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The Development of Route Selection Application to Avoid Flood Roads

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ABSTRACT

Street flooding is one of the problems faced by urban communities around the world, including Indonesia. The problem of street flooding is caused by various factors, including high rainfall and poor drainage. This problem certainly causes a lot of losses for road users, including vehicles becoming dirty and more severe damage. Therefore, it is necessary to choose the alternative route so that road users avoid the danger of flooding. This paper will discuss the development of applications that provide information to road users alternative routes to avoid flooded roads. An informed search algorithm called A* or A-star was employed to find the alternative paths. All flood road information, built from road users who share information through mobile applications.

*Keywords: Flood, reporting system, route selection, A**

Introduction

For some cities in Indonesia, flooding is one of the natural phenomena that must be anticipated because it causes a lot of losses for residents. This flood can be caused by overflowing seawater, high rainfall, or infrastructure that needs to be repaired. The water level that exceeds the banks of the river can cause the area around the river to be flooded. In addition, flooding can occur due to low soil carrying capacity resulting in an increase in groundwater which can cause large-scale flooding (See, 2019).

The occurrence of floods causes various impacts, including an economy that is very dependent on the mobility of people and goods. Extreme weather changes that cause flooding can affect the quality of road infrastructure availability (Pregnolato et al., 2017). According to data owned by the ministry of public works and public housing (PUPR), a total of 5252 times flooded in Indonesia during the period 2021 - to 2019, with the affected infrastructure being 1789 damaged bridges, and 8920 km of affected roads (PUPR, 2019). Other data related to the intensity of floods in Indonesia states that from January to September 2020 there have been 596 floods (katadata, 2020). The Ministry of Public Works and Public Housing (PUPR) also released information on the alert for potential flooding in Indonesia in September 2021. In this information release, PUPR informed several infrastructure numbers that could potentially be affected by flooding, including 432 national roads, 20 operating toll roads, and 3701 bridges (PUPR, 2021).

Flooded roads are very detrimental to road users. Floods can damage the engine, transmission, electrical components, and electronic systems of motor vehicles. Water is also very dangerous for car safety devices, such as airbags and braking systems that use ABS (Anti-lock braking system). In addition, there may be health problems involving mold and bacteria, due to

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damp vehicles, especially on cars. Other water-related problems may not be immediately apparent, for example, rust and corrosion which will develop over time.

The existence of a system that provides information on flood roads will greatly help road users to avoid flood roads. Research conducted by cools (Cools et al., 2016) recommends the involvement of residents in collecting flood information that can be used as an early warning. Citizen involvement in gathering information for environmental monitoring is becoming increasingly common and is often referred to as crowdsourcing (Bonney et al., 2009). Although crowdsourcing is generally applied in the field of conservation and biodiversity, recently, it is also applied in various fields in the field of geoscience (Zheng et al., 2018). The crowdsourcing approach empowers the “crowd” (crowd) to collect adequate data into the knowledge base through the internet media (Mihn et al., 2017; See et al., 2016). The data or knowledge provided by the crowd is then shared with other users as its main purpose.

Crowdsourcing is a way of obtaining information from the input of several people, whether paid or not, usually through the internet. Several previous studies have discussed the development of information technology solutions to prevent and mitigate flood disasters. Among them is the research that has been carried out by (Degrossi et al., 2014) by building a crowdsourcing platform for the flood citizen observatory. Through this platform, volunteers can share flood information with other users through the platform that has been built. The concept of crowdsourcing is also used in developing a system to collect data on flood-affected areas (Naik, 2016). The use of the crowdsourcing concept in several flood mitigation cases then inspired the development of a flood road reporting system (Mandyartha & Faroqi, 2021). Through a mobile application, road users can provide information on flood road points. In another study, the development of a decision support system for selecting the best route was used to reduce traffic congestion (Sholihah, 2015; Rifanti, 2017).

In the context of flooding, the presence of flooding will certainly cause congestion as well. Departing from this background, this study aims to build a route selection application to avoid flood roads.

Material and Methods

This research continues the previous research, namely the crowdsourcing-based flooded road reporting system Indonesia (Frostid) application (Mandyartha & Faroqi, 2021). This development enriches the frostid feature with an alternative route information feature to avoid road flooding. The flood points recorded in the Frostid application are then used as input as obstacles to be considered in the decision-making algorithm. This study uses a system development life cycle (SDLC) in application development. SDLC is a model or methodology used to help create or develop software. While the SDLC method used in this study is the waterfall. The waterfall method is a work method that emphasizes sequential and systematic phases. It is called a waterfall because the process flows in one direction like a waterfall. Application development is carried out sequentially according to the existing stages. The phases in the waterfall include requirements and design. coding, testing/deployment, and maintenance (Alshamrani & Bahattab, 2015). Figure 1 discovers the phases of the waterfall model.

Requirement analysis

Activities at this stage include analysis of system behavior. This includes determining the functional requirements and non-functional requirements of the system. Functional requirements are based on information gathered from end-users. At this stage, the most important functional requirement as an add-on to the frostid application feature is an alternative route information feature to avoid road flooding. This feature is then complemented by the basic features of a frostid flood reporting app. The results of the needs analysis at this stage are use case diagrams.

Design

This phase is a continuation of the needs analysis phase. At this stage, the results of the requirements analysis will be used as the basis for developing a model or application design. including database design, application interface design, and application architecture design. The output of this phase is the application design. Also, at this stage, if needed, the algorithm or mathematical model that will be used in the system is determined.

Coding

This phase is the implementation of the design that has been made at the design phase. The designs that have been made are translated into lines of code. the programming language used following the application design.

Testing/Deployment

The testing stage is the stage of testing the coding results. The coding results will be tested using the black box method which refers to the functional requirements and non-functional requirements that have been identified in the first stage. Functional requirements include testing application features, while non-functional requirements include the availability of access to applications.

Maintenance

The maintenance phase is the stage after the application is fully operational. This includes software upgrades, repairs, and software repairs if an error occurs.

Results and Discussion

Usecase diagrams

This route selection application to avoid flooding consists of two application platforms, a mobile application as a front-end, an interface that is seen by end-users when using the application, the second is a web-based application that is used by admins/application developers to monitor and maintain the use of mobile applications. Figures 2 and 3 display the results of the needs analysis in use case diagrams.

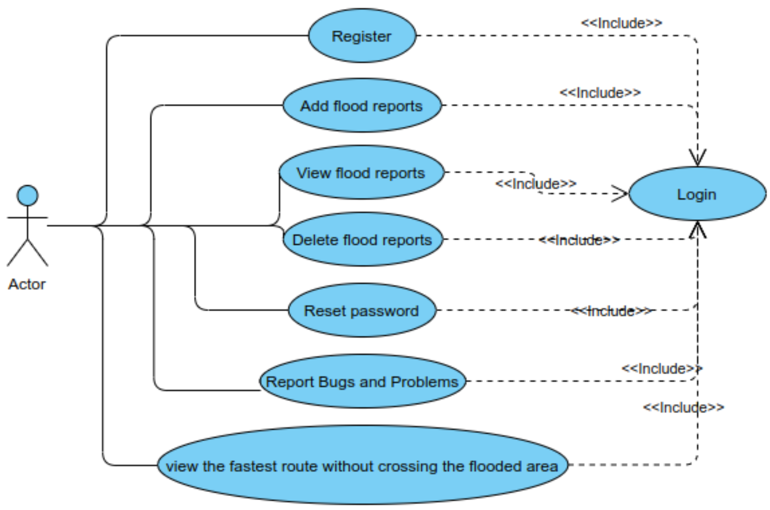

Figure 2. The Use case model for mobile platform

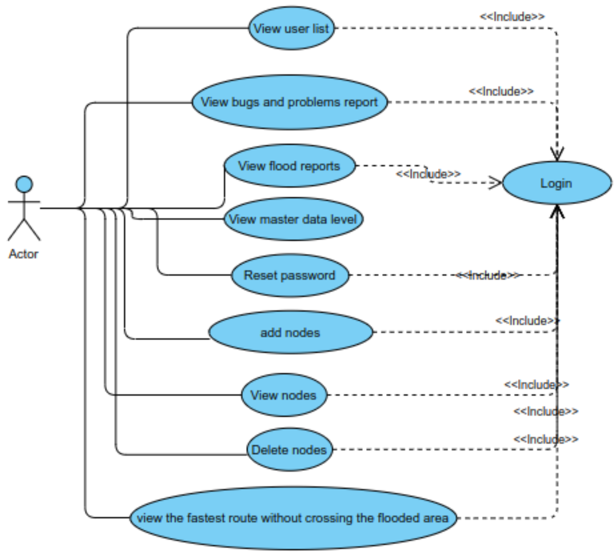

Figure 3. The Use case diagram for a web-based platform

Use case diagrams to illustrate the functionality of the system. Figure 2 describes the functionality of the system on a mobile platform. end-users who interact with the mobile application can perform the following behaviors: register, view, add and delete flood reports, reset passwords, report bugs, and problems, and view the fastest route without crossing the flooded area.

While Figure 3 illustrates the functionality of the system on the web platform. This web-based application is used by admins to manage and monitor mobile applications. Some of the features found in web-based applications that do not exist in mobile applications are: view, add, and delete nodes. Nodes are entered by the admin to be used in the calculation of the fastest path. The fastest route that is generated is an alternative route that can be passed by users to avoid flood areas.

Database design

Nine tables make up this application system, namely report_log, reports, report_level, report_pictures, users, user_levels, user_logs, nodes, and problems tables. The report's table is used to store flood report data. Flood level attributes, such as flood level icon color, flood level icon description, and flood level icon description, are defined in the report_levels table.

The user's table stores the Frostid user registration data that is used to log in. The user_logs table is used to store user activity data while using the Frostid application. The user_levels table defines the user's permissions to the system. Bug/problem report data reported by users are stored in the problems table. While the report_logs table stores flood report data deleted by users. The nodes table is used to store nodes that are used as input to the algorithm in determining alternative routes to avoid road flooding. Figure 4 illustrates the database design for this application system.

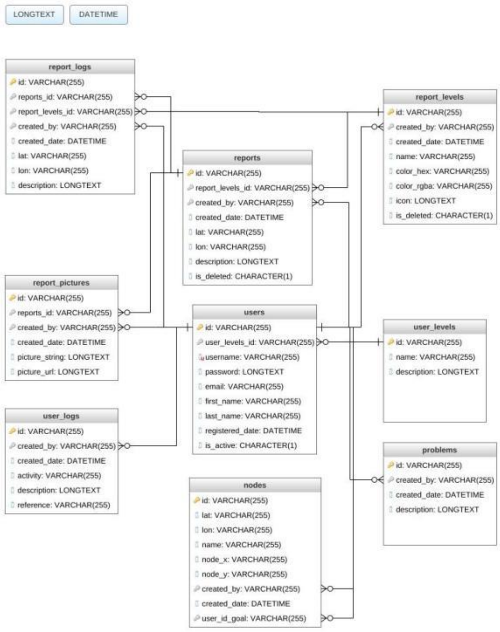

Figure 3. Database model

Application architecture design

There are three main components, namely Frostid Apps (mobile application), Route Planning, and Database Server. The flow of data from or to the Routes Planning module must go through an application programming interface (API). This also applies to the two-way communication with the Database Server. Figure 4 illustrates the application architecture design.

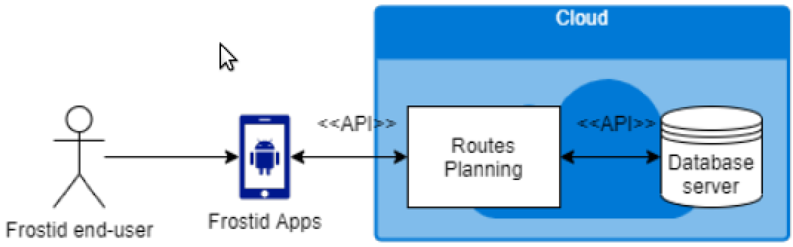

Figure 4. Architecture design of route selection app

Route planning is an application module that is responsible for calculating the shortest path between the initial coordinates and the destination coordinates. route planning will then check whether there is a flood area between the starting point and the destination point, if so then route planning will recalculate the shortest distance that does not pass through the flood area. To calculate the shortest distance, nodes on the map are needed. The route planning module then calculates the distance between the starting point and the destination point based on the availability of nodes. A* algorithm is used to calculate the distance based on these nodes. The A* search algorithm is one of the methods used to find the shortest path between two locations in a graph-based region (Dong et al., 2021).

The A* algorithm is the development of the Djikstra algorithm which combines the advantages of the Greedy Best-first search algorithm. The A* search algorithm belongs to the informed search algorithm, which means solving problems by searching based on all possible paths to the destination involving the smallest value. In this research proposal, the parameters that become the constraint in finding the smallest value are the distance traveled, travel time, and avoiding (avoiding) flood location points. The A* algorithm chooses the one that looks most likely to reach the destination from all available paths. By using a weighted graph starting from a specific node, the A* algorithm creates a tree starting from that node and spreads one by one through the branch tree until it finds the destination node.

Testing phase

Blackbox testing is used in testing the functionality of this application. The main functionality of the tested application is to see the shortest route to avoid flooded areas. In addition, basic functional requirements such as input, update, delete, and view flood road information will also be re-examined.

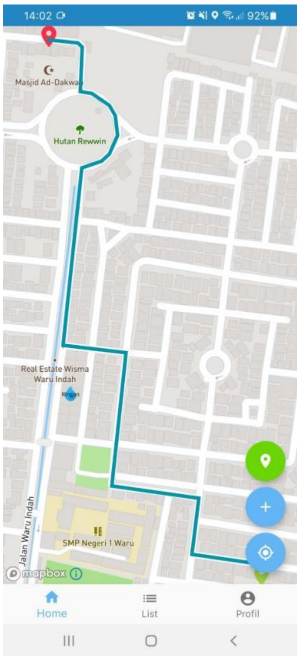

Figure 5. Testing alternative routes to avoid flood areas

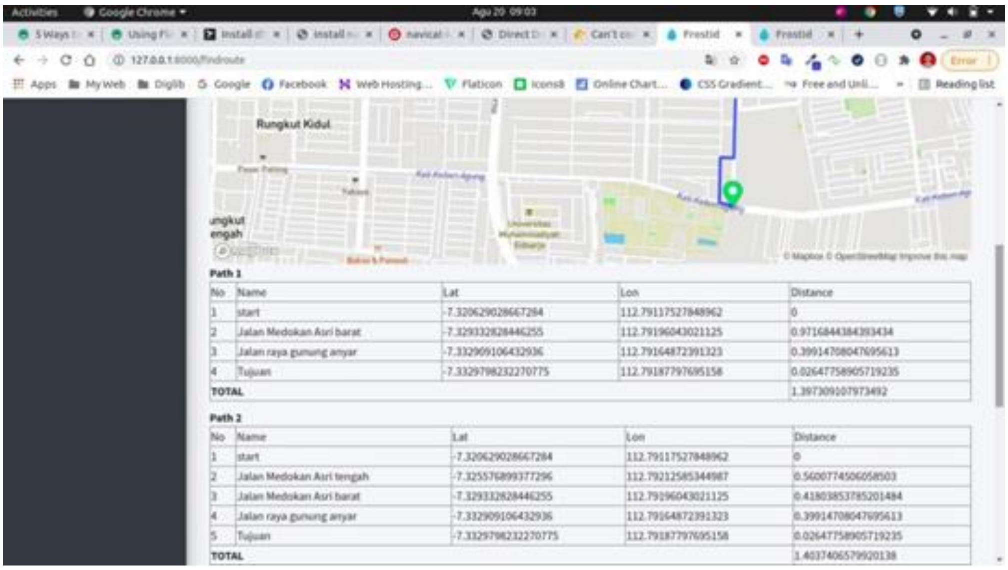

Figure 6. Test of the algorithm calculation to determine the most optimal

Figure 5 shows one process of testing alternative routes to avoid flood areas. While Figure 6 shows a test of the algorithm calculation to determine the most optimal route. The results of the complete system functionality test are written in table 1.

Table 1. Functional testing result

Platform	Functional Requirement	Testing Result
Mobile App	View the fastest route without crossing the flooded area	ok
	User registration	ok
	add flood rep	ok
	view flood report	ok
	delete flood report	ok
	reset password	ok
	report bugs and problems	ok
Web-based App	Login	ok
	View user list	ok
	view bugs and problems re-port	ok
	view flood report	ok
	view master data level (flood level)	ok
	reset password	ok
	add nodes	ok
	view nodes	ok
	delete nodes	ok
	view the fastest route without crossing the flooded area	ok

Conclusion

This research produces a crowdsourcing-based flood road reporting application with additional features of alternative route information to avoid flood areas. The route planning application module is the part of the application that is responsible for calculating the alternative shortest path to avoid flood areas. The A* algorithm is used to calculate the shortest distance between the starting point and the destination point entered by the end-user. The A* algorithm tests the nodes that have been inserted into the map and then calculate the weights of these nodes to get the fastest path.

The nodes used to get the fastest path, are entered manually by the development team. As a result, the accuracy and availability of information on alternative routes to avoid flooding are limited. This opens the opportunity to turn the nodes on the map into open-source data so that other developers can use and complement these nodes.

Then, the application that has been built is a prototype, the tests carried out are limited in resources, for example, the application testing carried out on a virtual private server turns out to have a rather long load time, this is due to the more nodes, the more calculations that need to be done. Further research is needed to test the optimization of the algorithm used.

The addition of useful information for users, especially related to small and local businesses in Indonesia, for example, the location of tire repairs and retail gasoline, can be used as development topics. In addition, the concept of gamification can be tried to be applied to complement the concept of crowdsourcing. Gamification is important because, in crowdsourcing-based applications, the effectiveness of the application depends on the activeness of the user. One of the concepts of gamification is to make users feel happy and actively use the application, such as achievements and rewards for active users.

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