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Implementation of a Geographic Information System in Website Design to Visualize Routes and Distances

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Abstract. This journal research was conducted with the primary objective of developing a system capable of visualizing the route and distance from SMK Raden Umar Said Kudus to various boarding houses located within Kudus Regency. The increasing number of students enrolling in the school, including those from outside the region, has created a growing need for accessible information regarding temporary accommodation near the school. Therefore, the proposed system is designed to assist students in identifying suitable boarding houses by providing geographic visualization of their locations and distances from the school. To achieve this objective, the system utilizes the Leaflet library as the main mapping tool to visualize geographic information in an interactive web based environment. Leaflet enables the display of maps, routes, and distance calculations in a user friendly format, making it easier for users to understand spatial relationships between the school and nearby boarding houses. The system itself is developed using PHP as the primary programming language. In addition, JavaScript is integrated with the Leaflet library to handle map interactions and geographic data visualization. The Waterfall development model was chosen as the system development methodology due to its clear and sequential. Through this approach, the research aims to produce a functional Geographic Information System that helps students efficiently locate temporary housing during their study period at SMK Raden Umar Said Kudus while also providing useful information for boarding house owners.

Keywords: Leaflet, Geographic Information System, Maps, Geographic

1 Introduction

The increasing demand for boarding houses located in Kudus Regency, particularly in the Gebog District, has become one of the main reasons for conducting this research. This demand has risen due to the growing reputation of a school in Kudus Regency, namely SMK Raden Umar Said, which has gained significant recognition over the past five years as the institution continues to develop. With study programs such as Animation, Game Development, and Visual Communication Design (DKV), the school has attracted many students to enroll. SMK Raden Umar Said was selected as the study case due to its high number of incoming students from outside regions, making it a representative environment for implementing a GIS based accommodation system in areas with high mobility demand. These students come not only from nearby regions but also from outside the island, including Kalimantan and Sulawesi.

However, the current process of searching for boarding houses is still inefficient, as students often rely on manual information sources such as word of mouth or social media, which lack spatial visualization, route information, and accurate distance measurement.Therefore, the development of a web based boarding house application is expected to serve as a platform that helps students find temporary accommodation while attending school.

This web based application will be integrated with a Geographic Information System (GIS) that allows boarding house owners to promote their properties more effectively, making them easier for students to locate. A Geographic Information System can be defined as a system that provides geographic mapping information of specific locations. In this study, the case focuses on SMK Raden Umar Said Kudus and the surrounding boarding houses within Kudus Regency. The GIS feature is designed using the Leaflet library to display routes and distances between boarding house locations and SMK Raden Umar Said. Through this feature, students searching for accommodation can easily visualize the distance between available boarding houses and the school, making the search process more efficient.

Research conducted by Maliha Anjely Putri Sinaga on mapping licensed medical practice locations in Medan using a Geographic Information System explains that the city has been successfully mapped through GIS methods to produce an interactive map utilizing Leaflet and GeoJSON for spatial data visualization. The map

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displays location points of licensed medical practitioners along with information such as name, type of practice, and address. Users can explore the map through several interactive features including zooming, rotation, and clicking on points to access additional details. The availability of clear and accessible information through this system improves transparency and accessibility in healthcare services in the city of Medan [1].

Another study conducted by Nur Sartika BR Ginting, NM Faizah, and Widyat Nurcahyo examined how tourist locations can be identified through route optimization using the Simulated Annealing method. The research resulted in a web based Geographic Information System application designed to guide tourists in identifying optimal tourism locations around Lake Toba. By implementing the Simulated Annealing algorithm, the system helps visitors discover lesser known tourist destinations and determine the nearest travel routes. The application also provides administrative features for managing data and system operations. With a user friendly interface and online accessibility, the system is able to reduce travel time, increase tourist interest, and contribute positively to the local economy. The system was developed using PHP and the CodeIgniter framework. However, certain technological limitations may affect the scalability and complexity of the application [2].

Research conducted by Eric Alfonsius, Susan Hasibuan, Jullie Titaley, and Yohanes Andreas Robert Langi developed a web based Geographic Information System to map the distribution of boarding houses around Sam Ratulangi University. The system provides up to date information regarding boarding house prices, facilities, and locations. This application assists students and newcomers in finding temporary accommodation through features such as boarding house location mapping, facility descriptions, and online booking capabilities. Black box testing conducted on the system demonstrated a 100% success rate, indicating that the system functions properly without significant errors [3].

Another study conducted by Ridwan Rinaldi and Dimas Aryo Anggoro explains that the implementation of Leaflet as a Geographic Information System tool produced an interactive web based map that helps users locate schools in the city of Surakarta. The map not only displays location markers but also provides interactive features such as pins, pop up information, and GPS based search functionality. These features enable users, especially parents, to easily search for and obtain information regarding nearby schools. The system simplifies the process of searching for educational institutions and assists users in making more informed decisions [4].

Although previous studies have implemented Geographic Information Systems (GIS) for location mapping and spatial visualization, most of these systems are limited to displaying static location points without providing integrated route visualization and real time distance calculation. Furthermore, existing systems often lack interactive features that support user decision making, such as the ability to compare distances, evaluate accessibility, and understand travel routes between locations. As a result, users are still required to interpret spatial information manually, which reduces the overall efficiency of the accommodation search process.

A Geographic Information System (GIS) can be defined as a computer based information system used to display digital representations and analyses of the Earth’s geographic surface [5]. It functions as a system that processes, stores, analyzes, and retrieves spatially referenced data for the purpose of geographic mapping [1].

GIS systems are capable of integrating various layers of spatial data, allowing maps to be visualized digitally according to user needs. One of the key advantages of GIS is its ability to represent spatial dimensions through geographic attributes such as latitude, longitude, and elevation values. These attributes help determine the position of objects within a defined geolocation and provide more realistic spatial representations for users [6].

JavaScript is a programming language used in web development that runs on the client side or browser. It is commonly used to manipulate HTML elements dynamically, allowing developers to create more interactive web interfaces. JavaScript code can be written directly within HTML documents using the <script> tag without the need to create separate files. The development of JavaScript has led to the creation of numerous frameworks and libraries, one of which is the Leaflet library that is widely used for geographic mapping applications [7].

Leaflet is widely chosen by developers for building interactive maps due to its open source nature. The library is designed to be lightweight, efficient, and user friendly, while still providing strong performance. These characteristics make Leaflet easy to implement in web based geographic applications [1].

PHP, or Hypertext Preprocessor, is a server side programming language designed specifically for web development. Created in 1994, PHP is distributed as open source software under the PHP License. This license differs slightly from the GNU General Public License (GPL), which is commonly used for many other open source projects [8].

Laravel is a web application framework for PHP that is also open source and developed by Taylor Otwell. Laravel is designed to simplify the development of web applications, particularly those that implement the MVC (Model View Controller) architecture. In this architecture, the Model is responsible for managing database operations, the View handles the user interface, and the Controller functions as an intermediary that connects the Model and the View while controlling application logic [9].

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Laragon is a development environment that functions similarly to a server and includes components such as MySQL and Apache. It is designed to be flexible, fast, and portable, allowing developers to manage and build modern web applications efficiently. Laragon is lightweight and emphasizes performance, stability, and flexibility. In addition to MySQL, it also supports integration with technologies such as Node.js, Java, and Python [10].

To ensure system reliability and accuracy, testing methods are required to verify whether the system functions according to its predefined requirements. One commonly used method is Black Box Testing, which evaluates the functionality of a software system by examining its outputs based on given inputs without analyzing the internal code structure [11].

MySQL is database management software used to store and manage various types of data. SQL, which stands for Structured Query Language, is a standardized query language used to interact with Database Management Systems (DBMS). MySQL serves as the database server that manages all instructions related to the database system. It operates on the server side and allows multiple clients to access and manage data simultaneously. Data within the database can be organized into one or more tables that may be interconnected. Common SQL commands include CREATE, DROP, ALTER, SHOW, INSERT, LOAD, SELECT, UPDATE, and DELETE [12].

Through this research entitled "Implementation of a Geographic Information System in Website Design to Visualize Routes and Distances," this study aims to assist new students in locating boarding houses more easily. Furthermore, this study contributes by developing a web based GIS system that integrates route visualization, distance calculation, and interactive user features to improve the efficiency of boarding house selection. In addition, the system is expected to benefit boarding house owners by providing a platform to promote their properties more effectively.

2 Methods

2.1 Research Methodology

The research methodology used in this study is qualitative in nature, where the data consist of route and distance information between the school and nearby boarding houses. The data obtained were collected through observation and interviews with boarding house owners. Qualitative research is a type of research aimed at examining phenomena in natural conditions, where the researcher acts as the primary instrument. In Indonesia, qualitative research is often referred to as naturalistic qualitative research, indicating that the study is conducted naturally under normal conditions without manipulation of the environment or research context [13].

Qualitative research was chosen as the research method in order to examine the system more comprehensively by exploring phenomena in depth. This approach emphasizes the importance of collecting detailed and in depth data related to the subject being studied. To ensure the accuracy and reliability of the collected data, validation was conducted through cross checking information obtained from boarding house owners and direct field verification. In addition, location coordinates were collected using GPS based tools to maintain spatial accuracy within the GIS system.

In qualitative research, data analysis is not limited to statistical methods but may also involve various forms of narrative analysis [13]. The research activities conducted to obtain the required data utilized three data collection methods, namely:

a. Observation

Observation was carried out to systematically observe the research objects by directly examining the ongoing conditions in the field. The author conducted observations at several boarding houses located in Kudus Regency. This observation activity aimed to obtain data regarding locations and other relevant information needed for designing the system.

b. Interview

Interviews were conducted as a form of question and answer interaction between the researcher and the boarding house owners as informants. These interviews were carried out at the residences of several boarding house owners, including Rusman and Tito. Through these dialogical activities with several boarding house owners in Kudus Regency, the researcher was able to gather information relevant to the system currently being designed.

c. Literature Review

The researcher also applied a literature study method by using the thesis presented in reference [1] as a primary reference in designing the system structure of the application related to the proposed research topic. The system design adopted in this reference shares similarities with the objectives of this study, particularly in the use of the Leaflet library and GeoJSON to visualize geographic areas. In addition to the thesis in reference [1], reference [4] was also used as an inspiration to demonstrate the benefits of designing a Geographic Information System in visualizing boarding house locations along with their routes.

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2.2 System Development Method

In developing the system, this research plans to apply the Waterfall method in order to demonstrate that a sequential software development approach consisting of five interrelated and influential stages can function effectively. The Waterfall model is one of the commonly used models in system development, where validation and system evolution are carried out sequentially based on the stages of the development process [14].

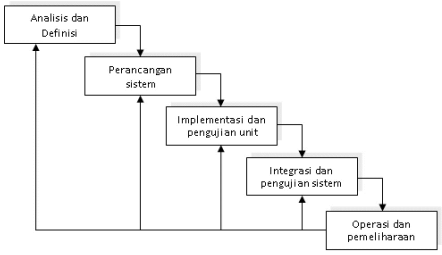

Figure 1. The Waterfall method is used by the author to design a system

The stages of system development using The Waterfall model structures the development process into sequential phases, ensuring that each stage (requirements analysis, system design, implementation, integration and testing, and maintenance) is completed before proceeding to the next stage, thereby improving system reliability and clarity. [15].

a. Requirements Analysis

At this stage, data are collected to identify the requirements needed to design the system. The purpose of this stage is to identify existing problems and formulate potential solutions that will guide the system design process [14].

Based on the results of the data collection conducted by the researcher, two types of requirements were identified. The first is functional requirements, which describe the main features and functions required in the system. The second is non functional requirements, which represent the supporting requirements that must be fulfilled during the development of the software system.

b. System Design

At the system design stage, it is necessary to design the database structure of the system as well as an interface that is appropriate and user friendly. This design is intended to make it easier for viewers, owners, and administrators to use the website that will be developed [14]. At this stage, the author plans to use a Flowchart to help users understand the workflow of the website.

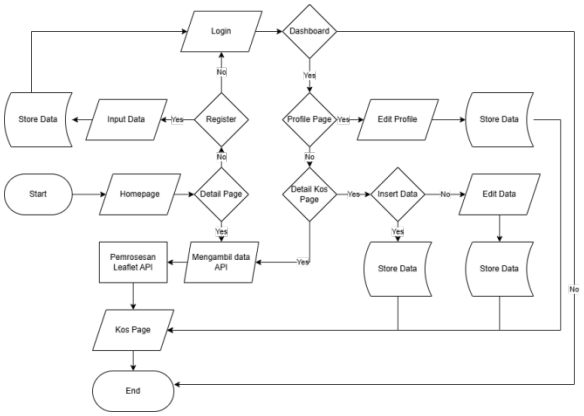

Figure 2. Flowchart illustrating the system workflow from the beginning to the completion of the process.

In addition to the flowchart, the author also uses Unified Modeling Language (UML) which is A standard language in the industry used to visualize, design, and document systems. UML facilitates the creation of application project models that are being developed . to illustrate the planned system diagrams in the design of the Geographic Information System. Three types of diagrams will be used, as described below:

1) *Use case Diagram*

In this diagram, the author visualizes the relationship between the designed system and the actors who interact with it. The use case diagram illustrates the various activities that can be performed by users within the system. There are three types of users involved in the system: admin, owner, and viewer, each having different access rights.The admin has the authority to add, edit, and delete user data, as well as respond to messages sent

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by users. The owner can send messages to the admin and manage boarding house data by adding, editing, and deleting boarding house information. Meanwhile, the viewer can view boarding house information and send messages to the admin. To perform these actions, all actors must first log into the system.

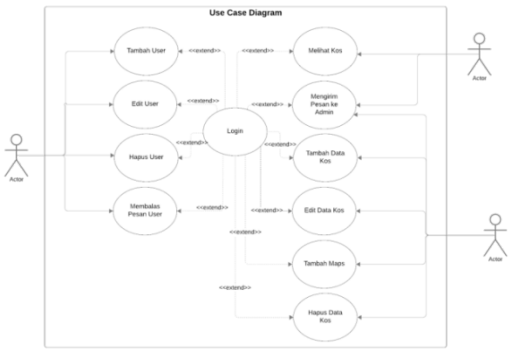

Figure 3. Use case diagram illustrating three actors with different roles and system interactions.

2) *Activity Diagram*

This diagram illustrates the system workflow designed to represent the processes occurring within the system. The activity diagram consists of three models: the admin activity diagram, the owner activity diagram, and the viewer activity diagram.

This activity diagram describes the workflow of the system performed by the admin. It consists of two main sections, namely the user and the system. The process begins when the admin logs into the system, after which the system accesses the database and displays the dashboard page. On the dashboard, the admin has two options: Edit User or Reply to Messages. This selection is determined through a decision making process within the system.

If the admin selects Edit User, the updated user data will be stored directly in the database. Meanwhile, if the admin chooses Reply to Messages, the message created by the admin will also be stored in the database. The process concludes with an activity end symbol. This diagram is designed to clearly and simply illustrate the interaction between the admin and the system.

This activity diagram also helps identify the main workflow and alternative processes that may occur within the system. For example, the decision making process performed by the admin reflects the system's flexibility in handling various administrative tasks. Furthermore, activities such as Edit User demonstrate how the system is designed to support direct data management, while Reply to Messages represents the communication functionality that allows the admin to remain connected with other users.

The separation between the user and system sections in the diagram emphasizes the division of responsibilities between actions performed by the admin and the automated responses generated by the system. This design aims to improve process transparency and assist developers in identifying critical points, such as login validation or data storage in the database.

This diagram not only serves to document the workflow but also functions as a guideline for developers and stakeholders to better understand the system requirements. With a simple yet detailed visualization, the diagram facilitates cross team discussions and minimizes the risk of misunderstandings during the development process.

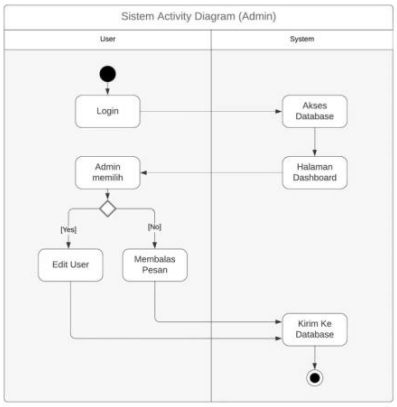

Figure 2. Activity diagram from the admin perspective showing the workflow of an admin within the system.

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Meanwhile, the activity process on the owner side differs slightly from that of the admin in terms of the available actions that can be performed, as illustrated in figure five.

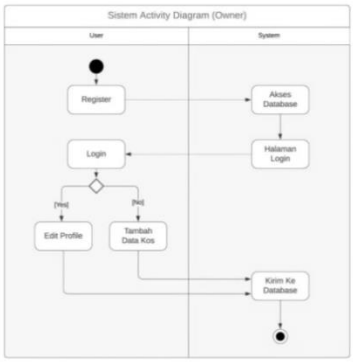

Figure 3. Activity diagram from the owner perspective showing the workflow of an owner within the system.

This activity diagram describes the system workflow performed by the owner. The diagram consists of two main sections, namely user and system. The process begins when the owner registers an account, after which the system accesses the database and displays the login page. After successfully logging in, the owner is directed to the dashboard page. On the dashboard, the owner has two options: Edit Profile or Add Boarding House Data. This selection is determined through the owner's decision making process. If the owner chooses Edit Profile, the updated data will be stored directly in the database. Meanwhile, if the owner selects Add Boarding House Data, the newly created boarding house information will also be stored in the database.

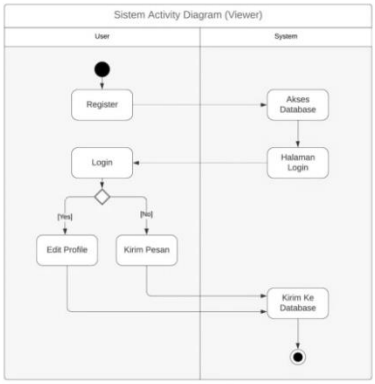

Figure 4. Activity diagram from the viewer perspective showing the workflow of a viewer within the system.

This activity diagram describes the workflow of the system from the viewer's perspective. Similar to the previous diagrams, it consists of two main sections: user and system. The process begins when the viewer registers an account, after which the system accesses the database and displays the login page. Once the login process is successful, the viewer is directed to the dashboard page. On the dashboard, the viewer has two options: Edit Profile or Send Message. This selection is determined through the viewer's decision making process. If the viewer selects Edit Profile, the updated data will be stored directly in the database. Meanwhile, if the viewer chooses Send Message, the message will be sent to the admin and stored in the database.

3) *Sequence Diagram*

At this stage, the author aims to visualize how the designed objects interact over time and how reciprocal relationships occur within the system. The sequence diagram illustrates the interaction flow between the user, the website page, the system, and the database. The process begins when the user accesses the website page, which then requests data from the system and displays it to the user. If the user adds or modifies data, the input is sent through the website page to the system and then forwarded to the database to be stored or updated. After the storage or update process is completed, the latest data is returned to the website page and displayed to the user, ensuring that the workflow remains organized and the data is managed effectively.

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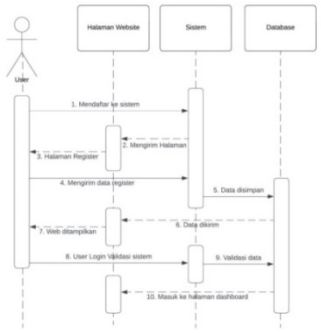

Figure 5. Sequence diagram illustrating the sequential workflow of how a user interacts with and accesses a website page.

c. Implementation

At this stage, the system is implemented using the programming languages determined during the requirement analysis stage. The use of the PHP programming language along with the Laravel framework allows the development process to be carried out more efficiently and systematically.

d. Integration and Testing

In this stage, the researcher uses Black Box Testing as the method for system testing. This testing method focuses on observing the functionality of the system by executing test data directly on the developed features without examining the internal code structure. The testing process is intended to determine whether the system operates according to the planned requirements. The testing includes several main functions of the system, such as account registration, login processes, CRUD features, and route and distance visualization features using the Leaflet library.

e. Maintenance

The maintenance stage is conducted to identify potential errors and perform necessary improvements. This maintenance process is carried out reactively, meaning that repairs are performed after the system experiences performance issues or failures in order to restore it to normal operating conditions. In addition, this stage also involves collecting user feedback to improve the performance of the implemented system. The system will be monitored regularly, and bug fixes will be applied to enhance system performance and ensure that the application becomes more user friendly.

2.3 System Architecture

The system architecture is divided into three main layers: presentation layer, application layer, and data layer. The presentation layer represents the user interface of the web application, which is responsible for displaying information and handling user interaction. The application layer handles the system logic, including data processing using PHP and Laravel, as well as client-side processing using JavaScript and the Leaflet library for map rendering, route visualization, and distance calculation. The data layer is responsible for storing and managing boarding house data using a MySQL database. This layered architecture ensures separation of concerns, improving system maintainability and scalability.

3 Result

This study produced results demonstrating that a website can be designed by integrating map components as a medium for visualizing routes and distances, thereby making it easier for users to determine how far a boarding house is located from the school. The implementation of a Geographic Information System through a web based platform enables users to access spatial information interactively, allowing them to understand the relationship between the school location and the surrounding boarding houses.

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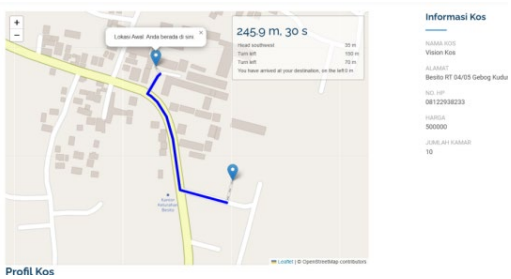

Figure 6. Implementation of Leaflet displaying map visualization with route and distance.

From Figure 8, it can be observed that the map displays the starting point at **SMK Raden Umar Said** and the destination point at one of the nearby boarding houses. The numbers shown in the upper corner indicate the total distance from the school to the boarding house, along with the estimated travel time and the route leading to the destination. This visualization demonstrates how map based technology can function as an interactive tool that helps users better understand geographic information. By presenting routes and distances visually, the system provides clearer information compared to traditional text based descriptions.

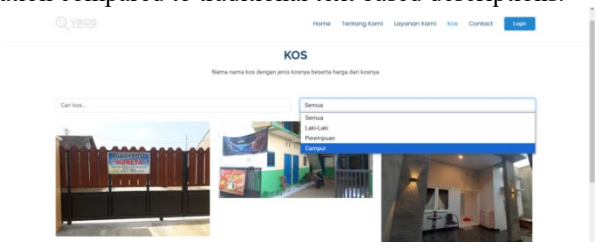

Figure 7. Interface displaying filtering options by boarding house type (male, female, mixed) and search functionality for locating boarding houses by name.

In addition to route and distance visualization, the system provides basic filtering and search functionalities to support user interaction. Users can filter boarding houses based on type, such as male-only, female-only, or mixed accommodation. Furthermore, a search feature is available to allow users to find boarding houses by name. These features help users narrow down available options and improve the efficiency of the selection process.

The capabilities of interactive maps extend beyond simple navigation functions. Web based mapping technologies allow geographic data to be presented in a way that enables users to interact directly with spatial information. By clicking specific points on the map, users can obtain additional information related to the location. In this context, route lines with different colors provide a visual representation that helps users interpret travel paths more easily. Furthermore, the system also calculates the total distance and estimated travel time, enabling users to gain a clearer understanding of the actual distance between locations in real world contexts.

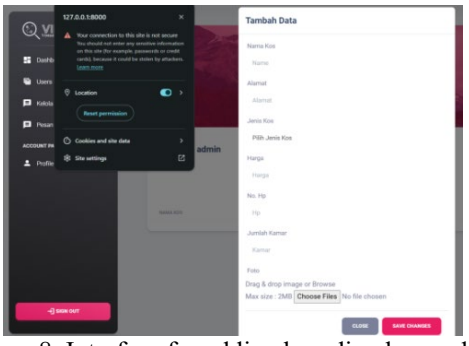

Figure 8. Interface for adding boarding house data.

Another feature shown in the system is the boarding house data input form, as illustrated in Figure 9. The interface contains several input fields such as boarding house name, address, type of boarding house, price, phone number, number of rooms, and photos. The interface also displays a notification requesting location access from the user. This location access allows the system to retrieve longitude and latitude coordinates from the selected location. Once the geographic coordinates are obtained, the system can automatically generate map visualizations similar to those shown in Figure 8.

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The implementation of this form reflects the application of the CRUD (Create, Read, Update, Delete) concept in web based application development. The form does not only function as a data input tool but also acts as an intuitive interface that allows users, particularly boarding house owners, to manage their property information easily. The ability to upload photos and collect location data enriches the information stored in the system, making each boarding house entry more contextual and geographically connected.

The integration between the input form and location access represents an important aspect of the system design. By utilizing geographic coordinate data, the application is capable of providing a more modern and relevant user experience. The map generated from this data does not only serve as a visual representation but also reflects accurate spatial information derived from the stored coordinates. As a result, the system can effectively display the relative distance between the school and each boarding house location.

In addition, the form interface is designed with principles of accessibility and usability, where important information is arranged systematically to simplify user interaction. This approach helps developers design a workflow that remains simple without reducing the essential features required by the system. The integration of mapping features with the boarding house data demonstrates how technology can be optimized to support user decision making, particularly when selecting a boarding house location based on distance or accessibility to the school.

Table 1. Results of blackbox testing for main features of the boarding house GIS

No	Function Tested	Input	Expected Output	Result
1	User Login	Valid username & password	User successfully logs into dashboard	Success
2	Add Boarding House Data	Complete input data	Data stored in database	Success
3	Map Visualization	Select house boarding location	Map displays route and distance	Success
4	Filtering	Select house boarding type	Filtered results displayed	Success
5	Search	Input boarding house name	Relevant data displayed	Success

Black Box Testing was conducted to evaluate key system functionalities, including login, data management, map visualization, filtering, and search. The results indicate that all tested features operate as expected without significant errors, confirming that the system performs reliably.

Overall, systems such as this offer significant opportunities for further development. Future improvements may include the implementation of location based analytics to analyze user search patterns or the addition of recommendation systems that suggest boarding houses based on user preferences and proximity to the school. Through these developments, the system has the potential to evolve from a simple geographic visualization tool into a more intelligent platform that enhances the overall user experience.

4 Conclusion

The conclusion that can be drawn from this study is that Leaflet can serve as an effective solution for designing a website based on a Geographic Information System (GIS). As one of the many JavaScript libraries available, Leaflet simplifies the implementation of geographic information systems within web applications. The location points entered by the owner into the system will be stored in the system's database. The utilization of Leaflet, as illustrated in Figure 6, shows that route and distance visualization features are particularly useful, as they help prospective students consider the distance between their boarding house and the school.

In addition, the use of Leaflet not only provides benefits in terms of visualization but also enhances the user experience when interacting with the system. With its capability to display geographic data dynamically, Leaflet allows developers to add additional features, such as marking important locations around the boarding house, for example restaurants, public facilities, or nearby transportation options. These features can provide added value to the geographic information system, making it more informative and relevant for its users.

The integration of Leaflet with the database also opens opportunities for further development, such as location analytics to understand geographical patterns in user preferences. For instance, developers could utilize location data to provide boarding house recommendations based on previous search patterns or offer suggestions based on distance and travel time. In this way, the system can function not only as an informational tool but also as an intelligent solution to support decision making.

Furthermore, the lightweight and responsive nature of Leaflet makes it a suitable choice for websites that require fast performance, even on devices with lower specifications. This demonstrates that Leaflet is not only

efficient in terms of functionality but also compatible with various devices, thereby expanding the potential reach of the system's users.

5 Acknowledgments

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