysia has experienced numerous floods and the results were devastating. Monsoonal floods account for a significant amount of damage for the past few decades. As a matter of fact, Malaysia is among the countries with the heaviest rainfall, averaging 2,500 mm of rainfall throughout the country in 2010. Overemphasizing developments and economic aspects has led to human activities such as deforestation. The ignorance portrayed by the nation in handling and managing flood hazards resulted in high flooding magnitudes. Rapid rate of change in water yield is poorly handled as natural systems cannot adapt to sudden changes [1].

Highly urbanized areas such as Kuala Lumpur and Georgetown are often flooded due to over-development. Recent sightings on flash floods in Johor Bahru had brought disturbance to the public. A flash flood management system was proposed specifically for Majlis Perbandaran Johor Bahru Tengah (MPJBT), namely Majlis Perbandaran Johor Bahru Tengah Flash Flood Management System (MPJBTFMS). The system will focus on monitoring flood levels in the city of Johor Bahru as well as feature the ability to monitor up-to-date flood levels and provide real-time alerts of flash flood events. All in all, the system will benefit the citizens of Johor Bahru tremendously.

2.2. Studies On Existing Flood Management Systems

A study was conducted to research existing flood management systems and identify strengths and weakness of each individual system. A total of 5 existing flood management systems were studied; wireless sensor networks for flood detection in Honduras, rainfall monitoring network in Xicheng District, Beijing, flood monitoring and forecasting in the Rambla del Albujon Watershed, flash flood monitoring and warnings in Iowa, and flash flood early warning system in Korchar Haor, Bangladesh.

Key strengths that were identified from the above study are as follows:

i. Real-time data logging
ii. Usage of multiple types of sensors
iii. Alerts and notifications
iv. Data security
v. Transmission of data over Internet
vi. Data stored for future usage

2.3. IoT

The technology of IoT has been rapidly expanding throughout the years. In general, IoT is a network of interconnected devices. These devices are capable of assisting us in our daily lives [4]. Sectors such as manufacturing, security, healthcare and education has benefited immensely through the implementation of IoT and the number of interconnected devices is expected to grow up to 26 billion in 2020 [5].

The Arduino is a microcontroller which contains several components onboard such as the processor, inputs and outputs, memory and peripherals. Paired together with sensors and actuators, the Arduino is a wonderful device that opens up new possibilities in the world of IoT [6]. The main philosophy behind the development of the Arduino lies in prototyping [7]. Due to its nature, the Arduino provides a platform for the audience to develop a diverse range of projects [8].

The invention of the Arduino has eased the hardware prototyping process with the high level framework that come with it. With the introduction of microcontrollers, the conventional method of working with hardware had since been revolutionized. Maintaining and modifying a device's logic Is now achievable with just a few keystrokes rather than the traditional way of cutting and soldering [7].

In order to develop the system, a few sensors were selected to be included in the system, mainly the ultrasonic water level sensor and the rainfall sensor. These sensors are connected to the Arduino which harnesses the data. The data is then used to power the system's main features such as providing real-time flash flood alerts.

2.4. System Requirement Analysis

Functional and non-functional requirements were identified prior to the design of the overall system architecture. Functional and non-functional requirements are represented by using graphical or text presentations. The system consists of 3 actors which are user, authority and administrator. A total of 6 use cases are present, namely Login, Register Account, Reset Password, Notification Delivering, View Flood Status, and Manage Account. Figure 1 shows the use case diagram of MPJBTFMS that highlights the interaction between actors and use cases.

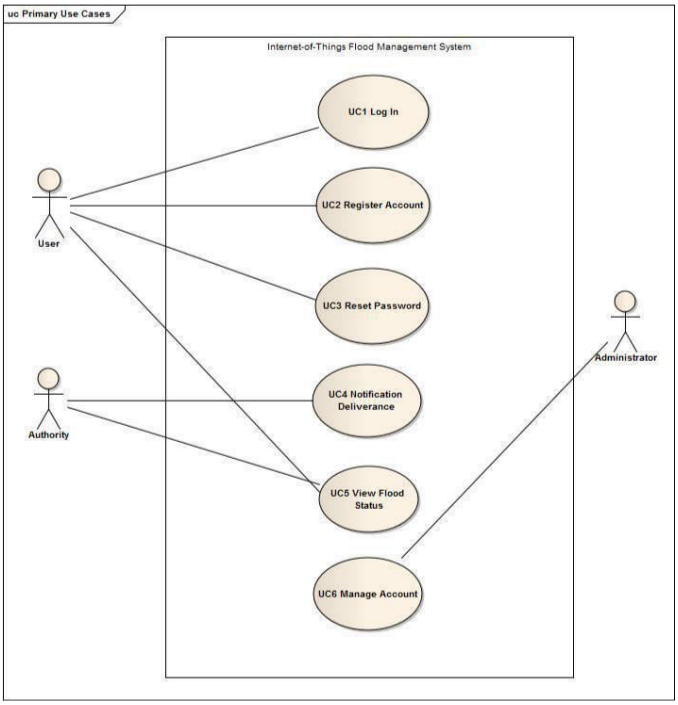

Figure 1. Use Case Diagram

2.5. System Architecture Design

The system architecture design is based on the Three-Tier Architecture. This architectural design divides the system into three main layers, namely the presentation layer, the application layer, and the data access layer.

Presentation layer refers to the interaction between human and the system through screen interfaces. Actions performed in the presentation layer will be processed and executed in the application layer. Application layer serves as the channel that connects the presentation layer with the data access layer. Depending on the action requested, data will be accessed and retrieved from the data access layer. Finally, the data will be represented in the presentation layer. Figure 2 shows an overview of the system architecture.

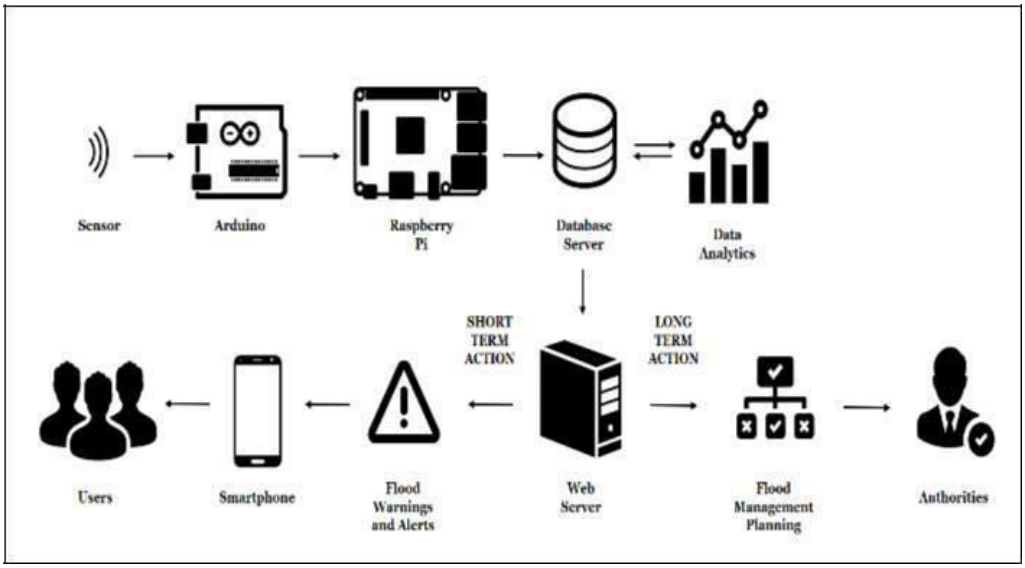

Figure 2. Over of the system architecture

2.6. System Development

MPJBTFMS is divided into two main modules, mainly the web module and the mobile application module. The web module is the back-end development of the system which includes databases and web server. On the other hand, the mobile application module refers to the front-end development of the system.

2.7. Software Testing

Once the system has been developed, software testing was performed in order to evaluate the performance of the developed system. Several tests were made which includes black-box testing and user acceptance testing.

Black-box testing was performed on several main functionalities of the system. System functionalities are tested without the tester knowing the internal structures or codes of the system. The test attempts to find errors such as interface errors, function errors, initialization and termination errors. Inputs are mapped against expected outputs to see for any deviation from the intended system.

User acceptance testing involves actual users in the software testing process to simulate real world scenarios. Participants are required to follow a set of procedures and give feedback on their user experience. The feedback is collected for future improvements of the system.

3. RESULTS

3.1. Project Achievements

The aim of the project is to create a platform for the Johor Bahru Tengah Municipal Council to relay information regarding flash flood to the residents of Johor Bahru. It was achieved by meeting the objectives set prior to the system development process.

The first objective was to study the state of existing flood management systems and identify flood parameters to monitor. The conducted study was very helpful in terms of defining the scope and features the proposed system should cover.

The second objective was to design the proposed system based on the IoT technology and mobile devices. Understanding the concept behind the implementation of IoT IoT helped

tremendously. Mobile device are perfect examples of platform to develop IoT-powered systems.

The final objective was to implement the proposed system and evaluate its performance. The system underwent software testing techniques and feedbacks were received. The feedbacks will play a part in further improving the system.

3.2. System Implementation

The interfaces are aimed at being simplistic yet offering the functional requirements identified earlier in the development phase. Figure3 shows several user interfaces of the system. Schematic diagram refers to a representation of the system using abstract and graphic symbols. It shows the significant components or parts available and its interconnections in the circuit. Figure 4 shows the schematic diagram of the system components.

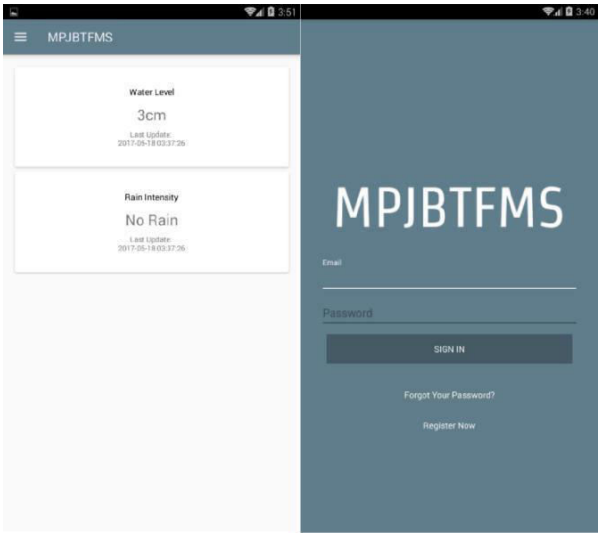

Figure 3. System Interface

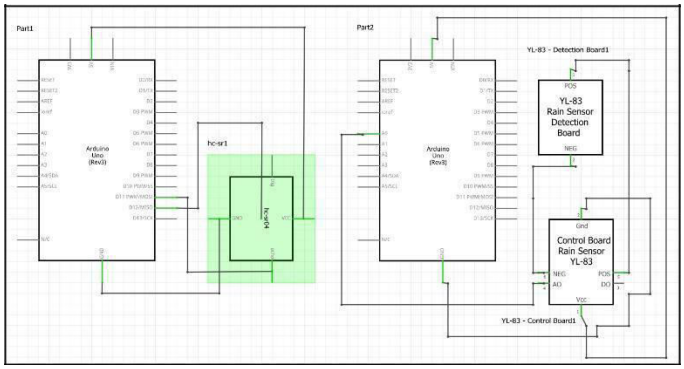

Figure 4. System Schematic Diagram

3.3. Suggestions to Improve

A few suggestions for improvement of the system surfaced throughout the system development process. One particular limitation that the system is currently facing is where

users are not able to contribute towards the project should they wish to do so. User inputs are as valuable as data obtained from the sensors. The system can be expanded in terms of implementing crowd sourcing to better facilitate flash flood disaster management.

Sensors are the components that collect data in order for the system to operate. Increasing the number or type of sensors available can be very beneficial. As for the long run, collaborating with local authorities such as the police and fire department will aid in managing flash floods.

3.4. Discussion

The importance of the system lies where the users are able to obtain real-time flash flood status and alerts. The existing system lacks in this area and this might be the deciding factor in terms of flash flood disaster management.

From the users' perspective, they now have a new source or channel to receive alerts should a flash flood happen. This would in turn minimize the potential loss a person has to suffer.

From the authorities' perspective, the system will aid them in their daily operations. With the implementation of the system, resources allocated for monitoring flood levels can be decreased and placed into areas that require more attention.

4. CONCLUSION

We found out that proper disaster management system is key to minimizing the impacts of a catastrophe outbreak. As for flash flood management, a system was developed in order to help the citizens of Johor Bahru. Studies were made on existing flood management systems and their strengths were identified. The nature and technology behind the system development process were discussed. System testing was conducted and the results were recorded for future improvements. All in all, the developed system would be beneficial for both the residents and authorities of Johor Bahru.

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