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Application of CNN in the Classification of Chili Varieties for Agricultural Efficiency

Febrian Trio Pamungkas[1*)], Irsyad Zainal Muttaqin[2]
[1]Informatics Engineering Study Program, Faculty of Informatics, Institut Teknologi Telkom Purwokerto
[2]Informatics Engineering Study Program, Faculty of Informatics, Institut Teknologi Telkom Purwokerto
Email: [1]21102140@ittelkom-pwt.ac.id, [2] 21102157@ittelkom-pwt.ac.id

Abstract – This research focuses on the problem of classifying chili harvests which is still done manually by farmers. This manual classification process will of course take a long time, require a lot of energy and will feel tedious. This research aims to develop a classification system for chili types using the Convolutional Neural Network (CNN) method. By utilizing CNN technology, it is hoped that the chili grouping process can be carried out automatically with a high level of accuracy, thereby increasing work efficiency and reducing errors in chili grouping. The data used in this research is primary data with a total of 500 images of chilies divided into 4 classes. These images were taken using a Samsung A7 smartphone camera under consistent conditions: all photos were captured during daylight hours with the same camera angle. The training and testing results of the CNN model in classifying types of chili showed an accuracy of 99.5% in the training stage and reached an accuracy of 94% in the testing stage. Based on these results, it shows that the application of the CNN method in classifying chili types can work very well and effectively.

Keywords – convolutional neural network, classification, type of chili.

I. INTRODUCTION

In Indonesia, chili is a very important food commodity and is needed by almost all levels of society [1]. The development of chili production in the next 5 years is estimated to be experienced an increase with a growth rate of 8.96%, namely from 2.59 million tons in 2019 to 3.97 million tons in 2024. Types of chilies vary greatly, In Indonesia itself there are various types of chilies that are usually cultivated by farmers, including large chilies consisting of large red chilies and curly red chilies, as well as cayenne pepper consisting of green cayenne pepper and red cayenne pepper [2]. When planting chilies, farmers usually do not only plant one type of chili but rather plant many varieties of chilies so that they can reduce the risk of crop failure caused by pest attacks, disease or unfavorable weather conditions [3]. Harvesting chilies takes around 70-75 days after planting [4]. After harvest, farmers usually classify the types of chilies that have been harvested. However, this classification process is still often done manually. This manual method is time consuming, requires a lot of labor and will cause boredom. Therefore, a more efficient and accurate solution is needed to classify the types of chilies that have been harvested. This research aims to develop a classification system for types of chilies using the Convolutional Neural Network (CNN) method. By utilizing CNN technology, it is hoped that the chili classification process can be carried out automatically with a high level of accuracy, thereby increasing work efficiency and reducing errors in chili classification. This will not only increase work efficiency and reduce errors in batching, but will also help farmers increase the productivity and quality of their crops.

In this study, the dataset used consists of 500 primary images of chilies, collected manually by photographing samples using a Samsung A7 smartphone under consistent conditions. The images were taken during daylight hours with a fixed camera angle to maintain uniformity. These images are divided into four classes: red curly chilies, green curly chilies, red cayenne peppers, and green cayenne peppers.

Convolutional neural networks are classification method carried out in research which is a neural network or a neural network that uses convolution as a replacement for multiplication general matrix, which is at least in each layer there is one convolution. Convolutional neural networks are capable analyzing features unsupervised, This makes this method different with other machine learning methods [5].

The Convolutional Neural Network (CNN) method has been widely used to solve the same problems in various fields, especially in image-based object classification. This method has proven to be effective in carrying out classification. For example, research conducted by Rangga and Toto showed that the results of applying the CNN method to classify chili seeds reached an accuracy level of 90% [6]. The CNN architecture was able to separate three types of seeds in chili plants by providing labels according to the input data. Other research conducted by Fani, Nila and Sri shows that the application of the CNN method is very effective in classifying eye diseases with very high accuracy, reaching 98.37% [7]. Apart from that, research from Apwabul and Herawan also proves that the CNN method is able to classify types of disease in rice plants with a high level of accuracy, namely 91.7% [8]. Ahmad, Irma and Andi's research shows that CNN is able to classify types of tomatoes with a high accuracy of up to 96,6% [9]. Subsequent research from Yoga and Indah showed that the CNN method was proven to work well in classifying types of Aglaonema plants, with an accuracy success rate of 96% from the 50 images tested [10]. Further research was carried out by Sandi and friends which showed that the CNN method could be applied to types of jellyfish and obtained quite high accuracy, namely 87% [11].

These results indicate that CNN is a very potential and reliable method for classification tasks, including the classification of chili types in this study. In this study, we will classify 4 types of chilies, namely red curly chilies, green curly chilies, red cayenne peppers and green cayenne peppers.

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II. RESEARCH METHODOLOGY

This research is to classify types of chilies using the Convolutional Neural Network method. The flow of this research can be seen in Figure 1.

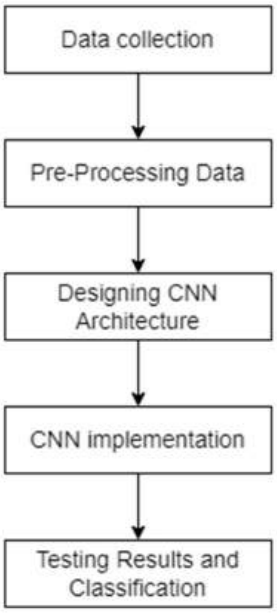

Figure 1 Research flow

Below is a further explanation of each step from journals, books and so on.

A. Data collection

Data collection is a stage research process where researchers apply methods and certain scientific techniques in order to collect data systematically for analysis purposes [12]. The data used in this research are pictures of chili peppers of various types. The data used is primary data obtained directly by researchers through chili sellers in the market who were photographed directly using the Oppo Reno 4 smartphone. The total data collected reached 500 images consisting of 4 different types of chilies, namely red curly chilies, green curly chilies, red cayenne peppers and green cayenne peppers, each class consists of 150 images. Each picture is labeled according to the type of chili present. One example The images used are listed below figure 2.

Figure 2 Sampel green curly chilies

Figure 3 Sampel red curly chilies

Figure 4 Sampel green cayenne pepper

Figure 5 Sampel red cayenne pepper

B. Pre-preprocessing Data

After the data collection process then data preprocessing is carried out to prepare pictures of chilies before use in model training and testing. In this stage, there are several images that contain a collection of chili images or background parts which is undesirable. To overcome this cropping the image manually with the aim of ensuring that the image is ready to be used in training. The image cropping process is carried out to delete the parts that are not desired in every image. After the next image cropping process, dividing or splitting data into data train, validation data and test data [13].

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C. Designed the CNN architecture

At this stage, architectural design is carried out CNN model. CNN is a deep learning algorithm designed to process data in the form of images, determine the importance of various aspects in the image through weights and biases that can be learned, and serves to differentiate one object from another [14]. CNN consists of two architectural layers, namely the feature learning layer and the classification layer [15], as shown in Figure 6.

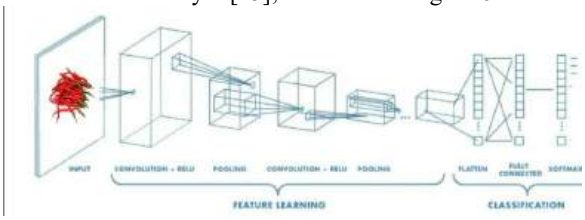

Figure 6 CNN architecture[16]

During the feature learning stage, there is a layer that directly takes image input and processes it into output data. This process involves convolution and pooling layers. Each step in these layers produces a feature map consisting of numbers representing the image, which is then passed to the classification layer. In the classification layer, there are several layers of neurons that are fully connected to each other. This layer receives input from the results of feature learning, then processes it through a flattening process and several fully connected hidden layers, to produce output in the form of classification accuracy for each class. [16].

D. CNN implementation

At this stage, clay chili data is implemented using the Convolutional Neural Network (CNN) method. Data that has passed the previous stages will be analyzed according to the stages in the CNN architecture which will be created using the Python programming language.

E. Testing Results and Classification

Accuracy is a metric used to assess the performance of a classification model. Accuracy is obtained by dividing the number of correct predictions from the model by the total number of predictions made, defined as follows [16].

$$Accuracy = \frac{correct\ prediction}{total\ predictions} \times 100\% \qquad (1)$$

III. RESULTS AND DISCUSSION

A. Dataset

The data used is in the form of images of types of chilies consisting of 500 images divided into 4 data classes. The author stipulates the data comparison is 80%: 20%, the data comparison is based on on the Pareto principle which is generally used in data mining, where the principle states that 80% of events result from the remaining 20%. The dataset distribution scenario can be seen in table 1.

Table 1 Dataset sharing scenario

class	Total Image	Data training	Data test
		80%	20%
Green Curly Chilies	125	100	25
Red Curly Chilies	125	100	25
Green Cayenne Pepper	125	100	25
Red Cayenne Pepper	125	100	25

B. Training Results

Training is carried out to create a model that will be implemented in system classification. Below are the results of the training.

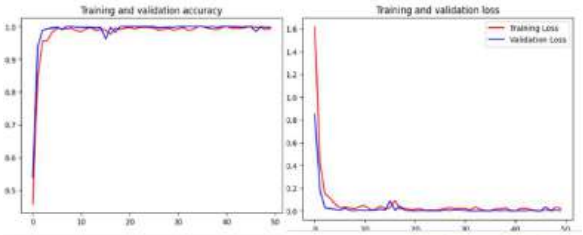

Figure 7 Training Results Graph

Figure 7 shows that the trained CNN model has a very high level of accuracy, almost reaching 100% and has low loss, indicating that the model is able to recognize and classify chili images very well without significant overfitting.

C. Test result

Testing uses test image data of 100 images. Does the image of the chili being tested match its class, an example of the test can be seen in the image

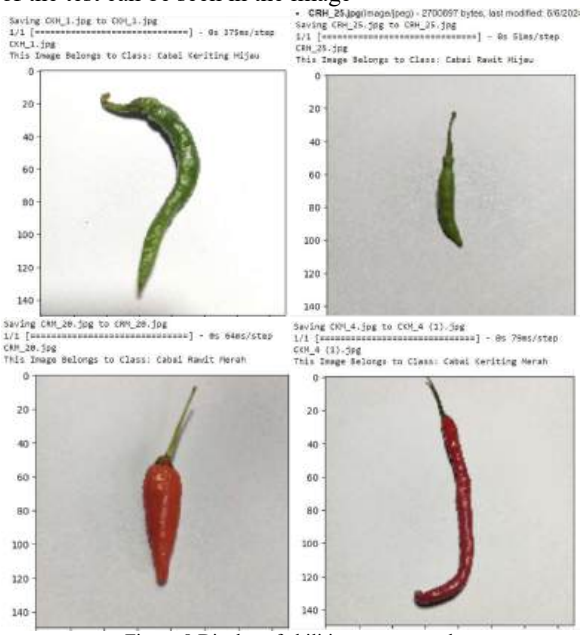

Figure 8 Display of chili image test results

It can be seen in Figure 8 that the CNN model can classify the types of chilies well. For each image entered, the CNN model can classify it according to its class. For more detailed results, see table 2

Table 2 CNN Model testing results

Class	Correct Prediction	Wrong Prediction
Green Curly Chilies	25	-
Red Curly Chilies	25	-
Green Cayenne Pepper	25	-

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Red Cayenne Pepper	19	6

Table 2 shows the results of testing the CNN model in classifying chilies. The test was carried out using 100 test data from various types of chilies. CNN accuracy level in classifying chili types can be calculated with the equation:

$$Accuracy = \frac{correct\ prediction}{total\ predictions} \times 100\%$$

$$Accuracy = \frac{94}{100} \times 100\% = 94\%$$

Convolutional Neural Network (CNN) model in classification types of chilies achieved an accuracy of 94%. This accuracy proves that CNN can classify the types of chilies very well.

IV. CONCLUSION

Based on several stages of testing that have been carried out, it can be concluded that the Convolutional Neural method Network (CNN) is able to classify chili types very well. The research results show that the model achieved 99.5% accuracy, indicating the model's ability to recognize patterns in the data very well. In testing using 100 images of chilies from the 4 types of chilies tested, the CNN model was able to recognize the types of chilies correctly with an accuracy of 94%. For future research, it is recommended to use a larger and more diverse dataset with more types of chilies, as well as exploring other classification methods such as Transfer Learning, Random Forest, Support Vector Machine, k-Nearest Neighbors, and YOLO (You Only Look Once) to improve and strengthen the results that have been achieved.

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Development of the Story of Life: A Narrative and Educational Game Using the Godot Engine for Android

Andhika Kusheryanto[1*)], Anis Mirza[2], Ari Syaripudin[3], Deanna Durbin Hutagalung[4]
[1]Informatic Engineering Study Program, Faculty of Computer Science, Universitas Pamulang

Email: [1]andhikakusheryanto7@gmail.com, [2]dosen00289@unpam.ac.id, [3]dosen00671@unpam.ac.id, [4]deanna.upn19@gmail.com

Abstract *– Godot Engine, as an open-source platform, offers flexibility and ease of use for developing both entertaining and educational games. This research showcases the creation of Story of Life, an educational game aimed at engaging players in learning through interactive storytelling and character-driven quests. The game features a character named Ucup, who explores various environments, clearing questions, and interacts with NPCs to gain knowledge and complete learning-based challenges. The development process followed the Agile Software Development Life Cycle (SDLC), with rigorous testing conducted through black-box and white-box methodologies. Testing results indicate a 97% success rate in functionality and performance on low-spec devices, confirming the game's compatibility and responsiveness. The findings demonstrate that Story of Life successfully combines narrative with educational content, providing a meaningful and accessible learning experience.*

Keywords – Game; Story; Education; Game Development; Godot Engine; Story of Life

I. INTRODUCTION

The rapid progress of technology has transformed how people, particularly students, use smartphones. Nowadays, phones serve not only as communication tools but also as platforms for gaming, often capturing children's attention for extended periods. In Indonesia, this trend has contributed to a decline in academic performance among students, as they spend more time on entertainment-focused games that offer little educational value. Observing children in the community, it is clear that excessive time spent on such games has impacted their school grades and overall literacy. This concern underscores the need for a game that provides an engaging yet educational experience, redirecting students' gaming habits towards learning and knowledge-building. In response, the researcher aims to develop *Story of Life*, a narrative-driven game that improves literacy, knowledge, and critical thinking. By embedding educational content within an immersive storyline, the game is designed to stimulate curiosity and provide learning experiences on topics beyond the conventional school curriculum, meeting an essential need for more constructive game-based learning tools.

This journal focuses on the development of *Story of Life*, a narrative-driven educational game created using the Godot Engine for Android. The research covers the design, development, and implementation of the game's core features, including the integration of educational content aimed at improving literacy, critical thinking, and knowledge across various subjects. The study evaluates the game's performance on low-spec Android devices, its usability, and the effectiveness of its interactive storytelling approach in engaging students. The scope of the journal does not include the development of similar games for other platforms, nor does it address other aspects of game development outside the educational content and user experience.

Practically, games can have a positive impact on children's development if used properly and following the rules that have been set by parents regarding the time of use and the content of games that children can access using technology. [1]

Based on the background described above, several issues can be identified: Students tend to spend a significant amount of time playing games, and the games lack educational content; They often experience boredom with conventional learning methods, which leads to a decrease in their interest in learning and a preference to play games; Many students and smartphone users are using the Android operating system, and the specification is low.

Indonesia is one of the largest countries in the world for active smartphone users. However, the increasing time spent on the internet is often misused by society. Despite the government's efforts to provide various conveniences to achieve the nation's goals, as outlined in the Preamble of the 1945 Constitution, particularly in educating the nation's life, the presence of the internet has led the younger generation astray. They have begun to neglect books and the habit of reading, resulting in a decrease in their knowledge acquisition. Additionally, their engagement in the teaching and learning process has also diminished. [2]

Teaching children about morals and ethics, particularly in relation to their parents, has not yet been effectively implemented. One of the main challenges in this learning process is the lack of engaging delivery methods. As educators, it is essential to prioritize a play-based learning approach in the teaching process, especially for young children. This is because primary school-aged children are naturally inclined toward play. [3]

According to Damien Djaouti et al., a video game is a form of electronic game that involves text or images, where

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interaction occurs between the game software and the player, facilitated by the hardware that processes the game. The game software provides output in the form of images or text, which is displayed through a medium (such as a television, computer, or mobile phone). The player then inputs commands via the hardware, which are subsequently reflected on the medium. [4]

The result of this research is a game prototype that can serve as a foundation for further development. In the long term, if this game can be implemented and used by the public in Indonesia, it will become a creative solution that supports the government's efforts to preserve and promote national culture. [5]

Education is crucial from an early age to ensure that children are not delayed in becoming familiar with the world of learning. Educational games are applications that can be used to teach and increase users' knowledge through engaging media. The author has designed a mobile-based educational English game for early childhood education students that is both engaging and educational, with the goal of motivating them in their learning activities. [6]

Engaging learning media can make the learning environment more interesting, reduce boredom, and enhance learning outcomes. The development of the learning media, specifically the board game "Labyrinth in the Forest," is aimed at junior high school students and focuses on the topic of numbers, which is the objective of this research. This developmental research uses the ADDIE development model. [7]

This limited use of technology results in students becoming easily bored, and the teacher has not yet fully utilized the potential of technology in the classroom. [8] This research aims to develop an animated game designed to enhance early childhood readiness for learning science. Research Related, the game helps children learn science through a fun, play-based approach that aligns with the characteristics and developmental stages of early childhood. [9] Further enhancements in development can include performance optimization, the addition of new features, and the exploration of game elements that can increase the game's appeal. [10]

The Software Development Life Cycle (SDLC) models provide a structured approach to software engineering, ensuring a systematic path to delivering high-quality products. Among the various SDLC models, the Agile methodology was selected for this project due to its iterative nature, which supports continuous improvement and adaptation, a key requirement for game development. Unlike traditional models, Agile emphasizes flexibility, allowing for frequent updates and enhancements based on user feedback and testing outcomes. This approach aligns with the researcher's plan to release monthly updates to *Story of Life*, ensuring that the game evolves in response to player needs and educational goals. Agile's focus on maintenance and continuous delivery makes it particularly suitable for developing a game that requires ongoing adjustments and improvements, setting it apart from more rigid, sequential models. [11]

The purpose of this research is to educate students and smartphone users, to develop a game that can operate on low-spec Android devices, and to demonstrate that a game or piece of software can be created using low-spec laptops or computers.

II. RESEARCH METHODOLOGY

2.1 Research Stages

A research method in a study is a set of steps that must be followed. The intention is for the author to properly design the research according to the topic. Furthermore, this research is prepared systematically so that it can be easily understood and become a guide to solving problems in the future. In this research, the author used the System Development Life Cycle (SDLC) method depicted in Figure 1. This method was chosen because it has clear and systematic stages in designing and developing software.

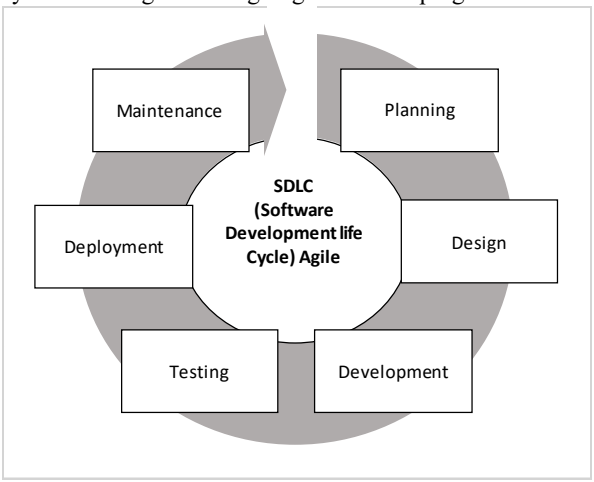

Figure 1. Software Development Life Cycle(SDLC)

1. Planning
   In this phase, the researcher plans the game development and performs the **system analysis** to define game requirements, core features, and functional specifications. This phase also involves analyzing the system architecture, user needs, and game flow. Diagrams such as the use case, class, and sequence diagrams are created to establish how the system should function. Based on this analysis, the development team can clearly understand the objectives and requirements for the next phase.
2. Design
   In this stage, the overall system design is conducted based on architectural planning, user interface design, database design, and module design.
3. Development
   In this stage, the researcher develops the game according to the established design and uses the planned programming languages to implement the software's logic and functions.
4. Testing
   The game is tested by involving several respondents to evaluate the effectiveness of the teaching, the storyline conveyed in the game, and user engagement during gameplay.
5. Deployment
   After the application is considered ready and tested, the

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game will be gradually published, starting from small markets to larger markets.

6. Maintenance
   This involves maintenance, updates, addressing bugs reported by players, adding features if necessary, and responding to feedback.

2.2 Research Supporting Theories

There are several theories that will support this research process that are useful for the basis of research related to existing theories. The theories is as follows:

1. Godot Engine
   Godot Engine is a piece of open-source software that lets people from all experiences levels and walk of life create games. The project was started in 2027 by Juan Linietsky and Ariel Manzur as an in-house engine for several Argentinian game studios. In late 2014, the engine got open-sourced, giving everyone free access to the code. Since then, it has gained lots of traction and is currently one of the most used game engines on the market. [12]
2. Game Engine
   Game Development is complex and involves a wide variety of knowledge and skill. To build a modern game, you need a great deal of underlying technology before you can make the actual game itself. imagine that you had to build your computer and write your own operating system before you could even start programming. Game development would be a lot like that if you truly had to start from scratch and make everything that you need. Godot script syntax is very closely modeled on the python language. If you are familiar with Python already, you will find Godot script very familiar. If you are comfortable with another dynamic language, such as JavaScript, you should find it relatively easy to learn. Python is very often recommended as good beginner language, and Godot script shares that user-friendliness. [13]

III. RESULTS AND DISCUSSION

3.1 Analysis System

The **Analysis System** phase is crucial for laying the foundation of the game *Story of Life*, as it defines the system's requirements, features, and interactions. This phase ensures that the game's development aligns with educational goals and provides an effective, engaging experience for students.

1. Recommendation System

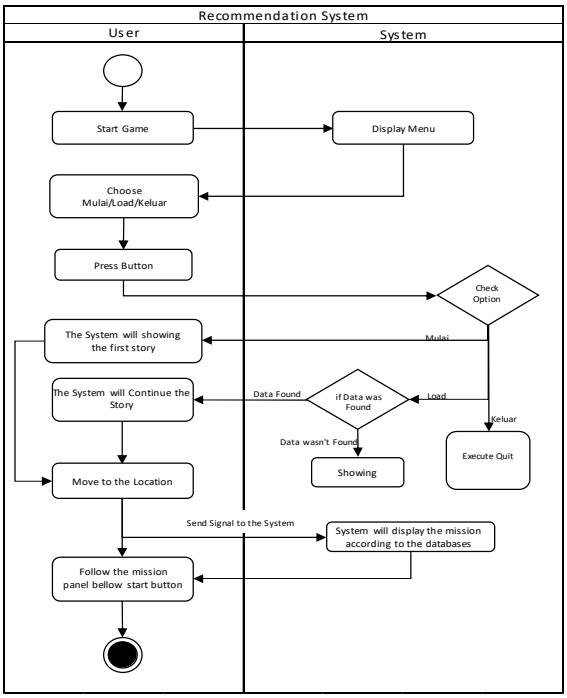

Figure 2. Recomendation System

Below is an explanation of the recommendation system:

1. The user starts the game, and the system will display a menu that the user can select from.
2. When the user selects "Start," the system will immediately transition the user to the opening story scene.
3. When the user selects "Load," the system will check the storage memory on the user's smartphone. If a saved game is found, the user will be directed to continue the story from that save; if not, an alert will appear.
4. Once the character is in a location or map where they can be controlled, the system will automatically receive a signal to provide the user's next objective, which will be displayed on the mission panel.

2. Use Case System

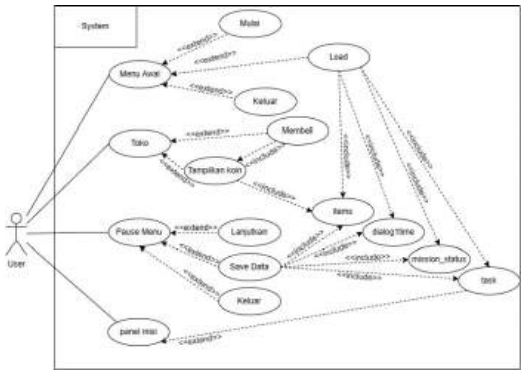

Figure 3. Use Case System

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Use Case Descriptions:

a. Use Case: Enter Menu
   Actor: User
   Description: The user selects either "Start" or "Load." If the user selects "Load" and no saved data is found on the smartphone, an alert will be displayed.
b. Use Case: Shop
   Actor: User
   Description: The user goes to the park and interacts with the kiosk to access or open the shop.
c. Use Case: Save Game
   Actor: User
   Description: The user presses the pause button, and a "Save Game" option appears. If the user selects it, the game will save data such as coins, keys, etc.
d. Use Case: Mission Panel
   Actor: User
   Description: The user is given instructions from the mission panel to continue the predetermined storyline.

3. Class Diagram

Class Diagram class diagram that the author used in this research:

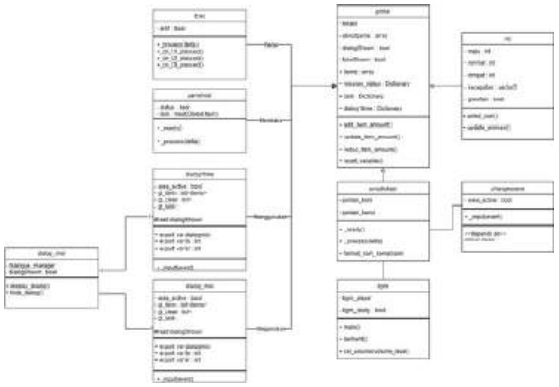

Figure 4. Class Diagram

4. Sequence Diagram
   a. Sequence Diagram First Menu

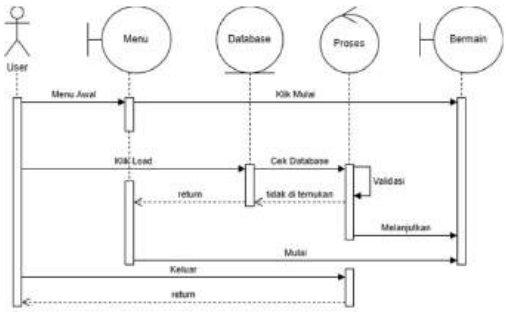

Figure 5. Sequence Diagram First Menu

class diagram that the author used in this research and The sequence diagram above explains the flow of the initial menu when the game is first started. There are three buttons: "Start," "Load," and "Exit." When the "Start" button is pressed, the system will display the opening story. If the "Load" button is pressed, the system will check a database and memory; if a saved game is found, the system will direct the player to continue the storyline. However, if no saved game is found, the system will display an alert. When the "Exit" button is pressed, the system will execute the command to exit the user from the game.

b. Sequence Diagram Pause Menu

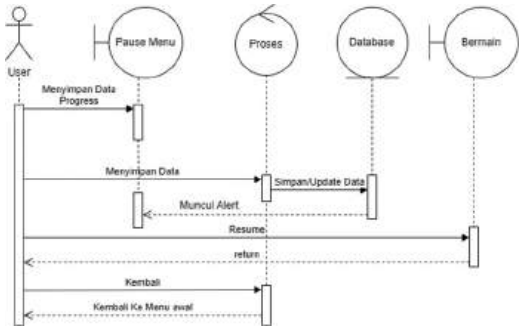

Figure 6. Sequence Diagram Pause Menu

The sequence diagram above explains the flow of the pause menu, which contains three buttons: "Resume," "Save Game," and "Exit." When the "Resume" button is pressed, the system will close the pause menu and continue the game. If the "Save Game" button is pressed, the system will save the game, and if successful, an alert will be displayed. When the "Exit" button is pressed, the system will redirect the user to the main menu.

c. Sequence Diagram Store System

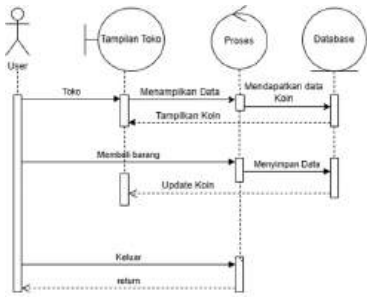

Figure 7. Sequence Diagram Store System

The sequence diagram above explains the flow of the shop system, where the user can open the shop panel at the shop's location. When interacted with, the shop will display several items available for purchase. The shop system works as follows: if an item button is pressed, the system will first check the user's coin balance. If the coins are sufficient, the item will be added, and a "purchase successful" alert will appear. However, if the coins are insufficient, a "not enough coins" alert will be displayed.

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d. Sequence Diagram Mission Panel

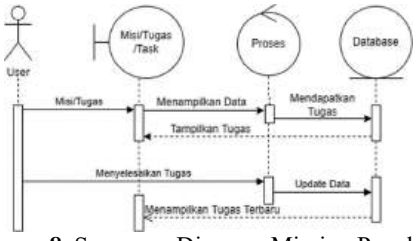

Figure 8. Sequence Diagram Mission Panel

The sequence diagram above illustrates the workflow of the mission panel. When the user completes a mission or enters a location, the system will perform a real-time check of the database and memory. If the user completes a mission listed on the mission panel, the system will assign a new mission.

5. Design User Interface
In this below are the user interface design for this game:
a. First Scene Load the Game
The UI design upon opening the game will display the following elements.

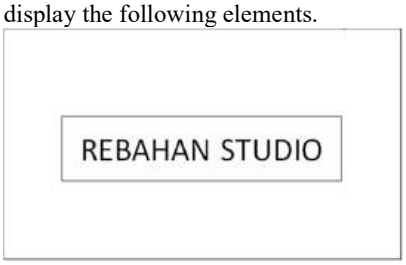

Figure 9. First Scene Load the Game

b. First Menu
The UI design upon entering the menu will display as shown below.

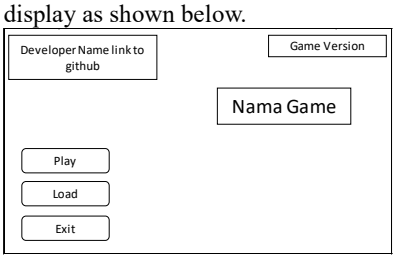

Figure 10. First Menu

c. Opening
When the start button is pressed, an opening story dialog will appear.

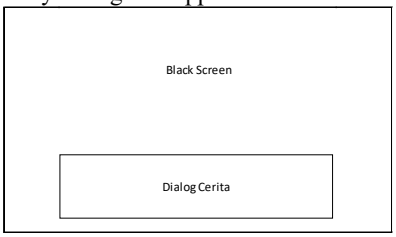

Figure 11. Opening Start Button

d. Paused Menu
The UI design for the pause menu is shown below, featuring three buttons: Continue, Save Game, and Quit.

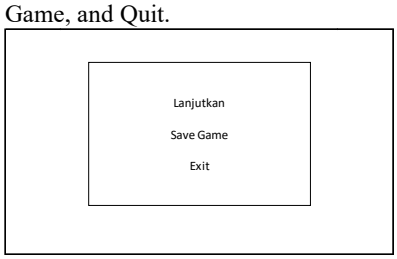

Figure 12. Pause Menu

e. Main Character
The design below shows the text that appears when the main character is in the active item area.

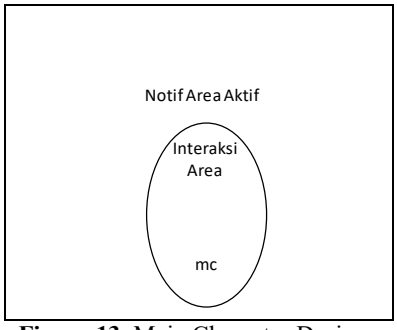

Figure 13. Main Character Design

f. Controller
The in-game controller design for controlling the character is shown below.

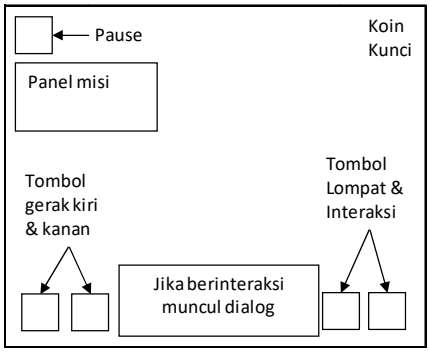

Figure 14. Controller

g. Shop
The shop design that appears upon interaction is shown below.

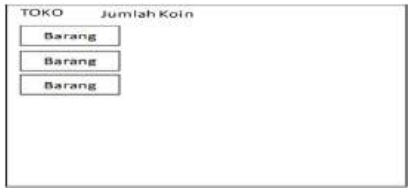

Figure 15. Shop User Interface

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h. Minigames before start
The mini-game design that appears before the start button is pressed is shown below.

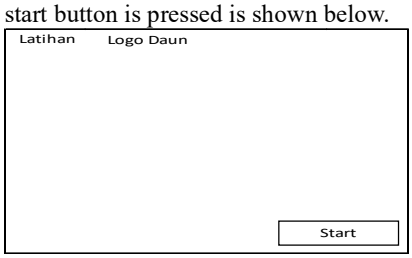

Figure 16. Minigames UI before start

i. Minigames after start
The mini-game design that appears after the start button is pressed will display a question in the center.

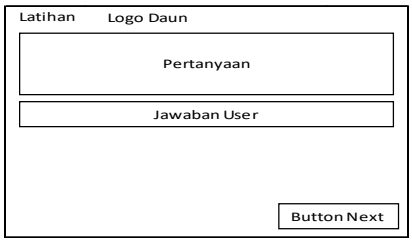

Figure 17. Minigames after start

j. House1-2
The design for the locations house1-2 is shown below.

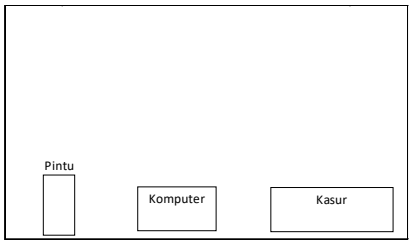

Figure 18. House1-2 Design

k. House1-1
The design for the locations house1-1 is shown below.

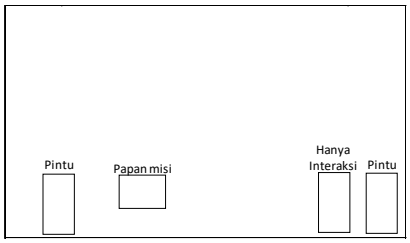

Figure 19. House1-1 Design

l. River
The design for the river location is shown below.

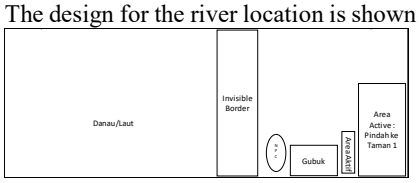

Figure 20. River Design

m. Garden1
The design for the garden1 location is shown below.

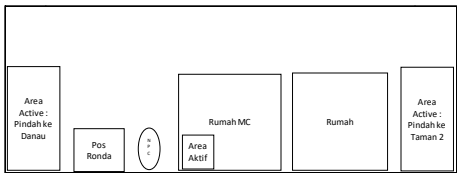

Figure 21. Garden1 Design

n. Garden2
The design for the river location is shown below.

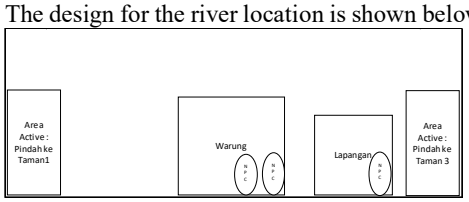

Figure 22. Garden2 Design

o. Garden3
The design for the garden3 location is shown below.

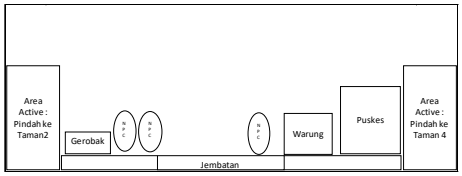

Figure 23. Garden3 Design

p. Garden4
The design for the garden4 location is shown below.

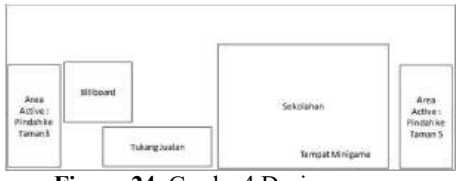

Figure 24. Garden4 Design

3.2 Software and Hardware Requirement

This section outlines the necessary software and hardware specifications required to run the game *Story of Life* effectively. The software requirements include the game engine, operating system, and any additional libraries or tools used for development.

1. Software Requrement
In this below the table of software requirement for this research.

Table 1. Software Requirement Table

NO	Perangkat Lunak	Keterangan
1	Sistem Operasi	Linux Ubuntu 20.04(Focal Fossa)
2	Bahasa Pemrograman	Godot Script
3	Code Editor	Godot Engine
4	Sprites/UI Editor	Pixelorama
5	UML Modelling Tool	Draw.io

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2. Hardware Requirement

In this below the table of hardware requirement for this research.

Table 2. Hardware Requirement Table

NO	Perangkat Keras	Keterangan
1	Device 1	Laptop Lenovo G400 Intel(R) Celeron 1005M, Ram 2GB
2	Device 2	Samsung A10, Rom 32gb,Ram 2gb
3	Device 3	Oppo A37,Rom 16gb,Ram 2gb

3.3 Implementation User Interface

The implementation of the User Interface (UI) focuses on translating the design concepts into a fully functional interface that enhances user interaction within the game. This phase involves coding and integrating various UI elements such as buttons, menus, text boxes, and interactive dialogues, ensuring they respond smoothly to user input. The UI is built to be both user-friendly and visually appealing, prioritizing accessibility and ease of navigation to provide players with a seamless and engaging experience throughout the game.

1. First Scene Load the Game

The initial screen that appears when the game starts will display an introduction, as shown below.

Figure 25. First Scene Load the Game

2. First Menu

To start the game, players can select the "Play" menu. If they want to use previously saved data, they can choose the "Load" menu.

Figure 26. First Menu

3. Opening

After selecting "Play," the game will display the introductory story, revealing the beginning of the game's narrative.

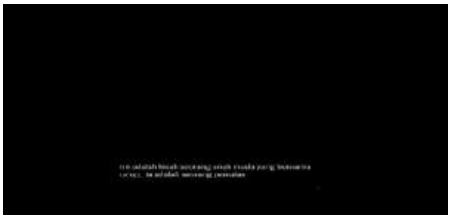

Figure 27. Opening

4. Controller

The interface includes the controller display, mission panel, currency, and pause button, all of which can be used by the player.

Figure 28. Controller

5. Shop

The shop interface features three items available for purchase. However, only one item will be visible until the main mission is completed.

Figure 29. Shop

6. Minigames

The minigame interface, as shown below, includes a science practice section. This section will present 10 questions for the user to answer, and the final score will be displayed once all questions have been answered.

Figure 30. Minigames

7. House1-2

After the introductory story is completed, the user will start from either Location House1-2 or the room.

Figure 31. House1-2

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8. House1-1
The interface for Location House1-1 or the living room is displayed as shown.

Figure 32. House1-1

9. River
The interface for the "Lake Shore" location features one NPC that can be interacted with for conversation.

Figure 33. River

10. Garden1
The interface for "Garden 1: Left Side" features two sections in each outdoor location due to the large size of the area. On the right side, there is a directional indicator that can be interacted with to learn about the location.

Figure 34. Garden1 left side

Figure 35. Garden1 right side

11. Garden2
The interface for "Garden 2: Left Side" includes a shop that can be interacted with. When interacted with, the shop will be displayed. On the right side, additionally, there are two people in the area who can be interacted with.

Figure 36. Garden2 left side

Figure 37. Garden2 right side

12. Garden3
The interface for "Garden 3: Left Side" is displayed as shown. On the right side of "Garden 3," the interface will include an "Uduk Rice Vendor" and a "Health Clinic" that can be interacted with in future versions.

Figure 38. Garden3 left side

Figure 39. Garden3 right side

13. Garden4
The interface for "Garden 4: Left Side" features several NPCs and a billboard. On "Garden 4—Right Side," the interface includes three interactive elements that allow users to start minigames or practice activities.

Figure 40. Garden4 left side

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Figure 41. Garden4 right side

3.4 Implementation System

At this stage, researchers will carry out three testing processes: blackbox testing, whitebox testing, and beta testing.

1. Blackbox Testing

   Blackbox testing is defined as a testing technique in which functionality of the Application Under Test(AUT) is tested without looking at the internal code, structure, implementation details and knowledge of internal path of the software. [14] In this research, the researcher conducted tests on the appearance and functionality of each scene.

   a. First Menu

   Table 3. Blackbox Test on the menu

Correct Test Data Case			
Input	**Expectation**	**Observation**	**Result**
Pressing the Start Button	System redirects the user to the initial story	Displays the initial story	Success
Pressing the Load Button	System checks memory to find saved data	Enters the game, continues the story, and retrieves inventory data	Success
Pressing the Exit Button	System immediately executes syntax to exit the game	User exits the game	Succes
Incorrect Test Data Case			
Input	**Expectation**	**Observation**	**Result**
Pressing the Load Button	System checks memory to find saved data	Displays alert "Failed to load data, data not found."	Success

   b. Controller

   Table 4. Blackbox Test on the controller

Input	Expectation	Observation	Result
Pressing the Pause Button	System displays the Pause Menu	Pause Menu appears	Success
Pressing the Jump Button, Moving Left or Right	System immediately executes syntax to move the character	Character moves according to the pressed button	Success
Pressing the Interaction Button	System immediately executes syntax for interaction	Dialog appears, viewing store, performing exercises	Success

   c. Panel Mission

   Table 5. Blackbox Test on the panelmission

Pressing the direction { on the mission panel	System immediately executes syntax to close the mission panel and display the button to open the mission panel	Mission panel is closed, and the button } to open the mission panel appears	Success
Pressing the button } on the mission panel	System immediately executes syntax to close the mission panel	Mission panel opens and the button to close the mission panel appears	Success

   d. Shop

   Table 6. Blackbox Test on the store

Correct Test Data Case			
Input	**Expectation**	**Observation**	**Result**
Pressing the Button labeled "salt" with 5000 coins	System checks the character's inventory; if coins are > 2999, it deducts 3000 coins and adds salt to the inventory	Coins are deducted, and salt is added to the inventory	Success
Completing the mission of giving salt to the mother	System checks the save data; if mission 1.2 is TRUE, the store displays new items besides salt	New items appear, namely a book and a pencil	Succe
Incorrect Test Data Case			
Input	**Expectation**	**Observation**	**Result**
Pressing the Button labeled "salt" with 0 coins	System checks the character's inventory; if coins are < 2999, it displays the alert "Not enough coins"	Alert appears: "Not enough coins"	Success

2. Whitebox Testing

   Whitebox testing is a way of testing the external functionality of the code by examining and testing the program code that realizes the external functionality. [15] In this research, the researcher tested the shop functionality with Godot Unit Test(GUI) to ensure that purchased items are properly detected and that the coin count decreases accordingly.

Figure 42. Result Whitebox

3. Beta Testing

   A questionnaire is an objective testing method where the system is directly tested and the application can be downloaded. By creating a questionnaire about the usefulness of the developed system, the goal is to determine whether the application meets user expectations. Testing is conducted by distributing the questionnaire to 15 individuals. The questionnaire consists of 8 questions with responses rated on a scale from 1 to 5.

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NO	Pertanyaan	Nilai				
		1	2	3	4	5
1	Is the appearance of the "Story of Life" application/game attractive?	0	0	0	10	5
2	Is the storyline in the "Story of Life" application/game interesting?	0	0	2	5	8
3	Does the system of this application/game work well?	0	0	2	9	4
4	Is the navigation within this application/game easy to understand?	0	0	2	7	6
5	Are the controls of this application/game easy to use?	0	0	1	8	6
6	Are the designs of each character in this application/game attractive?	0	0	5	6	4
7	In the "Garden 4" location in the game, there is a mini-game containing several questions about Science, Mathematics, and English. Does the mini-game in this game enhance knowledge?	1	0	1	6	7
8	Is this game worth playing?	0	0	0	7	8
TOTAL		1	0	13	58	48

Figure 43. Beta Testing

IV. CONCLUSION

Based on the research and testing conducted as follows, the "Story of Life" game serves as an educational solution for parents and students who are less interested in traditional learning. "Story of Life" holds significant potential as an effective educational and entertainment tool. By continuously improving and developing the application based on feedback from beta testing, it can become a popular and beneficial learning resource for children and students in Indonesia. The choice of the Android platform for this game's development is highly appropriate, given the large number of Android users in Indonesia. Additionally, the game is designed to be lightweight, ensuring it runs smoothly on low-spec Android devices, thereby increasing accessibility for users from various backgrounds.

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Decision Tree for Determining Hospital Treatment for Covid-19 Patients Based on Hematology Parameters Using the C5.0 Algorithm

Joko Riyono[1], Christina Eni Pujiastuti[2], Supriyadi[3], Dody Prayitno[4], Aina Latifa Riyana Putri[5]
[1,2,3,4]Teknik Mesin, Fakultas Teknologi Industri, Universitas Trisakti
[5]Sains Data, Fakultas Informatika, Telkom University
Email: jokoriyono@trisakti.ac.id[1],christina.eni@trisakti.ac.id[2], supri@trisakti.ac.id[3], dodyprayitno@trisakti.ac.id[4], ainaqp@telkomuniversity.ac.id[5]

Abstract – The rapid spread of the COVID-19 disease, which occurred globally from late 2019 to the early 2020s, significantly impacted communities worldwide, requires early detection of COVID-19 which is very important for patients and also the people around them to be able to fight the COVID-19 pandemic. Therefore, a classification analysis will be carried out to make decisions regarding determining COVID-19 patients who do not require hospitalization or who require Regular Ward, Semi-Intensive Care Unit, or Intensive Care Unit (ICU) in hospitals based on hematology parameters from the Machine Learning Repository. Kaggle Dataset uses the C5.0 algorithm assisted by Rstudio software. It is also known that because the data contains missing data, it is also necessary to handle missing data using the Mean Method assisted by SPSS software. Performance evaluated using the Confusion Matrix method produces an accuracy value of 78% which is considered quite good, where testing with the C5.0 Algorithm uses a training and testing data ratio of 40:60. This research simplifies and speeds up medical decision-making, improving patient management. With COVID-19 declining, the method can be applied to enhance healthcare systems' accuracy and efficiency in handling other diseases or emergencies, ensuring better preparedness for future challenges.

Keywords – Early Detection, Classification, Missing Data, Confusion Matrix

I. INTRODUCTION

Coronavirus is part of a group of viruses that generally infect animals but can adapt and eventually transmit to humans. In humans, this virus typically attacks the respiratory system, ranging from mild symptoms like the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS), which emerged in 2012, and Severe Acute Respiratory Syndrome (SARS) in 2002. The latest type of coronavirus was discovered in humans in Wuhan, China, in December 2019. This virus is named Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and causes the disease COVID-19. Due to its rapid global spread, the World Health Organization (WHO) declared this disease a pandemic on March 11, 2020.Clinical symptoms of COVID-19 infection can vary from asymptomatic (no symptoms) to fever, cough, runny nose, fatigue, sore throat, and severe conditions (e.g., acute respiratory distress syndrome [ARDS], acute heart injury, and kidney injury) [1]. As of April 19, 2022, the number of COVID-19 cases globally reached 504,571,336. Preventive measures have also been implemented by governments and WHO to help reduce COVID-19 cases, such as requiring activities to be accompanied by strict health protocols as part of daily life, travel restrictions between countries and cities, requiring vaccination, and RT-PCR (Real Time PCR COVID-19) tests as tools to detect the presence of the COVID-19 virus in the body. Furthermore, healthcare systems have been established to detect, test, isolate, treat each case, and track every contact. Preventive measures play a major role in reducing COVID-19 cases when protocol therapy is applied from the early stages [2]. Therefore, early detection of COVID-19 is crucial for patients and those around them to help prevent a resurgence of the pandemic. When patients receive timely and appropriate care, those around them are also protected.

COVID-19 is a systemic infection that significantly impacts the hematopoietic and hemostasis systems, leading to several cardiovascular complications [1], [3], [4]. Research indicates [1] that hematological indices are associated with disease severity and can contribute to decision-making for predicting whether a COVID-19 patient will require ICU admission upon hospital entry. Several hematological abnormalities have also been identified, with significant changes in hematological parameters observed in patients with severe COVID-19 requiring hospitalization and ICU care [5]. The hematological consequences of COVID-19 infection must be utilized by researchers and medical personnel to initiate new treatment approaches or breakthroughs in managing COVID-19 infection.

Therefore, a classification analysis will be conducted to make decisions regarding which COVID-19 patients do not require hospitalization or need care in a Regular Ward, Semi-Intensive Care Unit, or Intensive Care Unit (ICU) in the hospital, using a Kaggle Dataset and based on hematological parameters and the C5.0 algorithm. Since the dataset contains missing data, a method to handle missing data using the Mean Method will also be applied. The goal is to facilitate and accelerate the work of medical

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personnel, ensuring that COVID-19 patients receive timely and appropriate treatment, ultimately reducing COVID-19 cases in a population.

A. C5.0 Algorithm

The C5.0 algorithm is a data mining method that operates using a decision tree structure. This algorithm is a further development of the ID3 and C4.5 algorithms, with improved efficiency and better capability in categorizing data into appropriate groups. C5.0 is known for its superior performance in solving classification problems [6]. This algorithm has already been applied in various ways [7], such as to analyze the perceived stress levels of healthcare workers treating COVID-19 patients during the early stages of the pandemic in northeastern Mexico. The aim was to understand and categorize their stress levels, producing a visualization model to help identify stress risks and potential mental health issues; [8] as a decision-making tool and comparing performance in breast cancer diagnosis using C5.0 Algorithm and Boosting method.

The Mean method is the most common imputation technique, where missing data in a variable is replaced with the average value of all available data for that variable [9].

A decision tree is a structure resembling a flow diagram shaped like a tree, where each internal node represents a test on an attribute, each branch indicates the test result, and each leaf node represents a class or class distribution that is the final outcome of the test. The C5.0 algorithm is an enhancement of earlier decision tree algorithms developed by Ross Quinlan in 1987, specifically ID3 and C4.5. ID3 evolved into C4.5, which can handle both discrete and continuous attributes. C4.5 was further developed into C5.0 to address certain weaknesses, such as overlapping when handling large amounts of data, which increases decision-making time. C5.0 offers higher accuracy, faster decision-making, and more efficient memory usage compared to its predecessors.

The tree-building process in the C5.0 algorithm is similar to that of the C4.5 algorithm. However, while the C4.5 algorithm stops after calculating information gain, the C5.0 algorithm continues by calculating the gain ratio using the obtained information gain and entropy. Therefore, the calculations in the C5.0 algorithm involve several attributes, including entropy, information gain, and gain ratio. The C5.0 algorithm can select attributes based on the highest gain ratio.

The equation for calculating entropy is:

$$Entropy(S)=\sum_{j=1}^{k} -p_j \log_2(p_j) \quad (1)$$

Where:

S= Set of cases

k = Number of partitions of S

p_j = Propotions of S_j to S

Next, to obtain the Information Gain calculation, the following equation is used:

$$\text{Information Gain(S, A)} = \text{Entropy(S)} - \sum_{i=1}^{m} \frac{|S_i|}{|S|} \times Entropy(S_i) \quad (2)$$

Where:

S = Set of cases

A = Attribute

m = Number of categories in variable A

|Si| = Number of cases in partition i

|S| = Number of cases in S

Finally, to determine an attribute as a node in the C5.0 algorithm, the Gain Ratio is calculated using the formula:

$$Gain\ ratio = \frac{Information\ Gain\ (S,A)}{\sum_{i=1}^{m} Entropy(S_i)} \quad (3)$$

Where:

Gain(S,A) = Gain value of a variable

Si = Entropy value in a variable

The Gain Ratio calculation simplifies the decision tree produced by C5.0 compared to the C4.5 algorithm. The tree is built continuously until no further sample subsets can be split.

B. Mean Method for Handling Missing Data

Missing data is a frequent issue in most research studies, typically arising from non-sampling errors. These errors can include:

Interviewer recording errors, where questions may be skipped during data collection.

Respondent inability errors, where participants fail to provide accurate responses due to misunderstanding the question, experiencing fatigue, or losing interest.

Respondent unwillingness errors, where individuals choose not to answer sensitive questions related to topics such as income, age, weight, or legal history, leading to incomplete responses or abandonment of the survey.

One of the most straightforward and commonly used approaches to address missing data is the Mean imputation method. This technique involves replacing missing values in a dataset with the average of the available values. However, this method is only suitable for numerical data.

The formula used to calculate the mean for imputing missing data is as follows:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \quad (4)$$

Where:

$\bar{x}$ = Mean (average value)

n = Total number of data points

x_i = Individual data points

By applying this formula, missing data points are replaced with the calculated mean of the existing values.

C. The Confusion Matrix

The Confusion Matrix is a useful tool for assessing the accuracy of a classification model by comparing predicted values with actual outcomes. It is applicable to both binary and multi-class classification problems and consists of four key values:

True Positive (TP): The number of cases that are correctly predicted as positive.

True Negative (TN): The number of cases that are correctly predicted as negative.

False Positive (FP): The number of cases incorrectly predicted as positive when they are actually negative.

False Negative (FN): The number of cases incorrectly predicted as negative when they are actually positive.

These values allow for the calculation of Accuracy, which measures how well the model's predictions match the actual values.

The formula for Accuracy is:

$$Accuracy = \frac{(TP+TN)}{(TP+FP+FN+TN)} \quad (5)$$

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II. RESEARCH METHODOLOGY

In this study, the data to be used is secondary data from the Kaggle Dataset, "Diagnosis of COVID-19 and its clinical spectrum", https://www.kaggle.com/datasets/einsteindata4u/covid19 [10], created by Hospital Israelita Albert Einstein in São Paulo, Brazil. This dataset contains anonymous data from 5,644 patients at Hospital Israelita Albert Einstein in São Paulo, Brazil, including information such as patient ID, patient age, and other details. Additionally, samples collected from each patient who underwent RT-PCR testing for SARS-CoV-2 (both positive and negative for COVID-19), supplementary laboratory tests during hospital visits (such as hematocrit, hemoglobin, urine-urobilinogen, etc.), as well as the patients' COVID-19 care outcomes, are included. The latter includes whether the patient required care in the Regular Ward, Semi-Intensive Unit, Intensive Care Unit (ICU), or did not require hospitalization at all.

The Regular Ward is a hospital room with more than two beds, intended for patients who no longer require close monitoring and have a low level of dependency, where patients typically begin mobilizing in preparation for discharge.

The Semi-Intensive Unit is designated for patients who still require close monitoring but at a lower level than in the ICU.

The Intensive Care Unit (ICU) is designed for patients who require intensive monitoring and medical support.

In this study, classification analysis will be conducted to determine whether COVID-19 patients do not require hospitalization or if they need care in the Regular Ward, Semi-Intensive Care Unit, or Intensive Care Unit (ICU) based on hematological parameters using the C5.0 algorithm with a focus on accuracy. Since the dataset contains missing data**,** the Mean Method will be applied to handle the missing values. Therefore, several relevant variables that have a correlation with the study's objectives will be selected from the entire dataset.

The variables used in this study are as follows:

Table 1. Variable Identification

No.	Variable	Type
1	Hematocrit	Numerical
2	Hemoglobin	Numerical
3	Platelets	Numerical
4	Mean Platelet Volume (MPV)	Numerical
5	*Red Blood Cells*	Numerical
6	Lymphocytes	Numerical
7	Mean Corpuscular Hemoglobin Concentration (MCHC)	Numerical
8	Leukocytes	Numerical
9	Basophils	Numerical
10	Mean Corpuscular Hemoglobin (MCH)	Numerical
11	Eosinophils	Numerical
12	Mean Corpuscular Volume (MCV)	Numerical
13	Monocytes	Numerical
14	Red Blood Cell Distribution Width (RDW)	Numerical

In Table 1, the selection of variables is based on several previous studies. For example, in [11], hematocrit can significantly predict the risk of ICU admission in COVID-19 patients in Iran using multivariable analysis. Study [12] discusses red blood cells less frequently in the pathogenesis of COVID-19, but some studies have considered hemoglobin levels, which are also a major constituent of red blood cells. [13] shows that a decrease in hemoglobin levels in COVID-19 patients is associated with the severity of the disease. There is also a relationship between platelet levels in hospitalized patients and high severity of COVID-19 [14]. The MPV value was found to increase by 6.3% in COVID-19 patients with high severity [15]. Study [16] supports the hypothesis that lymphopenia (a condition when lymphocyte levels are low) can be a prognostic factor in determining the clinical course and severity of the disease in patients hospitalized due to COVID-19. High MCV or low MCHC was found in COVID-19 patients with high or critical severity [17]. Leukopenia (a condition when leukocyte levels are low) has also been reported in several studies, ranging from 28.1% to 68.1%, depending on the severity of the disease and underlying conditions, indicating a possible relationship between the severity of leukopenia and the severity of COVID-19 [12]. Severe COVID-19 cases are typically characterized by low lymphocyte counts, high leukocyte counts, increased neutrophil-lymphocyte ratio (NLR), as well as decreased percentages of monocytes, eosinophils, and basophils [18]. Study [19] found that RDW (Red Cell Distribution Width) could serve as an indicator for predicting the prognosis of COVID-19 patients experiencing severe conditions. A total of 96.4% and 90% of all COVID-19 patients showed low MCH and hemoglobin levels [20].

The stages of data analysis in this study are as illustrated in the following flowchart:

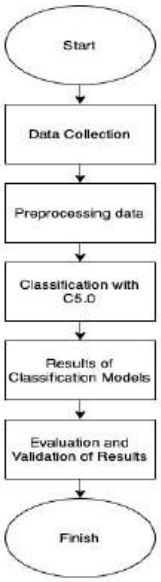

Figure 1. Data Analysis Method Flowchart

As shown in Figure 1, this study begins with the following stages:

Data Collection

This stage describes how and from where the data for this research is obtained. The data will be saved in files with a

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.xlsx extension.

Data Preprocessing

The initial data processing will include Data Selection, which involves selecting data from a larger dataset. The selected data will be used for data mining processes, specifically classification. After that, corrections will be made for errors in the data; in this study, missing values will first be filled using the Mean Method with the assistance of SPSS software. Furthermore, before classification, the data will also be divided into Training and Testing datasets.

Classification with C5.0

This stage involves classifying the data that has been processed in the Data Preprocessing stage using the C5.0 Algorithm with RStudio software.

Classification Results

The classification results will take the form of a decision tree to determine whether COVID-19 patients require hospitalization or need to be placed in a Regular Ward, Semi-Intensive Care Unit, or Intensive Care Unit (ICU) in the hospital based on hematological parameters.

Evaluation and Validation of Results

In this stage, the classification results will be evaluated using Confusion Matrix measurements

III. RESULTS AND DISCUSSION

The data mentioned in the Research Method section will undergo Data Selection by choosing several attributes that are relevant to this study. Therefore, from 5.644 patients, 83 COVID-19 positive patients who underwent blood tests upon hospital admission were selected. It is also known which ward these patients were placed in at the hospital. Below is the data used in this study.

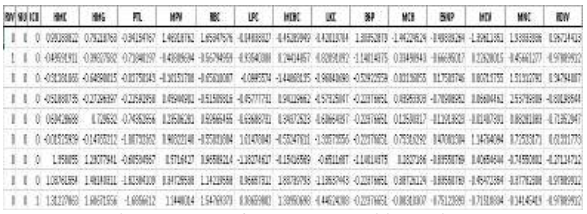

Figure 2. Data of COVID-19 Positive Patients

The description for Figure 2 can be found in Table 2. The next step is to convert the attributes into a format that can be processed by the program.

Table 2. Description of Figure 2

Notation	Description
RW	Regular Ward (1=yes, 0=no)
SIU	Semi-Intensive Unit (1=yes, 0=no)
ICU	Intensive Care Unit (1=yes, 0=no)
HMC	Hematocrit
HMG	Hemoglobin
PTL	Platelets
MPV	Mean Platelet Volume (MPV)
RBC	Red Blood Cells
LPC	Lymphocytes
MCHC	Mean Corpuscular Hemoglobin Concentration (MCHC)
LKC	Leukocytes
BSP	Basophils
MCH	Mean Corpuscular Hemoglobin (MCH)
ESNP	Eosinophils
MCV	Mean Corpuscular Volume (MCV)
MNC	Monocytes
RDW	Red Blood Cell Distribution Width (RDW)

The attributes RW, SIU, and ICU had their values converted from discrete to numeric (label) format in the program, resulting in numeric labels as shown in Table 3.

Table 3. Programming Label Results

Label	Description	Numeric
Care	No hospital care	0
	Patient admitted to Regular Ward	1
	Patient admitted to Semi-Intensive Unit	2
	Patient admitted to Intensive Care Unit	3

Figure 3 below shows that after converting the discrete attribute values into labels with numeric values, the data appears simpler and easier to process by machine learning algorithms. The next step is to search for missing values.

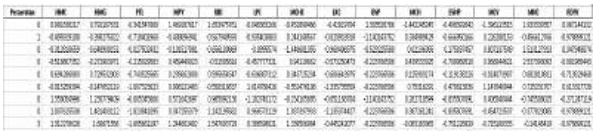

Figure 3. Latest Data of COVID-19 Positive Patients

It can be seen that several data entries have missing values, specifically in the MPV variable for patients 52 and 70, as shown in Figure 4. To address this issue, missing value imputation will be performed, considering that missing value imputation is a treatment for outliers in an effort to improve data quality [22. BPS, 2017].

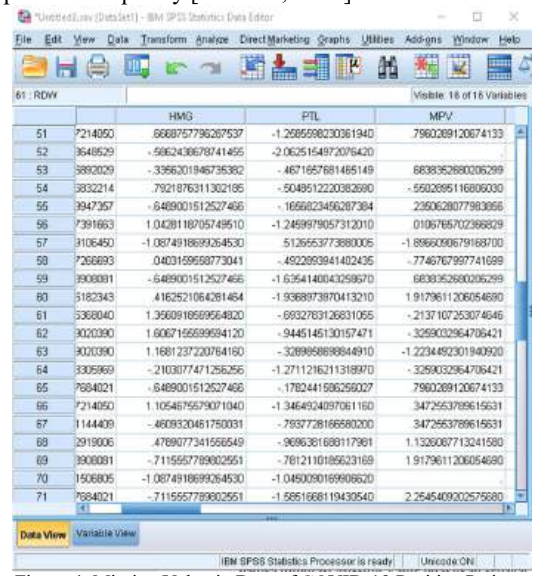

Figure 4. Missing Value in Data of COVID-19 Positive Patients

From the process carried out, the results are shown in Figure 5. In the figure below, it can be seen that the MPV variable has two missing values, with a valid count of 81, along with the Mean, Standard Deviation, Range, Minimum Value, Maximum Value, and Sum of the MPV variable.

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Statistics

MPV

N	Valid	81
	Missing	2
Mean		.2752305728
Std. Deviation		.8972492394
Range		4.599922419
Minimum		-1.89660907
Maximum		2.703313351
Sum		22.29367640

Figure 5. Output of Step 2: Missing Value Imputation

Figure 6 explains that the new variable "MPV_1" will perform imputation on the 2 missing values from 83 data entries using the function "SMEAN(MPV)."

Result Variables

	Result Variable	N of Replaced Missing Values	Case Number of Non-Missing Values		N of Valid Cases	Creating Function
			First	Last		
1	MPV_1	2	1	83	83	SMEAN(MPV)

Figure 6. Output of Step 4: Missing Value Imputation

As shown in Figure 7, the MPV values for patients 52 and 70 have been filled or replaced with the value 0.2752306, which is the mean of the MPV variable inserted into the cells containing the missing values.

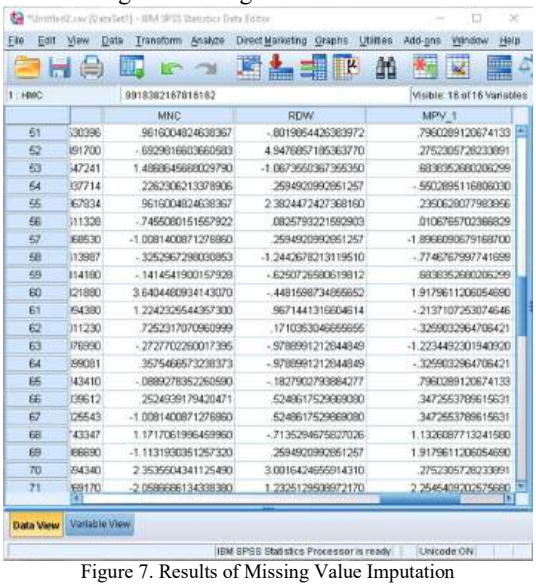

Figure 7. Results of Missing Value Imputation

Before the classification process begins, the data is typically divided into two parts: the training set and the testing set, according to a specific proportion. This separation uses the Train-Test Split method, which serves to evaluate the performance of the machine learning model. The training data is used to build and train the model, while the testing data is used to measure how well the model can predict data it has never seen before. This is important to ensure that the model has good generalization and can perform well on new data. Therefore, the training and testing data will be divided using RStudio software with the following steps:

• The data that has previously had missing values replaced will be imported in .xlsx file format using the "readxl" library, which has been downloaded beforehand, along with specifying the file name and the folder where the file is stored.

```
## tibble [83 x 15] (S3: tbl_df/tbl/data.frame)
##  $ Perawatan: num [1:83] 0 1 0 0 0 0 0 0 3 0 ...
##  $ HNC      : num [1:83] 0.992 -0.496 -0.313 -0.519 0.694 ...
##  $ HNG      : num [1:83] 0.792 -0.398 -0.649 -0.273 0.73 ...
##  $ PTL      : num [1:83] -0.3415 -0.7184 -0.0275 -0.2159 -0.7435 ...
##  $ MPV      : num [1:83] 1.469 -0.438 -0.102 0.459 0.235 ...
##  $ RBC      : num [1:83] 1.653 -0.568 -0.656 -0.515 0.596 ...
##  $ LPC      : num [1:83] -0.0484 -0.9354 -0.0996 -0.4578 -0.6369 ...
##  $ MCHC     : num [1:83] -0.453 0.244 -1.449 0.941 0.344 ...
##  $ LKC      : num [1:83] -0.42 -0.821 -0.968 -0.573 -0.607 ...
##  $ BSP      : num [1:83] 1.304 -1.14 -0.529 -0.224 -0.224 ...
##  $ MCH      : num [1:83] -1.4422 0.335 0.0214 0.4395 0.1259 ...
##  $ ESNP     : num [1:83] -0.498 -0.667 0.176 -0.709 -0.119 ...
##  $ MCV      : num [1:83] -1.3961 0.2263 0.8071 0.066 -0.0141 ...
##  $ MNC      : num [1:83] 1.933 -0.457 1.513 2.537 0.883 ...
##  $ RDW      : num [1:83] 0.967 -0.979 0.348 -0.802 -0.714 ...
```

Figure 8. Data Structure

In Figure 8, it can be seen that this dataset consists of 83 entries with 15 variables. Based on the data structure results above, some variable types need to be adjusted according to their characteristics, as described in the previous section. Specifically, the "Care" variable is converted from numeric to factor type with levels "No hospital care," "Patient admitted to Regular Ward," "Patient admitted to Semi-Intensive Unit," and "Patient admitted to Intensive Care Unit" using the following syntax. After changing the "Care" variable to factor data type, Figure 9 shows the structure of the dataset after adjustments have been made to the data structure.

```
## tibble [83 x 15] (S3: tbl_df/tbl/data.frame)
##  $ Perawatan: Factor w/ 4 levels "0","1","2","3": 1 2 1 1 1 1 1 1 4 1
...
##  $ HNC      : num [1:83] 0.992 -0.496 -0.313 -0.519 0.694 ...
##  $ HNG      : num [1:83] 0.792 -0.398 -0.649 -0.273 0.73 ...
##  $ PTL      : num [1:83] -0.3415 -0.7184 -0.0275 -0.2159 -0.7435 ...
##  $ MPV      : num [1:83] 1.469 -0.438 -0.102 0.459 0.235 ...
##  $ RBC      : num [1:83] 1.653 -0.568 -0.656 -0.515 0.596 ...
##  $ LPC      : num [1:83] -0.0484 -0.9354 -0.0996 -0.4578 -0.6369 ...
##  $ MCHC     : num [1:83] -0.453 0.244 -1.449 0.941 0.344 ...
##  $ LKC      : num [1:83] -0.42 -0.821 -0.968 -0.573 -0.607 ...
##  $ BSP      : num [1:83] 1.304 -1.14 -0.529 -0.224 -0.224 ...
##  $ MCH      : num [1:83] -1.4422 0.335 0.0214 0.4395 0.1259 ...
##  $ ESNP     : num [1:83] -0.498 -0.667 0.176 -0.709 -0.119 ...
##  $ MCV      : num [1:83] -1.3961 0.2263 0.8071 0.066 -0.0141 ...
##  $ MNC      : num [1:83] 1.933 -0.457 1.513 2.537 0.883 ...
##  $ RDW      : num [1:83] 0.967 -0.979 0.348 -0.802 -0.714 ...
```

Figure 9. Data Conversion Structure

To perform the splitting of Training Data and Testing Data from the 83 observation data, this study will allocate 40% as Training Data and 60% as Testing Data randomly. Below is the command to select 33 rows to be stored in the Training Data, with the remaining rows stored in the Testing Data.

```
#Training and Testing Set Preparation (40:60)
ic = HC[,-1]
set.seed(1234)
indeks_training_set = sample(83, 33)
input_training_set = ic[indeks_training_set,]
class_training_set = HC[indeks_training_set,]$Perawatan
input_testing_set = ic[-indeks_training_set,]
```

Figure 10. Data Splitting Syntax

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After splitting the data into training and testing sets, the classification process will be carried out using all variables with R software.
The first step is to prepare the packages that will be used during the classification process by installing R packages such as tidyrules, tidyverse, C50, pander, dplyr, and reshape2 using the function "install.packages( )." Once the installation process is complete, load the packages into the R session using the function "library( )" as shown in the figure below.

```
#Package Preparation
library(tidyrules)
library(tidyverse)

## -- Attaching packages --------------------------------------- tidyverse
1.3.1 --

## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.1     v dplyr   1.0.6
## v tidyr   1.1.3     v stringr 1.4.0
## v readr   1.4.0     v forcats 0.5.1

## -- Conflicts ------------------------------------------ tidyverse_confli
cts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()

library(C50)
library(pander)
library(dplyr)
library(reshape2)

##
## Attaching package: 'reshape2'

## The following object is masked from 'package:tidyr':
##
##     smiths
```

Figure 11. Loading Packages in R

And the packages are ready to use.
In Figure 12, "Number of samples" depicts the amount of data used, specifically the Training Data consisting of 33 entries. Meanwhile, "Number of predictors" refers to the number of attributes used, which includes 14 variables with "Care" as the Class in this classification. Using the C5.0 Algorithm, a decision tree with 6 branches will be generated.

```
##
## Call:
## C5.0.default(x = input_training_set, y = class_training_set)
##
## Classification Tree
## Number of samples: 33
## Number of predictors: 14
##
## Tree size: 6
##
## Non-standard options: attempt to group attributes
```

Figure 12. Number of Samples

```
##
## Call:
## C5.0.default(x = input_training_set, y = class_training_set)
##
## C5.0 [Release 2.07 GPL Edition]      Tue Jun 21 18:26:07 2022
## -------------------------------
##
## Class specified by attribute `outcome'
##
## Read 33 cases (15 attributes) from undefined.data
##
## Decision tree:
##
## ESNP > -0.4562533: 0 (10/2)
## ESNP <= -0.4562533:
## :...MCHC <= -0.353319: 1 (9/1)
##     MCHC > -0.353319:
##     :...LPC <= -0.6268073:
##         :...LPC <= -1.071899: 3 (3/1)
##         :   LPC > -1.071899: 2 (2)
##         LPC > -0.6268073:
##         :...LKC <= -0.960407: 0 (2)
##             LKC > -0.960407: 1 (9/2)
##
##
## Evaluation on training data (33 cases):
##
##      Decision Tree
##    ----------------
##    Size      Errors
##
##       6    0(18.2%)   <<
##
##
##     (a)   (b)   (c)   (d)    <-classified as
##    ----  ----  ----  ----
##      10     2                 (a): class 0
##       1    12                 (b): class 1
##       1          3            (c): class 2
##                  1     2      (d): class 3
##
##
## Attribute usage:
##
## 100.00% ESNP
##  60.70% MCHC
##  42.42% LPC
##  30.30% LKC
```

Figure 13. Output of C5.0 Algorithm Classification

The decision tree obtained from the C5.0 Algorithm is used for determining whether COVID-19 patients require hospitalization or if they should be placed in a Regular Ward, Semi-Intensive Care Unit, or Intensive Care Unit (ICU) in the hospital based on hematological parameters, as shown in the "Decision Tree" section below.

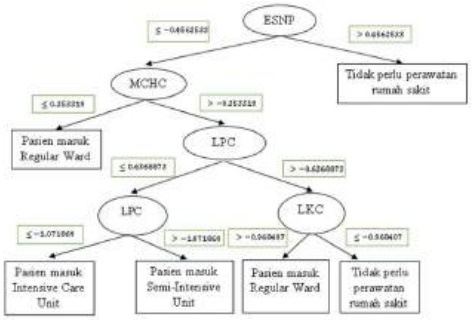

Figure 14. Decision Tree of C5.0 Algorithm Classification

In Figure 14, the decision tree of the C5.0 Algorithm can be interpreted as follows: for example, if a patient undergoes a blood test in the hospital and the ESNP result is > 0.4562533, then the patient can be predicted not to require hospitalization. If both ESNP and MHC values are considered, the patient can be predicted to be admitted to the Regular Ward, and so on. Figure 15 shows a plot of the decision tree from the C5.0 Algorithm.

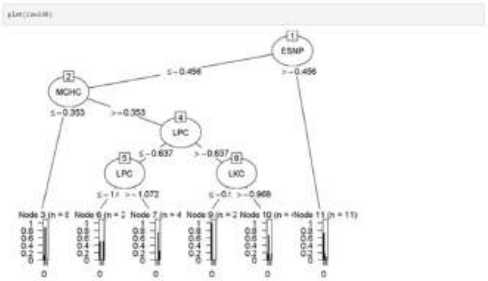

Figure 15. Plot of C5.0 Algorithm Decision Tree

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In Figure 13, the "Evaluation on training data" shows an error rate of 18.2% in the classification using the C5.0 Algorithm with the Training Data. Regarding "Attribute usage," it can be observed that there are 4 attributes considered influential in forming the decision tree of the C5.0 Algorithm in this study, with the ESNP attribute being the root or the most important attribute, accounting for 100% usage and so on. Thus, as you move down the tree, the usage of attributes decreases.

After using the Training Data for modeling, the next step is to perform predictions using the C5.0 Algorithm on the Testing Data.

```
##   hasil_prediksi  0  1 2 3
## 1              0 16  2 2 1
## 2              1  8 10 2 0
## 3              2  1  2 0 1
## 4              3  2  0 0 3
```

Figure 16. Output of Syntax 4 for C5.0 Algorithm Predictions

In Figure 16, the confusion matrix from the obtained model is shown. For the 0 category (Patients who do not require hospitalization), there were 0 correct predictions (Patients who do not require hospitalization) based on the previously described hematological parameters, totaling 16 cases. For the 0 category (Patients who do not require hospitalization) predicted as 1 (Patients admitted to the Regular Ward), there were 2 cases, and so on.

To measure the performance of the classification model, the Accuracy will be calculated. Using the formula in equation (5), an Accuracy of 0.78 is obtained. This means that 78% of the patients were correctly predicted as not needing hospitalization or requiring admission to the Regular Ward, Semi-Intensive Care Unit, or Intensive Care Unit (ICU). Therefore, the classification using the C5.0 Algorithm is considered quite good.

IV. CONCLUSION

In this study, a classification analysis was conducted to determine whether COVID-19 patients require hospitalization or admission to the Regular Ward, Semi-Intensive Care Unit, or Intensive Care Unit (ICU) in the hospital based on hematological parameters using the C5.0 algorithm. A decision tree was obtained for identifying COVID-19 patients who do not require hospitalization or those needing admission to the Regular Ward, Semi-Intensive Care Unit, or Intensive Care Unit (ICU) with an accuracy of 78%. The classification using the C5.0 Algorithm is considered quite good.

It is suggested that future research could improve the accuracy by increasing the sample size. It is also hoped that this study can facilitate and expedite the work of medical personnel, enabling COVID-19 patients to receive prompt and appropriate care to help reduce COVID-19 cases in a population.

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Cloud Computing Technology in Supporting the Implementation of One Data Indonesia

Dara Sawitri
Electrical Engineering Study Program, Faculty of Engineering and Computer, Universitas Harapan Medan
Email: dara.sawitri.24@Gmail.com

Abstract – Cloud computing services provide resources in the form of infrastructure platforms, software, and other hosting to customers. Data provided by digital systems is carried out in a cloud computing model service, providing data access anywhere as long as it is connected to the internet. In today's digital era, cloud computing supports the implementation of One Data Indonesia (SDI) to obtain quality data that is well integrated between local governments and the central government. With One Data Indonesia, it is hoped that data will have consistency so that it can be relied on for analysis and has a good level of security. One Data Indonesia is an idea from the Indonesian government to combine and maximize the use of data generated by government agencies in Indonesia so that it is useful for decision-making, planning, and more optimal public services. In realizing SDI, cloud computing can be utilized for data storage, ease of access, and creating better cooperation between government agencies. Cloud computing can help the Indonesian government optimize public services safely, and reliably, and maximize data potential in various fields to gain competitive advantages in all sectors of government.

Keywords – Cloud Computing, One Data Indonesia, Internet, Digital Era, Data.

I. INTRODUCTION

At this time, the emergence of the use of internet networks that are easily accessible anywhere and anytime makes human activities in obtaining data and information easier. This causes humans to experience a flood of data, because of the availability of abundant data [1]. The term flood is used to describe the surge in information that continues to increase rapidly, where the information produced exceeds human capabilities in managing and using the information optimally. The internet network has made major changes to humans in various aspects of their lives such as the way they work, where working using the internet network allows humans to work remotely, do E-commerce, Email, video calls, social media and so on. The internet refers to the emergence of the digital era, where digital technology and information have influenced many aspects of people's lives in Indonesia. In the digital era, there has been a large data explosion and increasing data complexity, requiring the ability to manage the data surge professionally [2]. The growth in the volume of data and information among local and central governments has brought challenges for the Indonesian government to be able to manage data so that data can be used effectively in producing innovative ideas and can generate profits in facing problems. In addition, effective data processing will produce optimal and efficient results to overcome problems according to public needs [3]. The implementation of One Data Indonesia (SDI) is expected to be able to carry out integrated data management properly so that administrative activities and public services to the community can be carried out quickly and accurately, in order to support decision-making based on significant and up-to-date data [4].

Integrated data will enable the government to work well so that there is a smooth exchange of information between central and regional government agencies. With the smooth flow of information between government agencies, it will accelerate decision-making encourage development, and increase public trust in government performance [5]. Well-integrated data is a valuable asset for the development of new innovations, and public services and also as a driver of economic growth for the welfare of the wider community. To obtain well-integrated, updated, and valid data so that it can be used by the central and regional governments has been stated in Presidential Regulation Number 39 of 2019 concerning One Data Indonesia [6].

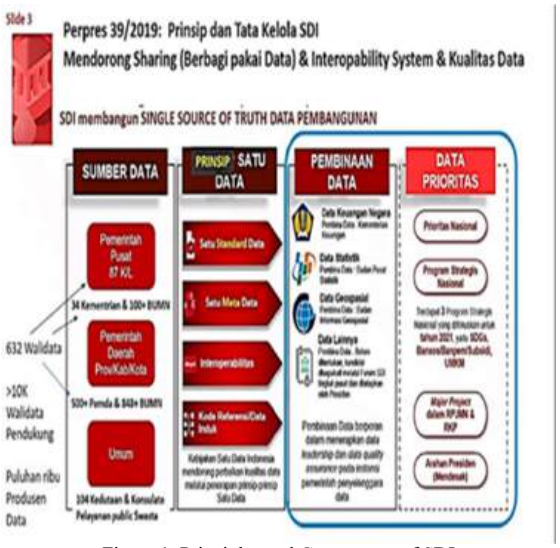

Figure 1. Principles and Governance of SDI
(Source ABDI.ID)

Where the implementation of One Data Indonesia has principles for managing data, namely data specifications, standard metadata, interactions between systems, and single identifiers.

The benefits obtained from One Data Indonesia are efficiency in the use of data sources to avoid data duplication, can be used as a basis for better decision-making, and improve public services [7]. With One Data Indonesia, it is possible to coordinate the sharing of

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information exchange, manage public data more openly, increase public trust in the government, for the development of new innovations and also provide E-Government services in Indonesia [8]. In addition to the benefits of implementing One Data Indonesia, there are also challenges in its implementation, namely [9]:

a. in the form of the need for systems, technology, and infrastructure that are not yet adequate to support One Data Indonesia
b. Data security from cyber threats.
c. data policies to facilitate data exchange, require adequate human resources, support from organizational structures is needed and good coordination between government agencies and public institutions is needed.

Cloud Computing is a computing model where by using internet facilities users can access data, store data, and use cloud services from different geographical areas. Cloud computing is data processing where resources such as software, databases, data storage media, server computers, and internet networks can be used together according to the needs of the user flexibly and payments are adjusted to what is used by the user. Cloud service providers will share the use of resources so that they can be used by many users simultaneously [10]. The basic principle of cloud computing is that users can easily access computing resources (On-Demand Access), such as hardware and software resources, flexibility in the use of computing resources, cheaper costs, and where users only pay according to what they use [11]. In addition, it also provides good data security services, such as data encryption, and users can access resources on cloud computing from different places worldwide. In providing its services, cloud computing has three main service models [12].

Figure 2 Cloud computing
(Source: Indonesian Cloud)

Each service model is needed to provide benefits for institutions or users. The three service models are IaaS (infrastructure as a service), namely virtual server services, virtual storage, and virtual computers, SaaS (software as a service), namely services in the form of sending simple to complex software via the internet network and PaaS (platform as a service), namely services that combine IaaS and SaaS into one package [13], [14].

The use of cloud computing for One Data Indonesia can provide benefits, namely being able to store data in the cloud where security is more guaranteed at an affordable cost, data on cloud computing can be used as integrated data, large-scale data analysis can be carried out, and cloud computing can facilitate easy collaboration between various government agencies.

Figure 3 IaaS, PaaS and SaaS
(Source: exabyte)

For data management, cloud computing helps the Indonesian government optimize public services safely, reliably, and faster digital services to maximize the potential of data in various fields such as public services, transportation, administrative services to the public, education, health, and so on [15].

II. RESEARCH METHODOLOGY

A. Research Stages

The author conducted a study on the role of cloud computing in supporting the implementation of One Data Indonesia using the literature research method. This method is expected to provide clarity on how cloud computing technology can optimize and support efficient data management facilities in the implementation of One Data Indonesia. Figure 4 below shows the image of the research method.

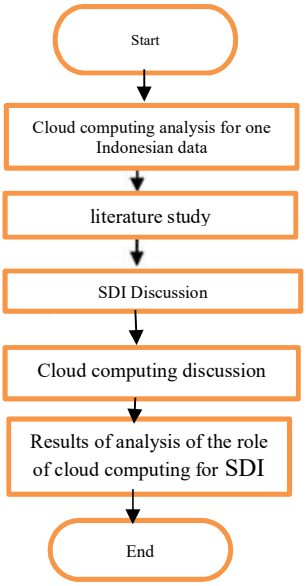

Figure 4. Research Methods

Figure 4 above analyzes the study of how cloud computing supports the success of the implementation of One Data Indonesia. In analyzing, a literature study is carried out, from the literature study it helps researchers to understand

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the theory, concept or all the latest things from the thing being studied. By conducting a research method, researchers can choose the most appropriate methodology for their research being carried out. A good literature study will greatly support the chosen research method. After that, a discussion of One Data Indonesia is carried out based on the literature study that has been carried out. The discussion of the cloud that has been carried out after that will obtain the results of the analysis, the analysis has a function so that existing data management can be obtained properly and accurately. The analysis also aims to be able to understand the research results so that from the raw data it can produce accurate information for the role of cloud computing for One Data Indonesia.

B. Cloud Computing Aspects Affect One Data Indonesia

There are several aspects of cloud computing that affect One Data Indonesia, namely:

a. In terms of data storage capacity, cloud computing can adjust the size of data storage media according to the needs of One Data Indonesia. This is because the data on One Data Indonesia is quite large.

b. Cloud computing allows people or groups of people who work in distant places or in different regions to work using the same data so that good performance effectiveness is created for One Data Indonesia.

c. In One Data Indonesia with cloud computing, data storage in the cloud is possible so that the level of security is high and data can be backed up faster if data is lost due to system failure. This needs to be considered because Indonesia has a geographical area of islands, mountains and oceans so that it is prone to natural disasters.

C. Cloud Computing Architecture Towards One Data Indonesia

In building the right cloud computing architecture, it is very dependent on the needs, size, and objectives of the project to be built against Satu Data Indonesia. In addition to depending on the needs, size and objectives of the project, the basis for choosing a cloud computing architecture is also the configuration depending on the cloud provider that suits the needs, choice of geographic area, cloud service class, security, cost management, scalability and data backup [16]. Satu Data Indonesia is very dependent on the needs, size, and objectives of the cloud computing project. This is expected to remain responsive in adjusting resources according to changes that will occur in the future. Changes that may occur are due to user needs or geographic changes so that there is no need to change the infrastructure as a whole and it is also important (significant) considering that Satu Data Indonesia is used to exchange data with a fairly wide geographic area.

D. Government Data Management and Cloud Computing

As a result of the development of digital transformation in large-scale data processing, the use of cloud computing services in Indonesia is increasingly widespread in various government sectors, where to reduce operational costs with the ability to repair disasters and data damage quickly [17]. Digital transformation itself is a process in which an organization can implement digital technology with new methods or approaches to modify the way it operates, interacts with users in order to achieve the goals of the business organization that have been previously set. Before cloud computing was used in the government sector, data management using data storage system infrastructure in physical locations by the government separately by the government could result in several problems including data redundancy, data isolation and inefficiency, varying data quality, data analysis becomes more difficult and data security problems. Data redundancy problems are situations where there are several copies of the same or very similar data on a computer system or in several data storage media. This can happen because different hardware and software are used to store the same data or because data is downloaded or copied manually (without the help of a computer). Data redundancy can cause inconsistent data, waste of data storage media and difficulty in data maintenance (data management) because data is spread across various storage media. Data isolation can occur when data is managed separately by the government because information needed at a certain level of government may not be available or cannot be accessed by other government entities that need it. This causes high costs, varying data quality, making it difficult to analyze data, maintain data security and hinder government efficiency in providing services to the public. Therefore, One Data Indonesia is an idea from the Indonesian government to unify and maximize the use of data produced by government agencies in Indonesia so that it is useful for decision making [18]. An example of the application of One Data Indonesia that has been implemented by the Indonesian government is the Population Identification Number and E-KTP [19].

III. RESULTS AND DISCUSSION

Data analysis and mapping will support efficient data management and appropriate policy making. One Data Indonesia is expected to produce quality data, so that it can support development and data uniformity between the central government and local governments. In digitalization services, the role of quality data is very important, therefore data analysis and evaluation are needed to follow technological development trends. Cloud computing provides services where data can be transferred from a cloud server to another cloud server. Transferring data from one server to another aims to increase the productivity of cloud technology for the implementation of One Data Indonesia. In addition, cloud computing technology can be a data storage medium with high capacity at affordable operational costs. One Data Indonesia can be more optimally organized with cloud computing technology where it gets benefits in data management as well as with a good level of data security. With One Data Indonesia supported by cloud computing technology, an effective, efficient and optimal configuration is created to integrate data from various applications, data sources, and platforms as well as possible

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for the government. This is the basis for a better decision-making process with a good planning cycle for One Data Indonesia and easier and more accurate access to data for the government to gain competitive advantages in all government sectors.

III.1 Data Analysis and Mapping

Analyzing and mapping data is an important step in understanding and illustrating information stored in a set of data. In Satu Data Indonesia, there are several steps to analyze and map data. These steps are:

a. Identifying related data sources from various entities, namely government institutions, non-government institutions, statistical agencies and so on.
b. Implementing an integrated data system for easy access and analysis.
c. Conducting a data filtering process so that data is free from inconsistencies, data redundancies and data gaps. In addition, data normalization is also needed.
d. Statistical analysis can be carried out to obtain useful information so that it can be used as a basis for decision making.
e. In data containing spatial elements, geographic mapping techniques need to be used to visualize information based on its geographical location.
f. Implementing information security, namely maintaining data security.
g. Documenting data.
h. Implementing metadata.
i. Maintaining data accuracy.
j. Data analysis and mapping are important steps that support Satu Data Indonesia's goal of developing a system that unifies and is effective in using data.

III.2 Data Architecture Plan on One Data Indonesia

What is meant by data architecture in Satu Data Indonesia is how to take an approach that can be done to organize data originating from various sources for management, uniting data into integrated data, storage and exchange in order to facilitate the need for integrated information for government institutions. In addition, the data architecture in Satu Data Indonesia includes criteria, guidelines and rules that must be obeyed so that data remains consistent, interoperable and creates security for information (information security). Table 1 below contains several factors that can be included in the data architecture plan for Satu Data Indonesia.

Table 1 Data Architecture Planning Factors

No	Arsitektur	Prinsip	Deskripsi
1	Data Grouping	Identifying data types	Demographic, Economic, Environmental, Geographic, Health, Social, Financial, Technology and Communication Data.
2	Business Objectives	Targets to be achieved	Analysis, Reporting and Decision Making
3	Data Quality	Accessibility of relevant, accurate and consistent data	Data Cleaning, Validation and Standardization
4	Security Information	Privacy regulations	Giving individuals control over personal information. Policies, laws
5	Technology Infrastructure	Development, use and functionality of technology.	Hardware and software, communication networks, data storage systems and servers, data centers and the internet
6	Data Integration	Combining data from different entities.	The creation of a structured, organized data environment supports business and analytical needs.
7	Continuous Maintenance and Development	Data maintenance, management and growth.	Quality control, Regular updates, Innovation and Expansion of data and model development.

III.3 Data Integration

To maintain data integration in One Data Indonesia, cloud computing offers a centralized platform that accommodates the collection, storage, and access to data from various sources. In the following table 2, the role of cloud computing in maintaining data integration:

Tabel 2 Cloud Computing Maintains Data Integration

No	Cloud Computing	Penjelasan
1	Integrated Data Center	Cloud computing enables a centralized data warehouse, so that data from multiple sources can be collected and stored in a standardized format
2	Application Programming Interfaces and Web-Based Services	Cloud computing provides API services so that data can be exchanged securely between dissimilar systems so that data is integrated in real-time
3	Data Centralization	With cloud computing, government agencies can implement consistent and centralized data management policies to maintain data integrity and quality
4	Cooperation / Collaboration	Facilitate resources that enable multiple stakeholders to collaborate on the same dataset.
5	Security and Privacy	Protecting data from unauthorized access to ensure that data management is carried out securely
6	Access Management	Access management where management of access to data determines the rights to data to only view, the right to change certain information to support data integrity

Data integrity reflects the quality of stored information including the truth of the stored information and its authenticity. With well-integrated data, competent information will be obtained throughout its stages, so that it can reduce data discrepancies when used to create reports. In One Data Indonesia, data integrity supports cooperation in exchanging information between several government institutions so that it is more efficient and runs smoothly in the decision-making process. Openness and

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accountability of well-integrated data will have a positive effect on One Data Indonesia in terms of governance, accuracy, and improving services in a number of public sectors to the wider community. It can be said that the role of cloud computing is very important in providing the necessary infrastructure to ensure efficient and effective data integration and is one of the pillars of One Data Indonesia.

III.4 Dashboard One-Stop Data

The one-stop data dashboard is an integrated access interface to various data and information so that users can easily access and analyze information, so that the data or information available is easy to understand even though it comes from various different places. At Satu Data Indonesia, the one-stop data dashboard aims to provide a platform that makes it easy to access various data needed by users from various fields so that they can make the right decisions based on the available data and information. Some preparations that can be made for the one-stop dashboard are understanding the purpose of creating the one-stop data dashboard, identifying data sources, both internal and external data sources, determining access rights to data for users who have the authority only, data and information in the dashboard is accurate data. In addition, preparations that can be made for the one-stop dashboard include ensuring that the data in the dashboard is well integrated, managing the dashboard, conducting training on the use of the dashboard and ensuring that data security is maintained. The One-Stop Data dashboard, in addition to facilitating data analysis, is also useful for data integration, data visualization, data updates in the form of the latest information on the basis of decision making, customization, flexibility, supporting teamwork, identifying trends and patterns in data and accurate accessibility. The One-Stop Data Dashboard for One Data Indonesia is useful in terms of increasing the efficiency and effectiveness of integrated data management and utilization for government institutions and their stakeholders.

III.5 Documentation

In the concept of One Data Indonesia, documentation is in the form of official records related to the collection, processing, storage, and distribution of data by government institutions. The purpose of documentation is to clarify the methodology, ensure data quality, and support cooperation between government institutions when data management occurs. Data documentation in Indonesia refers to the process or results of recording information related to existing data. Things included in documentation in One Data Indonesia are how to set rules related to instructions for accessing data, data guides to obtain information about the availability of what data and where the data comes from, implementing technical guidelines that provide instructions for data integration, data transfer and API (Application Programming Interface). In addition, data security and reports on existing data analysis are also included in the documentation in One Data Indonesia. With good documentation, users of the One Data Indonesia platform can maximize its use. The components of documentation for One Data Indonesia include:

1. Contextual Data in the form of information about the dataset, such as title, abstract, keywords, time and date of collection, data format, and collection methodology.
2. Standards of Documents that explain technical and procedural standards in the implementation of data collection, storage, processing, and distribution.
3. Government Regulations in the form of One Data Indonesia regulations for data management and distribution policies.
4. Procedure Manuals in the form of instructions for implementing the data processing process in accordance with One Data Indonesia.
5. Data security in the form of maintaining data security, data access, data transfer, and data deletion.

Documentation aims to maintain data integrity and quality, data transparency, minimize data duplication in order to obtain more accurate data as a basis for decision making for the government.

III.6 Cloud Computing And One Data Management Indonesia

The implementation of cloud computing in the management of One Data Indonesia can provide many benefits for the government, organizations and other fields. Where the management and storage of large data sets to be more effective, efficient and optimal. This is very beneficial for the government and organizations in Indonesia. Cloud computing provides scalability as well as various resources needed to handle One Data Indonesia better. Where cloud computing is able to facilitate collaboration from better data sharing among various stakeholders in the government in Indonesia. This is very important for the central government and local governments, which require cross-sector collaboration on sharing various data for various purposes such as improving services to the community as well as a basis for decision making. To be able to manage data and to be able to provide access services from various data sources on centralized data, cloud computing has a very important role. Cloud computing creates integrated data by providing services and basic facilities in the form of storing and controlling data from different sources. So that it can carry out data management, data retrieval and data analysis in one platform for One Data Indonesia. Cloud computing technology can provide the ability to handle increased data additions or performance by adding or reducing resources. Cloud computing technology for One Data Indonesia carries out several methods, namely by adjusting capacity by users, making payments based on scalable usage, automatic infrastructure management, carrying out parallel processing and fast services that can be accessed from different places[20]. Dengan layanan berbasis cloud, maka Satu Data Indonesia dapat melakukan penyimpanan, pemrosesan, juga menganalisis data dalam jumlah besar secara optimal tanpa harus memerlukan infrastruktur lokal komprehensif. Sehingga dapat dilakukan penghematan biaya namun tetap memberikan skalabilitas dan fleksibilitas untuk memenuhi tuntutan manajemen data yang progresif. Cloud computing memiliki peran besar dalam mendukung manajemen Satu Data Indonesia yaitu berupa memfasilitasi infrastruktur skalabel, efisien, dan fleksibel sehingga tercipta integrasi serta analisis data yang

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cukup luas dari berbagai sumber pemerintah dan lembaga-lembaganya. Berikut ini adalah peran cloud computing dalam manajemen Satu Data Indonesia sebagai pembagian sumber daya, scalability, keamanan data, menganalisis data besar, efisiensi anggaran, pemeliharaan dan pembaruan. Dalam Satu Data Indonesia dengan penerapan cloud computing memiliki beberapa tantangan berupa masalah keamanan data dimana data harus dapat dilindungi dari ancaman cyber serta kerusakan data serta ketergantngan terhadap provider yaitu pihak penyedia layanan cloud. Selain itu perlu adanya pelatihan terhadap sumber daya manusia bagi penggunaan teknologi cloud computing dalam implementasi Satu Data Indonesia.

IV. CONCLUSION

By implementing cloud computing in supporting One Data Indonesia, more effective data quality and more secure data will be created, where only those who are entitled to the data can access it. Cloud computing plays a role in well-integrated data management, so that the government can be more efficient in government administration in order to create transparency, accountability, collaboration facilities between government institutions in data processing and create development for innovation in many government sectors. The role of cloud computing to support the implementation of One Data Indonesia includes ease of accessibility, the creation of an integrated system, good data protection in the form of data security, more efficient large-scale data analysis, information management without direct infrastructure management and paying for services based on usage so that cost savings occur. One Data Indonesia is a solid foundation for creating a transparent government, a responsive system, can be well connected according to what the public expects so that more efficient services are created for the wider community and are right on target. With cloud computing, it is expected to smooth the country's information technology infrastructure to support and improve the quality of decision making. Cloud computing requires a stable internet network that is easy to access anywhere and anytime in order to run smoothly. The implementation of One Data Indonesia uses cloud computing for data storage, optimizing public services safely, reliably, and faster digital services. Thus maximizing the potential of data in various fields in order to create more optimal cooperation between fellow government agencies with data that has been well integrated in order to gain competitive advantages in all sectors of government.

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Smart-Working and Hot Desking Application Development using Agile and Extreme Programming Method at Xtra Cowork

Daeng Ahmad Nurdin[1*)], Dodik Firmansah[2], Akrom Hafifi[3], Muhammad Darwis[4]
[1,2,3,4]Program Studi Teknik Informatika, Fakultas Ilmu Rekayasa, Universitas Paramadina
Email: [1]daeng.nurdin@students.paramadina.ac.id, [2]dodik.firmansah@students.paramadina.ac.id,
[3]akrom.hafifi@students.paramadina.ac.id, [4]muhammad.darwis@paramadina.ac.id

Abstract – The current condition of working desks often faces challenges such as poor management and inefficiency in space utilization, which complicates the adoption of Smart-Working culture at Xtra Cowork. To address these issues, the writer aims to facilitate the transition for offices adopting Smart-Working culture by designing a hot desking supporting mobile app. Through observation, the research identifies the need for a reliable system to support hot desking practices. To complete this research, the writer uses agile and extreme programming methods. For app designing, the writer uses UML. The main tools used for developing the app are Flutter with Dart language. The developed mobile app successfully fulfills these requirements. The results of the application testing using the black box method has passed 100% of the test cases. It shows that all functions have worked as designed and could be used by the users as intended. Future researchers can build upon this work to address other Smart-Working culture needs.

Keywords – mobile apps, extreme programming, hot desk apps, black-box method

I. INTRODUCTION

Xtra Cowork is an initial of the real office that the writer takes this research on, is adopting Smart-working culture. For almost two years, the company already adopt this culture, but recently this company is facing a new problem on its plan to resize the maximum work seat capacity to only 60%. The problem the company faces is how to maximize the spread of work seat utilization, therefore in this research, writer provide an idea to solve this issue.

Smart-Working by its definition is a framework that gives the employees the freedom to choose the time, place on the way they work [1]. The culture is based on ethos, process and technologies to aims the improve on work environments, productivity and also cost savings [2]. Claimed by Yolyntseva there are several advantages for an office to implement this revolutionizing culture such as enhanced energy efficiency, improved productivity, and seamless connectivity [3]. The aforementioned benefit of the Smart-Working culture has been experienced by the writer as someone who currently work in an office.

The adoption of Smart-Working at Xtra Cowork been followed by the emergence of hot desking concept. Hot desking by definition is a system in a work office where each space is available for each worker, rather than reserved for specific person, so it possible for the same space to be occupied by different person along the day or week [4]. The "Desk" refers to a working spot or space that usually has table in it which shared by multiple persons in the office, therefore the "Desk" word is used. In some case, the initial motivation of hot desking implementation is due to the cost reduction through space saving [5]. As mentioned earlier, the Xtra Cowork also has the plan to reduce its working space. To support the hot desking practices, a well-tailored mobile application would be needed.

A mobile application, commonly referred to as an "app," is a software program specifically designed to operate on mobile devices such as smartphones or tablets [6]. As a statistic data that was brought by the Statista predict that by 2024, the number of smartphone user in Indonesia will reach 194 million users [7]. With that much smart-phone user in Indonesia, the development of a mobile application hot desking support is chosen by the writer. Another reason writer decides to develop a mobile application for the hot desking support is because of its ease-of-use nature that could be accessed anytime and anywhere by the user.

In developing a software, a development method is needed to ensure the software will be well-planed and well-developed to achieve its critical function. The Agile project management methodology will be used in this research as it's adaptive nature that would easily evolves the requirement and the software target as new ideas emerged. Agile project management

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methodology is an iterative approach that emphasizes flexibility, collaboration, and responsiveness to change throughout the project lifecycle [8]. It is a popular alternative to traditional project management methodologies like the waterfall approach, offering a more adaptive and customer-centric way of delivering projects [9]. To be specific, in this research, writer using the Xtreme Programming methodology.

Extreme Programming (XP) is an agile software development methodology that originated from the Chrysler C3 project in 1996 Dybå & Dingsøyr (2008) [10]. XP focuses on twelve core practices for software development, including planning games, short releases, system metaphors, simple design, testing, refactoring, pair programming, collective ownership, continuous integration, maintaining a 40-hour workweek, having on-site customers, and adhering to coding standards [11]. One of the benefits of this approach by using the Agile Development methodology with Extreme Programming is that in the development cycle each team will be enabled to correct each other out, with the development time considered shorter and also quickly adapting with changes of any form without reducing the quality of the software being built [12].

The goal of this research is to develop a well hot desking supporting mobile application that could be used by the employee as user and also for the administrator to have the control over the hot desking regulation.

II. RESEARCH METHODOLOGY

Since the goal of this research is to develop a well-built mobile application that could support the hot desking at Xtra Cowork, the writer uses the research methodology of this paper is by reading the already existing literature and finding additional literature that could support this research by giving the understanding of the theory and concept of a well-built mobile application.

Development methodology that will be used to develop this mobile application is using the Agile Development methodology with Extreme Programming that classified as light software development methodology.

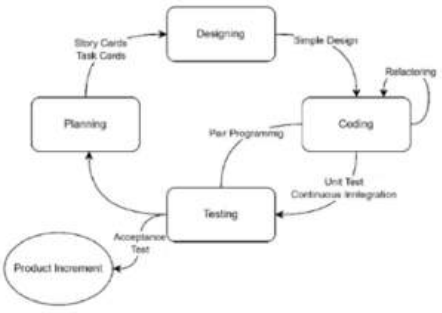

Figure. 1 Extreme Programming Model

As explained by Figure 1, the extreme programming model has it steps that needed to be implemented to ensure a software being developed is well-built and well-planed. The steps of extreme programming development process that will be done in this research are as followings:

A. Planning

In this step, user story creation is being done to ensure the functional requirement is align with the goals of supporting the hot desking process.

B. Designing

In the designing phase, the system flow and database flow will be drawn in UML to ease the coding steps, then the evaluation will be done for the flow to recheck the requirement functionality goals.

C. Coding

In this step, the previously generate flow UML will be implemented into real solution. In this research, we will use the Flutter framework as the base application code, and the SQL Server for the database.

D. Testing

The mobile application that has been coded will be tested using Black-Box testing methods, this method of testing is more focused on functionality specification of a software, tester could define several input conditions in which the test will be done and the expected results of the software.

III. RESULTS AND DISCUSSION

In this section, writer will discuss the implementation of the SDLC methodology of agile development model with extreme programming in the hot desking supporting mobile application design.

3.1 Analysis

The writer done the analysis and data collection using observation and interview methods. The analysis and data collection were being done in order to identify the requirement of this particular mobile app. In this stage, the writer will be presenting the software requirement specification of the mobile app.

The need for software design and development in the hot desking supporting mobile app are as the following:

1. Employee Booking:
   - Employees can easily book a desk for today or tomorrow.
   - Select the desired date and department.
   - View available desks on a floor map and confirm bookings.
2. Admin Dashboard:
   - Admins can upload floor maps and map desks to buttons.

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- Set up departments and associate desks with specific departments.

3. Login:
- Admins and employee need to be authorized before doing actions in the app.

To ensure the employee's needs of hot desking, the app must fulfill the needs based on the first point as shown above. While the second point was aimed to fulfill the admin needs to manage the content change also administration. Lastly the third point was required in order to each user could be authorized and the app variable could adjust based on their roles and user information.

3.2 Planning

For designing, Unified Modelling Language (or UML for short) is being used by writer to describe the system design, flow and its interaction between user and also the system itself. UML is a general-purpose visual modeling language that standardize visualization of system design [13]. In this stage, writer will present how the app works by using the Use Case Diagram and Activity diagram.

1. Use Case Diagram

Use case diagram explain about the interaction between the system and the user(s) [14]. The use case diagram of hot desking supporting mobile app shown below was designed to fulfill its software requirement specification.

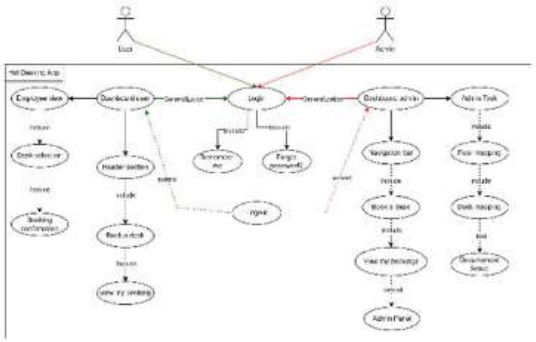

Figure. 2 Use Case Diagram of hot desking supporting mobile app

In figure 2, the admin and user both shared several features (that shown as generalization on the diagram), including the login for authentication and logout to delete the app session. The login features itself was included as it was included in the software requirement specification in the analysis section earlier in the research. Both the user and the admin have their own separated function that does not cross each other as their function was tailored based on their needs and task that each user could do and authorized to do.

The user side functions of the app have to fulfill the needs as described in analysis section, the user must be able to book a desk for the date they choose, the user also able to View available desks on a floor map and confirm bookings.

While the admin's side of function that presented on the figure 2 also has functions that could fulfill its needs based on the software specification requirement on the analysis section earlier, admins can upload floor maps and map desks to buttons. Admin also need to be able to set up departments and associate desks with specific departments.

2. Activity Diagram

Activity diagram was used in the research to explain the flow of the user's interaction with the system, it also based on the unified modelling language which was not constrained by any programming language and measured to could transfer the technical idea [15]. In this research the activity diagram that will be presented will be grouped based on their actor, the user and also the admin.

a. Activity diagram User

There are two activity diagrams drawn to explain the user interaction with system that will be shown in figure 3 and also figure 4. Each of the diagram will present different activity, namely the first one will present the flow of user interaction to book a desk, while the second one will present the flow of how user interact with system to cancel a booking.

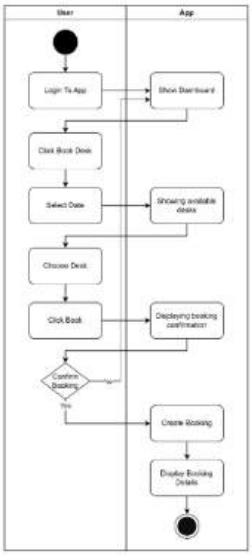

Figure. 3 Activity Diagram User of Hot desking supporting app 1

Figure 3 explaining the flow interaction between user and also the system on how the user will interacting when the user wants to create a desk booking or reservation via the mobile app. The user first must login then initiates the booking by clicking on the book desk menu, the system will response by displaying the right information regarding the user interaction.

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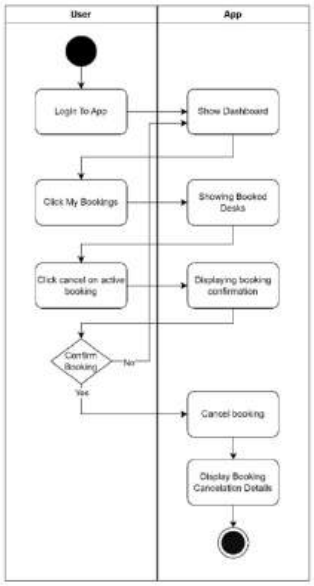

Figure. 4 Activity Diagram User of Hot desking supporting app 2

In figure 4, the user interacting with the system in activity to cancel the booking that has been made earlier by itself. The user initiates the activity by opening the "*my bookings*" menu to then proceed to select the booking he/she want to cancel. The system then will send the confirmation prompt to the user, this step will also prevent unintended input of the system to cancel the bookings.

b. Activity Diagram Admin

Same as the activity diagram prepared for user, the admin's activity diagram also consists of two activity diagram that representing different activity of admin on figure 6 and figure 7. The first diagram will explain the admin interaction with system on activity create new floor layout to be used by users. While the second one aimed to explain the interaction on activity of admin updating the user department setting.

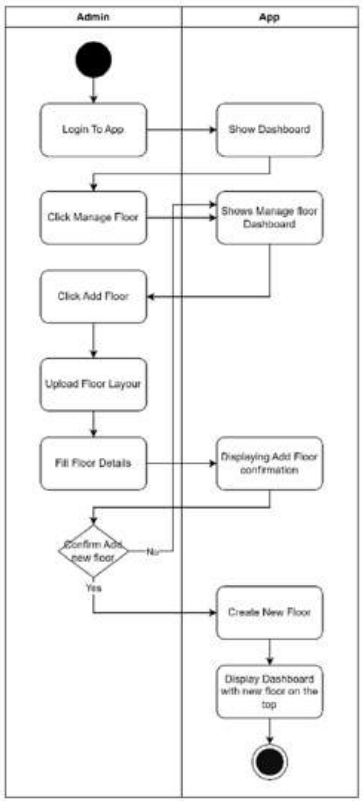

Figure. 5 Activity Diagram Admin of Hot desking supporting app 1

Activity diagram that shown on figure 5 explaining the interaction of admin and system on activity of admin setting up a new floor layout to be used by the users. As shown above, the admin initiates the activity by clicking on *manage floor* menu that exclusively accessed by the admin. As the interaction of the system, the app displaying information as the admin's input on the system, lastly it also notifies the admin about the result of its action.

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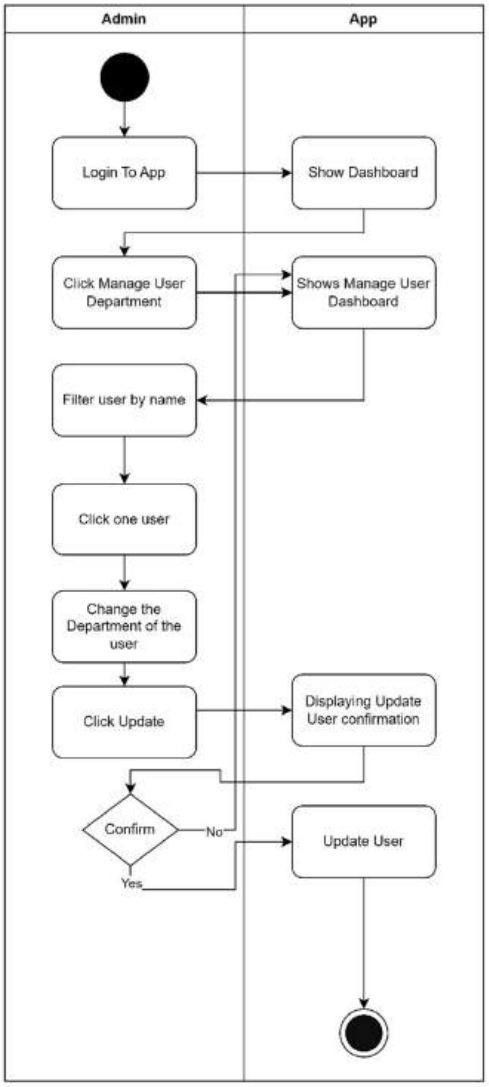

Figure. 6 Activity Diagram Admin of Hot desking supporting app 2

The activity diagram in figure 6 explaining the interaction between admin and system on the activity of admin want to change the department of a user. The activity was initiated by the admin and ended by the system updating the user department information.

3.3 Designing

In the designing step, the writer will explain on how the system will be built based on its classes and how it interacts with each other. To achieve such goal, the writer will be presenting it by using class diagram that also based on unified modelling language. A class diagram could describe the structure of a system by showing the system's classes, their attributes, operations (or methods), and the relationships among objects [16]. As class diagram function is a fit to explain the system design, therefore the writer will use this diagram for explaining the system design.

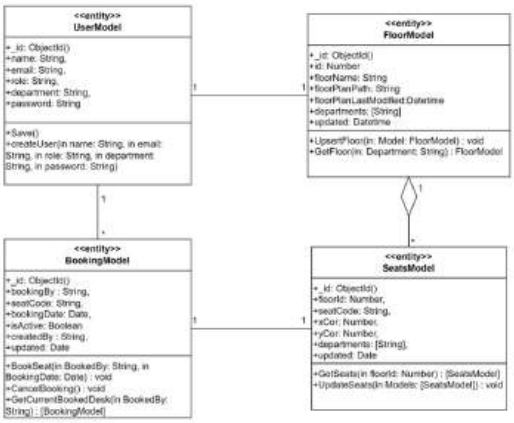

Figure. 7 Class Diagram of Hot desking supporting app

As shown by the figure 7 above, the hot desking supporting mobile app will be consisted of 4 main classes that interact with each other based on their relationship.

The *UserModel* class representing the user profile, it includes the user identifier, name, email, role, department, and also password. The user password will be protected by salting and hashing the password to ensure the secureness of the authorization function of the hot desking supporting mobile app. The *UserModel* could have as many *BookingModel* object, while it only could have 1 *FloorModel* object to determine its booking availability by the user's department.

BookingModel class included to represent the booking that will be made by the user. For each *BookingModel*, it will occupy a *DeskModel* for a timeslot. The timeslot was defined on the *BookingModel* as *bookingDate* property. Therefore, for each day, a desk could only be occupied by one booking.

DeskModel class in the figure 7 representing the bookable desk and also unavailable booking, it will draw itself based on coordination that included as class properties, namely *xCor* and *yCor* properties as shown above.

Lastly the *FloorModel* included in the diagram representing the floor layout and also its mapping based on the user departments.

3.4 Implementing

In this phase, the writer will show the UI of the hot desking supporting mobile app that has been built.

1. Start Page

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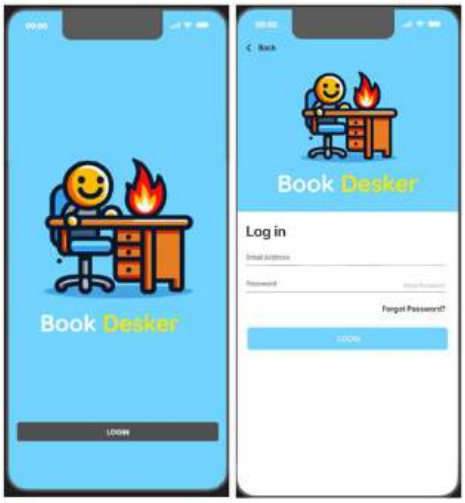

Figure. 8 Start Page UI

Figure 8 shows the start page of the hot desking supporting mobile app. The users will be redirected to this page first as the login page.

2. Home

Figure. 9 Home Page UI

After logging in, the user will be redirected to this page as shown in figure 9. Here the user could see the latest information about the company, also it could see the active booking he/she made earlier.

3. Desk Book

Figure. 10 Desk Book Menu

The figure 10 shows the interface of the hot desking supporting mobile app when a user wants to book a desk.

4. Booking History

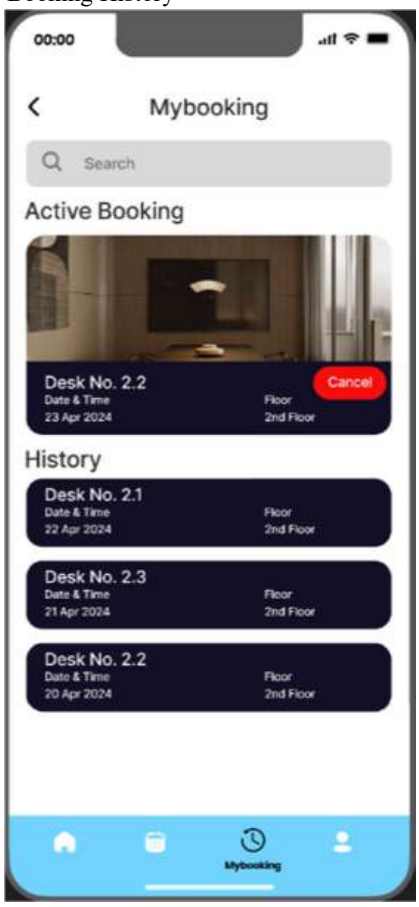

Figure. 11 My Booking Menu

Figure 11 show the UI of Booking History, or as it called in the app is *MyBooking page.*

5. Admin Dashboard

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Figure. 12 Dashboard Admin UI

Figure 12 show the UI of admin's task dashboard. Here showed that the admin has privilege for updating maintaining the floor map, desk map, and also the management setup.

6. Floor Mapping

Figure. 13 Floor Mapping UI

The figure 13 contains the UI of floor mapping menu that could be accessed by the admin to manage the floors.

7. Desk Mapping

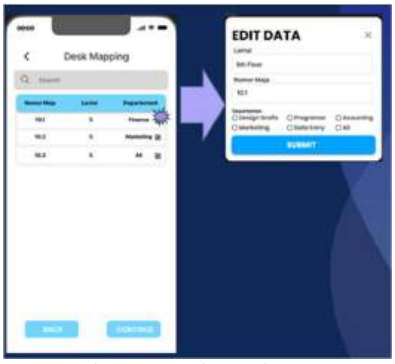

Figure. 14 Desk Mapping UI

Figure 14 shows the UI of and admin that want to edit a mapping of a desk by app.

8. Department Mapping

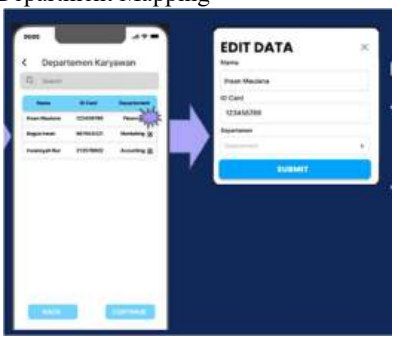

Figure. 15 User Department Mapping UI

Figure 15 shows the hot desking supporting mobile app UI when an admin wants to update a user department information.

3.5 Testing

The hot desking supporting mobile app will be tested by using Black Box testing method. Black Box testing is used as application testing method to obtain the system response and compare it to the expected response based on the system requirement [17]. The result of testing with Black Box Method are shown below in Table 1.

Table 1 Unit Test Results

Unit	System Testing	System Reaction	Test Result	Tested By
Login	1. Fill in the login form 2. Click Login	Redirect to home view	Succeed	User
Create Booking	1. Click Book Desk 2. Select Date 3. Choose desk 4. Click Book 5. Confirm	Booking created, booking details displayed	Succeed	User
Cancel Booking	1. Click My Booking menu 2. Choose a desk to be cancelled 3. Click Cancel 4. Confirm	Booking cancelled	Succeed	User
Create new floor map	1. Click Floor Mapping 2. Click Plus Icon 3. Upload Floor Layout 4. Fill in floor details 5. Click Confirm	New floor map registered	Succeed	Admin
Change a department of a desk	1. Click Desk Mapping 2. Choose a desk to be updated 3. Change department from IT to HR 4. Click Update 5. Click Confirm	Desk department ownership updated	Succeed	Admin

Based on the table 1 above from five test that prepared, the system passed 100% of the test cases. the hot desking supporting mobile app is already passed all the test, and it's ready to be used by masses.

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IV. CONCLUSION

The writer is designing hot desking supporting mobile app in order to ease the transition for offices that want to implement the Smart-Working culture. Based on that reason, the writer in this research analyzing the needs of hot desking supporting mobile app by observation and interviews. One of which the needs come from the hot desking practice that being implemented. The needs of a reliable system to support the hot desking practice in smart working.

Based on the test results, the development of hot desking mobile app has fulfilled the needs that has been described in the analysis stage.

For the next researcher, the writer hopes could develop the mobile app to fulfill the other Smart-Working culture needs.

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Prediction of Carbon Emissions in Indonesia Using Machine Learning: A Focus on Environmental Impact

Rizaldi Putra[1*)], Memet Sanjaya[2], Deni Utama[3] ,Berliana[4]
[1234]Program Studi Bisnis Digital Politeknik Takumi
Email: [1]rizaldi.rip@takumi.ac.id, [2]memet.msa@takumi.ac.id, [3]deni.utama@takumi.ac.id,
[4]effendyberliana@gmail.com

Abstract – Carbon emissions represent a critical driver of global climate change, exerting profound impacts on environmental sustainability and public health. This research examines Indonesia's carbon emission trends using a comprehensive dataset spanning global emissions from 1960 to 2018, with specific focus on Indonesia, obtained from Kaggle. Employing Linear Regression (LR) as the primary machine learning technique, the study effectively models and forecasts future carbon emission levels for Indonesia. The findings indicate a projected increase in emissions to 2.38 tons per capita annually by 2030, underscoring the urgent need for robust environmental policies.

Keywords: Machine Learning, Carbon Emission, Indonesia, Linear Regression.

I. INTRODUCTION

Numerous studies have demonstrated the significant environmental and health risks associated with increasing carbon emissions. For instance, carbon emissions not only contribute to global warming but also exacerbate public health risks, particularly in rapidly industrializing nations such as China[1]. Indonesia, with its heavy reliance on fossil fuels, faces similar challenges, especially as its emissions continue to rise. A study [2] demonstrates a strong connection between energy consumption and carbon dioxide emissions. An increase in energy use correlates with higher carbon dioxide emissions, primarily due to fossil fuel consumption. Consequently, greater fossil fuel use results in significantly elevated emissions. The environmental consequences, such as rising sea levels, extreme weather events, and water scarcity, further underscore the importance of addressing carbon emissions. According to the United Nations Sustainable Development Goals (SDGs), reducing carbon emissions is essential for achieving environmental sustainability and mitigating the harmful effects of climate change [3].

This study utilizes global carbon emissions data spanning from 1960 to 2018, obtained from publicly accessible open data on Kaggle. This dataset was selected because it provides a comprehensive overview of global carbon emissions, with a specific focus on Indonesia. Indonesia's demographic bonus, projected to peak around 2030, makes this data particularly relevant for developing a predictive model. The objective of this model is to forecast carbon emissions and analyze potential impacts, offering insights that could inform policy and strategic interventions in response to environmental challenges.

This research utilizes machine learning algorithms - Linear Regression (LR) to predict future carbon emissions in Indonesia. Linear regression remains a foundational method in machine learning due to its simplicity, computational efficiency, and interpretability, particularly when analyzing linear relationships between variables. It is highly valued in applications such as financial forecasting, where transparency in understanding variable influence is essential to ensuring reliability in complex datasets[4]. While models such as support vector machines (SVMs) and multilayer perceptrons (MLPs) may outperform linear regression in handling non-linear or large-scale data, linear regression remains competitive in its niche for clear and efficient predictions. The LR method can produce highly accurate predictive correlation coefficients[5]. The study leverages historical data to provide accurate forecasts that can inform national policies and global efforts to mitigate climate change.

II. RESEARCH METHODOLOGY

This study uses machine learning algorithms, particularly linear regression, to model the relationship between two variables by fitting a linear equation to historical data, with one acting as the explanatory variable and the other as the dependent variable [6], to predict future carbon emissions in Indonesia. The methodology involves data collection, preprocessing, model training and interpretation to generate accurate predictions of future emissions. The analysis is conducted using libraries such as Pandas, NumPy, and Scikit-learn in Python. Libraries like Pandas in Python are among the best available today [7].

A. Data Collection

The data used in this study were sourced from Kaggle, comprising global carbon emissions data from 1960 to 2018, covering 266 countries. The data titled “CO2

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emissions (metric tons per capita) from 1960 to 2018" can be access from this link. The dataset was filtered to focus on Indonesia, a country experiencing a significant rise in emissions due to industrial and economic growth. The study indicated that a 1% increase in economic growth and fossil fuel consumption leads to a 0.36% and 0.67% rise in carbon dioxide emissions[8]

Image 1: carbon emission data from 266 countries

The global carbon emissions dataset from 1960 to 2018 offers a detailed view of CO2 emissions from 266 countries, capturing trends across nearly six decades. It tracks total emissions, per capita figures, and sectoral contributions, revealing a steady rise in emissions, particularly after industrialization, with notable increases from emerging economies in recent decades. The data underscores how economic growth, energy consumption, and population dynamics drive emission patterns, with developed countries contributing heavily in earlier periods and developing nations like Indonesia.

Before training the models, the data underwent preprocessing to ensure quality and consistency. The preprocessing involved the following steps:

1. **Data Import and Cleaning:** Missing values in the dataset were identified and managed through imputation or removal, ensuring that the model would not be biased by incomplete data.

```
df=df.dropna(axis='rows')
df .head()                                    (1)
```

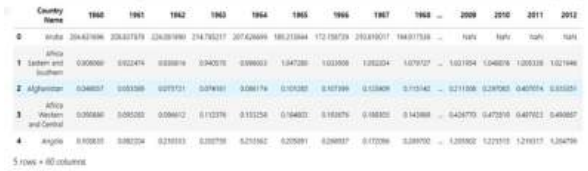

Image 2: Processing data

In data preprocessing, handling missing values is crucial to ensure that the model is not biased or skewed by incomplete data. One common method is removing rows with missing values to maintain the integrity of the dataset. The code provided on Phyton does this by using *df.dropna(axis='rows'),* which removes any rows that contain missing data, and then the *df.head()* function displays the first few rows of the cleaned dataset

2. **Normalization:** Features such as year and emission levels were normalized to standardize the range of data, which is crucial for algorithms sensitive to the scale of input variables.

```
indo=df [df['Country Name']=='Indonesia']
indo                                          (2)

ina = indo.melt(id_vars='Country Name'
      var_name='year,
      value_name='emission'                   (3)
```

	Country Name	year	emission
0	Indonesia	1960	0.243920
1	Indonesia	1961	0.288848
2	Indonesia	1962	0.248553
3	Indonesia	1963	0.239783
4	Indonesia	1964	0.229458
5	Indonesia	1965	0.246241
6	Indonesia	1966	0.227084
7	Indonesia	1967	0.232007
8	Indonesia	1968	0.253602
9	Indonesia	1969	0.298784
10	Indonesia	1970	0.312065

Image 3: Data normalization

Normalization is an essential preprocessing step in machine learning, particularly when using algorithms sensitive to the scale of input variables, such as gradient descent-based models. By normalizing features like the year and emission levels, their values are scaled to a standard range, preventing features with larger ranges from disproportionately influencing the model. This process ensures that each feature contributes equally to the model, improving performance and convergence speed.

The code provided above filters the dataset for Indonesia and reshapes it using the melt function. This operation converts the data from wide format (with columns for each year) to long format, where emission levels are associated with individual years for easier analysis. In this context, the reshaped data allows for more manageable analysis of emission levels over time, facilitating trend identification and model training.

3. **Exploratory Data Analysis:** Visualization techniques were employed to identify trends and patterns in carbon emissions over time. This included plotting historical data to observe fluctuations and averages.

```
import plotly.express as px                   (4)

L = px.scatter (data_frame=ina, x='tahun',
y='emisi', trendline='ols')
```

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```
L.show()                                                    (5)
```

Exploratory Data Analysis (EDA) is an essential step in understanding the dataset and identifying underlying trends, patterns, and potential relationships. Visualization techniques, such as scatter plots, help in observing the fluctuations, trends, and averages of carbon emissions over time. The code provided uses Plotly Express to create a scatter plot of emissions data for Indonesia, with a trendline fitted using Ordinary Least Squares (OLS) regression. This allows for a clearer view of the historical relationship between year and emissions, highlighting any potential upward or downward trends.

The scatter plot provides a visual representation of carbon emissions over time, while the OLS trendline shows the overall direction of the data, allowing for easy identification of trends and changes. This technique is essential for understanding the impact of various factors on emissions and for making informed predictions

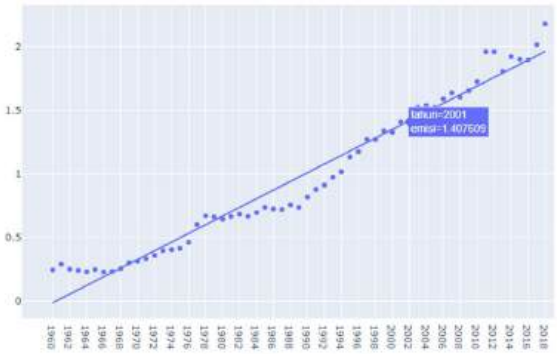

Image 4: Emission trends in Indonesia

The graph above illustrates a consistent upward trend in carbon emissions over time. The relatively narrow gaps between data points suggest that the rate of growth has remained steady throughout the observed period, indicating a linear progression. This pattern supports the use of linear regression as an appropriate method for creating prediction models, as the method is particularly effective when data exhibits a clear, linear relationship between the independent and dependent variables. Linear regression's simplicity and efficiency make it well-suited for modeling scenarios where growth patterns follow a steady, predictable trajectory

B. Model Training and Interpretation

The algorithm was trained on the historical data to establish a linear relationship between the independent variable (year) and the dependent variable (carbon emissions). The performance of the model was evaluated using the R-squared metric value ranges from 0 to 1, with higher values indicating that the model better explains the variation in the data. The use of R-square provides consistent insights without confusing interpretations, making it a reliable choice for evaluating regression analyses in various fields (Chicco et al., 2021).

```
model= LinearRegression().fit(x,y)
a=model.intercept_
b=model.coef_
r=model.score(x,y)
print(a)
print(b)
print(r)                                                    (6)
```

Model training involves fitting an algorithm to historical data to establish a relationship between the independent variable (year) and the dependent variable (carbon emissions). In this case, the linear regression model is trained using the *LinearRegression().fit(x, y)* function, where x represents the year and y represents the emissions. The model's performance is then evaluated using the R-squared metric, which quantifies how well the independent variable(s) explain the variation in the dependent variable. An R-squared value ranges from 0 to 1, with higher values indicating better explanatory power of the model. The model's coefficients *(model.coef_)* and intercept *(model.intercept_)* are also retrieved to understand the relationship, where *model.score(x, y)* provides the R-squared value, offering a clear and interpretable measure of the model's accuracy.

```
-66.8111390918693
[0.03407986]
0.9640214200712264
```

Image 5: result of the data accuracy

Predictions are made using the linear regression formula, where the intercept and coefficients are derived from a previously trained linear regression model. According to the image above, the prediction accuracy is 96%.

```
value=int(input(masukan tahun: '))
prediction=-66.8+(0.03407986*value)
print (prediction)
        (6)
```

The code above allows users to input a year, which is then used in a linear regression formula to predict carbon emissions. The *int(input())* function collects the user input and converts it to an integer, which is stored in the variable nilai. The formula *prediction = -66.8 + (0.03407986 * value)* calculates the emission prediction using the regression model's intercept and coefficient values, which are based on historical data. The predicted value is then displayed using *print(prediction)*. This method provides a simple way to forecast emissions based on the year,

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leveraging the relationship between time and emissions in a linear regression model

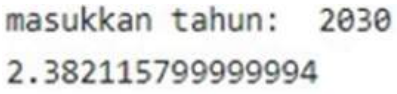

Image 6: result of prediction

Based on the image above, the prediction model estimates that carbon emissions in Indonesia will reach 2.38 units in the year 2030, based on the linear regression formula. This result indicates a consistent upward trend in emissions, aligning with projections of continued growth. By using the formula derived from historical data, the model provides insights into future emissions, allowing policymakers to anticipate environmental impacts and potentially take preventive measures.

We selected the year 2030 for our carbon emissions prediction due to Indonesia's expected demographic bonus in 2045. This five-year gap between 2030 and 2045 is significant point for assessing the potential impacts on various sectors, including the environment and public health. A significant increase in the working-age population is anticipated, which could lead to greater industrial activity, energy consumption, and, consequently, higher carbon emissions. This has a direct impact on public health, as increased emissions can exacerbate air pollution and contribute to respiratory diseases, heat-related illnesses, and other health challenges. Therefore, predicting carbon emissions for this year is crucial for anticipating future health risks and implementing effective policies for sustainable development.

III. RESULTS AND DISCUSSION

A. Prediction Result

To better understanding the prediction result, the data is presented in table below.

Tabel 1: Prediction result from 2025 to 2030

Year	Predicted Emissions (tons per capita)
2025	2.21
2026	2.24
2027	2.27
2028	2.31
2029	2.34
2030	2.38

The prediction models yielded accurate results. The Linear Regression model predicted that Indonesia's carbon emissions will rise to 2.38 tons per capita annually by 2030. The predicted carbon emissions for Indonesia show a steady increase from 2025 to 2030, with emissions per capita rising from 2.21 tons in 2025 to 2.38 tons in 2030. This gradual increase suggests a continued upward trend in emissions as industrial activities and population growth drive energy consumption. These predictions highlight the potential environmental challenges for Indonesia. Effective strategies to manage emissions are essential to mitigate the health risks associated with higher carbon levels, including respiratory issues and other pollution-related diseases.

The projected rise in carbon emissions aligns with global trends, where increasing industrialization drives emissions upward. For instance, previous research [9] demonstrates the effectiveness of machine learning in predicting embodied carbon emissions in residential buildings, reinforcing the utility of predictive models across various contexts. Similarly, studies on ammonia emissions from composting highlight the potential of machine learning in environmental modeling [10].

The findings are consistent with earlier studies that found higher carbon emissions in industrialized countries correlate with public health impacts due to poor air quality [1]. Li et al (2017)[11] Also emphasized the role of household carbon emissions in contributing to indoor and outdoor air pollution.

B. Implication for Policy

The findings of this study highlight the urgent need for Indonesia to implement strong policy measures to manage its carbon emissions. Failure to do so could result in severe environmental degradation, including rising sea levels, biodiversity loss, and public health crises [12]. The healthcare sector also contributes significantly to carbon emissions, underscoring the need for cross-sectoral strategies to reduce environmental damage[13].

Additionally, there is a growing body of evidence suggesting that carbon emissions influence broader economic indicators, such as country risk. (Chaudhry et al., 2020) demonstrated that higher emissions increase the risk profile of G7 economies[12]. Other research[14] discuss the paradox in which economic growth, driven by increased consumption, correlates with lower levels of well-being unless balanced by sustainability measures.

Other studies have also explored machine learning's role in predicting emissions across various sectors. For example, integrating building information modeling (BIM) and machine learning can help predict carbon emissions during construction phases [15]. This potential integration of technology into emissions tracking can provide valuable tools for policymakers and industries aiming to reduce their carbon footprints.

IV. CONCLUSION

This study demonstrates the utility of machine learning algorithms—specifically Linear Regression in predicting future carbon emissions in Indonesia. The model provides accurate forecasts, projecting that Indonesia's

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carbon emissions will reach 2.38 tons per capita annually by 2030. These findings underscore the urgent need for robust environmental policies aimed at reducing emissions and addressing the environmental challenges posed by rapid industrialization and urbanization.

The predicted increase in carbon emissions highlights potential environmental degradation and raises significant public health concerns. Policymakers must take proactive measures to mitigate emissions across various sectors, including energy, transportation, and healthcare. Future research could expand on this study by incorporating additional factors such as deforestation rates, industrial output, and energy consumption patterns, thereby refining predictive models and enhancing the effectiveness of environmental strategies. By leveraging machine learning and data analysis, Indonesia can develop informed policies that prioritize sustainability and public health, ultimately contributing to global efforts to combat climate change.

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Design and Development of an Android-Based Merchandise Management Application for K-pop Consignment Services

Nilam Putri Cahyani[1*)], Sutarman[2]

[1]Informatics Study Program, Faculty of Science and Technology, University Technology of Yogyakarta
[2]Department of Information Technology, Postgraduate Program, University Technology of Yogyakarta
Email : [1]nilam.5210411327@student.uty.ac.id, [2]sutarman@uty.ac.id

Abstact– The rapid development of technology has increased various societal needs, especially in the e-commerce sector, including the delivery service of K-pop merchandise. The global popularity of K-pop has led to high demand for related merchandise such as albums, lightsticks, and exclusive clothing and accessories, often difficult to source internationally. This demand creates challenges for businesses in managing product data, inventory, and transactions effectively. Zena.id, as a business providing K-pop merchandise delivery services, faces specific issues with ensuring accurate transaction recording and real-time inventory monitoring. An efficient system is needed to reduce human error, prevent inventory discrepancies, and meet customer expectations for product availability. This research aims to develop an Android-based application to automate transaction recording and inventory monitoring at Zena.id. The application is designed to improve operational efficiency through an integrated system for accurate stock monitoring and transaction processing. Developed using the Kotlin programming language and an Agile approach, this method allows for flexible, iterative improvements. Testing results showed a 83.33% accuracy rate in transaction processing and inventory updates, significantly simplifying management tasks and reducing potential errors. Additionally, the user-friendly interface enhances satisfaction for both business managers and customers. This application serves as an optimal solution to address the unique challenges faced by K-pop merchandise delivery services in the digital era.

Keywords: *Android, Goods data management, E-commerce, Kotlin*

I. INTRODUCTION

In the era of increasingly advanced technological development across various fields, societal needs have also grown significantly, particularly in e-commerce, where merchandise delivery services focused on K-pop have shown remarkable growth. The global rise of K-pop has triggered a surge in demand for various related products, ranging from music albums and clothing to official merchandise and collectibles. This phenomenon, known as the Korean Wave or Hallyu, began with the establishment of diplomatic relations between South Korea and China in 1992. In the mid-1990s, South Korea aggressively promoted its entertainment products, starting with musical dance performances and later followed by the boy band H.O.T's concert in Beijing. K-pop also entered Indonesia, triggered by South Korea hosting the 2002 World Cup, an event broadcast on Indonesian television that further popularized it [1].

Previous research has demonstrated the potential for real-time delivery information to enhance customer satisfaction [2]. Furthermore, a dropshipping website designed to bridge communication between travelers and luggage storage has proven effective in fulfilling goods needs through pre-order services [3], [4]. nother study developed a shopping consignment service application using JavaScript with the React Native and ReactJS frameworks, facilitating users in meeting their shopping needs [5]. Finally, a mobile application connecting buyers with travelers was designed using design thinking to understand user needs and provide a secure transaction platform [6].

The K-pop merchandise consignment business has become one of the rapidly growing sectors, especially in Indonesia. However, this business still faces various challenges, particularly in managing sales and inventory, which are still done manually. For instance, Zena.id uses a simple application for managing product data that often results in slow transaction recording and errors. Additionally, inventory monitoring is also done manually, leading to data inaccuracies and difficulties in tracking product availability in real time. To overcome these challenges, an innovative solution is needed for managing merchandise data for K-pop consignment businesses. One solution is the development of an Android-based application that can automate transaction recording, monitor inventory, and update order status by the admin. This merchandise data management application is developed using Android development technology specifically for e-commerce. Leveraging the advantages of the Android platform, this application is designed to simplify transaction processes and improve inventory management, providing an optimal solution to support the needs of e-commerce businesses.

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Mobile applications are among the most popular and rapidly growing technologies today, used for various purposes such as communication, information, entertainment, education, and business [7]. Android, a Linux-based mobile operating system, provides an open-source platform for developers to create applications and includes an OS, middleware, and applications [8], [9]. Initially acquired by Google Inc. from Android Inc., it offers a runtime environment called the Dalvik Virtual Machine (DVM), optimized for devices with limited memory. Android Studio, based on IntelliJ IDEA, serves as an integrated development environment (IDE) for Android development, featuring tools that assist developers, particularly those at a basic level [10]. Additionally, UML (Unified Modeling Language) provides a standardized set of diagramming techniques used to model system development projects from analysis through implementation [11]. Common UML diagrams include use case diagrams, which represent interactions between a system and external actors and illustrate relationships like extending and generalizing [12], [13]; activity diagrams, which model processes within a system using elements such as start, swimlanes, activities, branches, and end [14]; and sequence diagrams, which document processes, visualize technical scenarios during runtime, and help predict system behavior [15].

II. RESEARCH METHOD

In this research, researchers first analyzed the need for managing item data required in Zena.id. This need includes recording transactions, monitoring stock in real-time, and overall inventory management to increase operational efficiency and customer satisfaction.

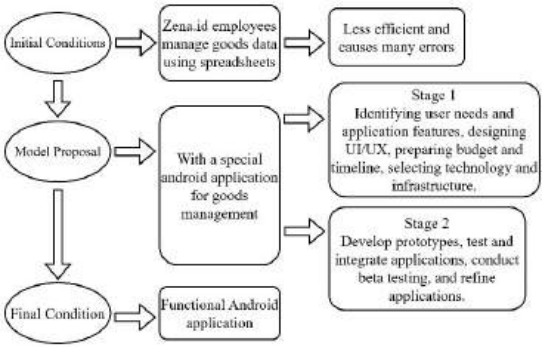

Figure 1 Research Framework

A. Initial Conditions

At this stage, the initial conditions for managing item data are still done manually. This method usually involves recording in books or spreadsheets which is errorprone and inefficient. With the increasing number of items that must be managed, manual systems are no longer sufficient. There is an urgent need to increase efficiency in stock management. Applications that can automatically update stock and provide real-time information are needed. Trends in mobile device usage drive the need for Android-based applications that can be easily accessed by users anytime and anywhere. The mobile application allows operational staff to access and manage goods data in real-time, which increases responsiveness and flexibility.

B. Proposal

Develop an Android based application that can automate stock updates and provide real-time access to users. The app is also designed to ensure a good user experience and meets industry standards.

C. Proposed Stage

This application was developed using an Agile approach, which allows for iterative development and continuous feedback at every stage. The research stages are also an ongoing and iterative process, often involving the repetition or modification of certain stages to ensure the validity and reliability of the research results [16]. The research stages carried out are as shown in Figure 2.

1. Requirements, this first stage involves analyzing the requirements to understand what features and functions the application must have.
2. Design, at this stage, the application architecture, database design, and intuitive user interface are designed.
3. Development, includes the process of writing code, system integration, and unit testing to ensure each component of the application functions properly.
4. Testing, testing is performed to ensure the functionality, performance, and security of the application is in accordance with specifications and safe to use.
5. Deployment, the application is installed on the server, users are trained, and data is moved from the old system to the new system.
6. Review, at this stage, the implementation results are reviewed, including feedback from users, to make improvements if necessary.
7. Launch, nce all processes are complete and the application has been tested and refined, the application is launched for use by users.

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Figure 2 Research Stages Using Agile Methods

III. RESULTS AND DISCUSSION

3.1 Analysis and Design

1. Functional Requirements

   Users can enter new data into the inventory with information such as name, stock and price. Users can also update stock and product prices, as well as add, edit or delete products as needed. Users can also update item data, including stock and prices, as well as add, edit and delete items as needed. Any data changes will be automatically updated in the system and validated to ensure accuracy. The low stock notification feature notifies users when stock reaches a minimum limit, allowing timely restocking or purchasing actions to be taken. Apart from that, the system also provides a complete display of item information to facilitate inventory management and monitoring. All these features a.

2. Non-Functional Needs
   a. Operating System : Android Snow Cone (Android 12)
   b. Android Studio
   c. Laptop Acer Nitro 5 AMD Ryzen 5 3550H with Radeon Vega Mobile Gfx 2.10 GHz
   d. Smartphone Vivo Y15S

3.2 Conceptual Design

1. Use Case Diagram

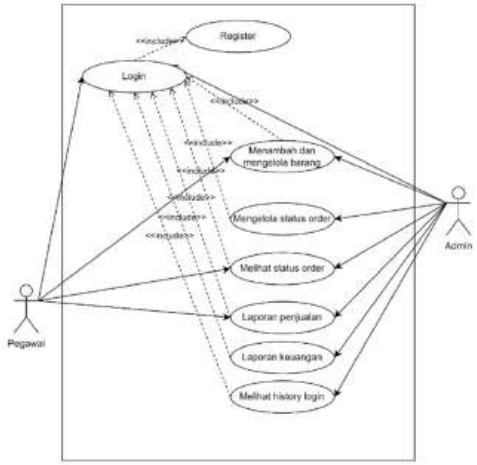

Figure 3 Use Case Diagram

In this product data management application system, there are two types of users: users (employees) and admins. Users can register and log in to access features such as adding and managing items, monitoring order status, and viewing sales reports. Admins have broader access rights, including adding, editing, or deleting items, managing order status, viewing financial reports, and monitoring user login history. This system can be accessed mobile, allowing users and admins to carry out tasks anytime and anywhere, increasing efficiency and flexibility in stock management.

2. Sequence Diagram

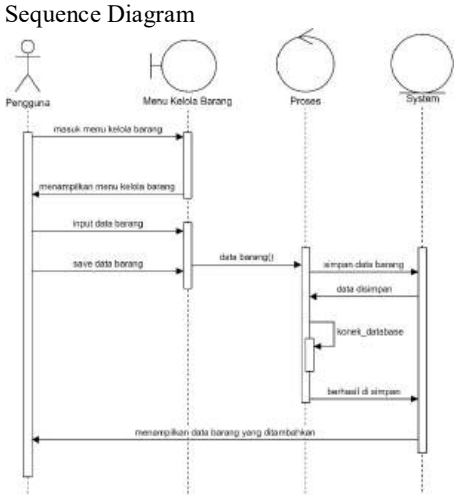

Figure 4 Sequence Diagram for Managing Goods

Shows the user opening the manage items menu. Here,, the user enters the newly added data, such as name, stock quantity, and price. After filling in all the

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information, the user presses the button to save the item data. The entered item data is sent to the "Process" component in the system. This component then contacts the database to store item data. After the item data is successfully stored in the database, the system confirms that the storage process has been successful. This confirmation is sent back to the manage items menu, which then displays the newly added items. Users can see that new items have been successfully added to the system.

3. Activity Diagram

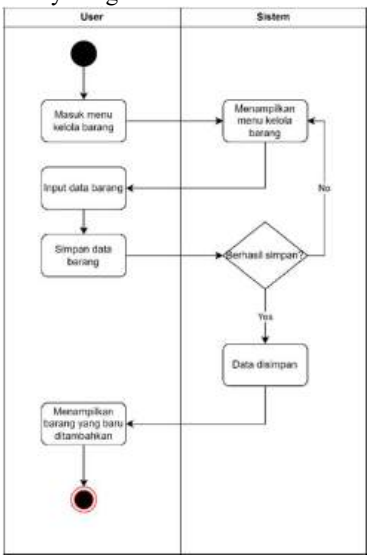

Figure 5 Activity Diagram Sequence Diagram for Managing Goods

The user accesses the item management menu in the application. The system then displays the item management menu. The user enters the data for the item they wish to add and saves that data. The system will check whether the data has been successfully saved. If the data is successfully saved, the system stores the data and displays the newly added item. If not, the system returns to the step of inputting item data for correction or to repeat the process.

3.3 Table Structure

This section discusses the tables used in the inventory management system application. A detailed table structure will help understand how data is stored and organized in the system's database. With a good understanding of the table structure, we can see how data is managed and extracted to support inventory management, transactions, and user history. The following is a detailed description of the tables used in the system.

Table 1 User

Column Name	Data Type	Information
User_id	Integer	Primary Key , unique ID for each user
Name	Varchar	User's full name
Email	Varchar	Unique email address for each user
Password	Varchar	User password

The User Table stores crucial data about each application user, including a unique user ID, full name, email address, and password. The user ID (id_pengguna) acts as the Primary Key to ensure each user has a unique identity within the system. The Name column stores the user's full name, while Email and Password are used for user authentication and communication, respectively.

Table 2 Items

Column Name	Data Type	Information
Item_id	Integer	Primary Key , unique ID for each user
Item_name	Varchar	Name of item
Stock_amount	Integer	The number of stock items available.
Price	Integer	Proce of goods per unit

The Items table stores information about the goods available in the system. This table has several columns, namely Item_id, Item_name, Stock_amount, and Price. Item_id is the Primary Key with an Integer data type that serves as a unique ID for each item. Item_name stores the name of the item in Varchar format. The Stock_amount column, with an Integer data type, indicates the quantity of stock available, while Price stores the price of the item per unit, also in Integer data type. This table allows for structured storage of item data, making it easy to manage information regarding stock and pricing.

Table 3 Transactions

Column	Data Type	Information

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Transaction_id	Integer	Primary Key , unique ID for each user
Buyer_name	Varchar	Name of the buyer who made the transaction
Item_id	Integer	Fraonresiagcnti Koney, connects to the item table
Amount	Integer	Number of items purchased
Total price	Integer	Total price for the number of items purchased
Transaction_date	Timestamp	Transaction time

The Transactions table records every transaction that occurs in the system. The columns in this table include Transaction_id, Buyer_name, Item_id, Amount, Total_price, and Transaction_date. Transaction_id is the Primary Key with an Integer data type that provides a unique ID for each transaction. Buyer_name stores the name of the buyer making the transaction in Varchar format. The Item_id column serves as a Foreign Key that links this table to the Items table, allowing for the identification of items purchased in each transaction. Amount, with an Integer data type, records the quantity of items purchased, while Total_price stores the total price for that quantity of items. The Transaction_date column, which is of Timestamp type, records the time the transaction occurred. With this table, every transaction can be fully tracked, including who the buyer is, the items purchased, their quantities, and the time of purchase.

3.4 Implementation

1. Login Page

Figure 6 Login Page

On the login page, the Zena.id logo is prominently displayed at the top center, serving as a consistent and recognizable visual identity. In the middle of the page, there is a form for users to enter their email and password, ensuring easy access. Below the password field, there is a "Forgot Password" link that allows users to reset their password if needed. Additionally, a "Login" button is conveniently placed for users to access their accounts. At the bottom of the page, a message reading "Don't have an account? Register" invites new users to sign up, making navigation and access to Zena.id services simple and user-friendly.

2. Register Page

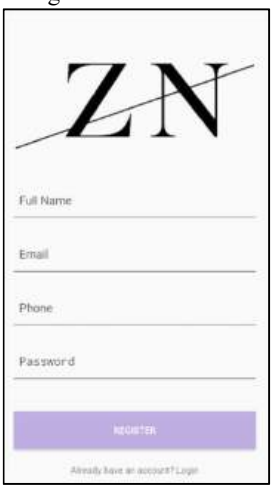

Figure 7 Register Page

The registration page prominently displays the ZN logo at the top center, ensuring brand visibility and identity.

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Below the logo, the form includes fields for users to enter their Full Name, Email, Phone, and Password, providing a straightforward and user-friendly registration process. A clearly defined Register button, styled in a light purple color, is placed at the bottom of the form for users to complete their registration. Additionally, at the very bottom of the page, a subtle message, "Already have an account? Login", encourages users who already have an account to switch to the login page. The overall design is clean, minimalistic, and functional, enhancing the user experience.

3. Main Menu Page

Figure 8 Main Menu

The Zena.id main menu page displays various product categories at the top, allowing users to explore products easily. There is a plus button (+) to add a new category. The navigation menu below includes “Items” to view and manage products, “Transactions” to track transactions, and “Order Status” to monitor orders. In addition, there is a "Reports" menu to access various important reports and "Profile" to manage user account information. The intuitive design ensures easy access to all important functions, providing an efficient and comfortable user experience.

4. Add Item Category Page

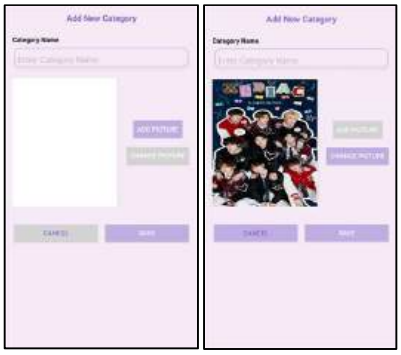

Figure 9 Add New Category

Zena.id's "Add New Category" page allows users to input category names and add photos as icons in the main menu. Users can upload photos of new icons with "Change Picture" button which makes it easy to change images. In addition, there is a "Cancel" button to cancel changes and a "Save" button to save the new category. This page design ensures the process of adding new categories is smooth and intuitive.

5. Main menu page after successfully adding an item

Figure 10 main menu page after successfully adding an item

After the image has been successfully added, the main menu page displays the new collection visible in the "Item" section. The uploaded image is clearly shown, showcasing the content related to the managed item. There is also an additional option (+) next to the image, allowing users to add a new item.

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The main navigation menu at the top still provides access to other features, such as "Transaction" and "Order Status," while the menu at the bottom continues to offer convenience for viewing reports or the user profile.

3.5 Testing

The final step is testing the system that has been created. This test was carried out to measure the extent to which problem resolution was achieved through the Zena.id application. The following is a system testing table using the black box method:

Table 4 Testing Result

No	Tested Features	Test Type	Description	Status
1.	User Registration	Functionality Testing	Test whether new users can register with valid data.	Succeed
2.	User Login	Input Validation Testing	Ensure users can log in only with the correct email and password.	Succeed
3.	Forgot Passwors	Input Validation Testing	Test whether users can request a password reset link by providing a valid email address and whether the system sends the reset link accordingly.	In Progress
4.	Upload Image	Data Limitation Testing	Test whether the system can accept images of the appropriate size and reject those that exceed the limit.	Succeed
5.	Add Item Process	Functionality Testing	Test whether users can add new items to the system with complete information.	Succeed
6.	Item Delete Process	Functionality Testing	Test whether users can delete existing items from the items list.	Succeed

IV. CONCLUSION

Based on research on the goods data management system in K-pop merchandise delivery services, it can be concluded that the system effectively restricts access based on user roles, granting owners full control over all application features while limiting staff access according to their responsibilities. This approach enhances data security and operational efficiency. The development process focuses on creating an intuitive interface, structured input forms, and

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role-based access control, making it easy for users to manage goods and transaction data. Black box testing results show an overall success rate of 83.33%, with 5 out of 6 main features functioning as expected. However, the "Forgot Password" feature remains "In Progress," accounting for 16.67% of the total tested features, indicating that further testing and optimization are required to better meet user needs and preferences.

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Development of Mobile GIS Based Digital Map Location Marking Application for Navigation Purposes

Alif Ghifari[1*)], Sutarman[2]

[1]Informatics Study Program, Faculty of Science and Technology, University Technology of Yogyakarta
[2]Department of Information Technology, Postgraduate Program, University Technology of Yogyakarta
Email : [1]alif.5210411321@student.uty.ac.id, [2]sutarman@uty.ac.id

Abstrak— In today's digital era, map and navigation applications have become essential tools for users to find locations, obtain the fastest routes, and explore new places. Google Maps is one of the most popular and comprehensive mapping applications that offers various features, such as navigation. However, despite being highly beneficial, Google Maps has several limitations, particularly regarding map markers, personalized, creating individual routes, and offline map usage on navigation. To address these issues, this research develops an innovative application called StellarPath. StellarPath is a mobile-based digital map location marker application that adopts Location Based Service (LBS) methods for more effective navigation. This application focuses on offline usability as a digital map marker and includes features such as offline maps stored indefinitely, offline navigation, manual route creation, and higher personalization, allowing users to save and manage markers with additional information offline. Test results show a success rate of 92.5%, indicating the application's effectiveness. The conclusion drawn is that the application can download and store maps offline, although it has shortcomings in managing downloaded maps. The offline navigation feature allows users to draw, save, and manage manual routes on the map. Users can create and save location markers with additional information offline. Navigation is flexible, with the option to start navigation by tapping on the map and features that can be enabled or disabled. This research aims to provide a more flexible and personalized navigation solution compared to existing standard map and navigation applications, such as Google Maps.

Keywords: Location Markers, StellarPath, Mobile GIS, Location Based Service, Kotlin, Android.

I. INTRODUCTION

The internet is one of the media increasingly utilized by the wider community, both through desktops and mobile devices. With the growing development of internet technology, it significantly aids in the development of Geographic Information Systems [1]. Location-based services are location-based services or a common term used to describe the technology used to find the location of the user's device. This service utilizes Global Positioning System (GPS) technology and cell-based location from Google [2]. A previous GIS application built by [3] facilitates tourist access to tourism information, increases visitor interest, and simplifies location searches. The development of more sophisticated and efficient navigation applications becomes relevant. Furthermore, in previous research conducted by [4], an application was developed to assist people in providing travel routes, estimated travel time, and distance. In previous research titled "Development of an Application as a Marker Regarding Thematic Creative Villages in Bogor City Smart Branding Based on Android" by [5], to deepen knowledge of navigation, techniques, and knowledge of assistive tools such as compasses, Global Positioning Systems (GPS), altimeters, and maps are crucial to learn. In addition, another important aspect to understand is reading the terrain and natural or man-made landmarks for direction. In navigation, the accuracy of location markers is essential. In previous research conducted by [6], Mobile GIS-based location mapping is an integrated technology mobile devices. By utilizing GPS and LBS technology, navigation applications can provide more precise and accurate location markers, minimizing the risk of navigation errors. In previous research, the application built by [7] used Location Based Services (LBS), utilizing the Global Positioning System (GPS).

In today's digital era, map and navigation applications have become essential tools for users to find locations, obtain the fastest routes, and explore new places. Google Maps is one of the most popular and comprehensive map applications, offering various features such as navigation. However, despite its usefulness, Google Maps has some limitations. Google Maps locks applications into the Web Mercator projection, a small set of color palettes, and a limited number of points on each map [8]. For example map markers, personalized, and creating individual routes. Google Maps automatically takes over most of the tasks, it is still a subjective requirement for them to be able to actively participate. For example, respondents state that they would like to be able to choose their own favourites from the routes presented and additionally adapt them to their own needs. In

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terms of agency, options like creating individual routes and saving favourite places are very much appreciated. This gives users the opportunity to have a say in which places could be found on the app and to actively participate in its design [9]. The visualization of route in the maps requires path information from Google server for path and GPS position from GPS system (in-built) for locations. Hence there is a need of path information for visualization which is to be fetched from the internet. However the facility of fetching path information through internet is not available in every region, especially at remote forest. In such cases, offline based navigation systems will be very helpful [10]. People often experience difficulties when there is no network connection or when encountering routes such as unmapped small roads. Mapping digital maps is challenging due to limitations in offline usage in the navigation applications used. The application like google maps, imaps provides location based service of the current location by GPS positioning or network positioning. With the combination of GPS and using Google Map API, the navigation system provides functions such as current location, get the navigation route, address query and view historical location records. However the facility of getting path information through online navigation system is insufficient in these regions as it is remote areas. It is hard to load google maps to locate in the Sathuragiri forest due to absence of network services. Thus, in this region the offline based navigation system will be suitable[11]. Google Maps is designed more for highway and city use, making it less optimal for outdoor activities in remote areas with limited internet connectivity. In this context, the proposed solution is the development of StellarPath, a mobile GIS-based application that can run on the Android platform. StellarPath offers various additional features that not only add functionality but also provide flexibility and personalization. Key features such as digital map markers and other features like unlimited offline map storage, offline navigation, manual route creation, and higher personalization. In its implementation, the StellarPath application uses OpenStreetMap. When downloading, extracting and symbolizing the data can be successful if the map on OpenStreetMap is enlarged to a large scale, scale 1: 2000 or greater for areas of heavy building or up to a scale of 1: 10,000 for rural areas with less number of buildings [12]. With a base map using free OpenStreetMap this application is ideal for users who frequently engage in outdoor activities involving routes not mapped by Google Maps or travel to areas with limited internet connectivity. This solution is expected to provide a better experience for users in mapping and managing location information in their daily lives. Based on the above problems, the researcher created a mobile GIS-based application that runs on the Android platform and developed it as a Final Project for the Informatics Department at Yogyakarta Technology University.

1.1. Theoretical Foundation

Android is an operating system widely used on mobile devices that is currently very well-known and popular on smartphones. Android is also a programming platform developed by Google for smartphones and other mobile devices [13]. Android provides tools and development environments such as Android Studio, SDK, Open Street Maps Library, Location Services, SQLite Database, and Google Play Services. Android Studio is a native mobile development environment that is easy to understand and use. Google launched Android Studio as a new integrated development environment (IDE) for Android based on IntelliJ IDEA [14]. Android Studio is used to build mobile GIS-based digital map location marker applications that can be used with devices equipped with Global Positioning System (GPS) technology. The Global Positioning System (GPS) is a satellite-based navigation system consisting of interconnected satellites in orbit. With 24 satellites in use. To determine a person's position, a device called a GPS receiver is needed, which functions to receive signals sent from GPS satellites [15]. The key to developing a application for navigation using Location Based Services is a service that functions to search using Global Positioning Service (GPS) technology and Google's Cell-based Location. Maps and location-based services use latitude and longitude to determine geographic locations [16]. Mobile GIS is an integration of mobile device technology, the Global Positioning System (GPS), and wireless communication to access GIS on the internet. The combination of these technologies allows mobile GIS to capture, store, update, manipulate, analyze, and display geographic information accurately. Thus, through this technology, a database can be created that is accessed directly by personnel in the field at any place and time [17]. This system accelerates access and decision-making based on geospatial data, which is very useful in various navigation and mapping applications. Based on maps using OpenStreetMap, OpenStreetMap

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(OSM) is an open-source mapping project that provides free and editable map data to the public. Unlike proprietary mapping platforms such as Google Maps and Mapbox, OpenStreetMap allows developers to access, use, and contribute to map data freely without restrictions. To integrate OpenStreetMap into your Android app, you can use third-party libraries such as osmdroid or Mapsforge, which provide APIs for displaying OSM tiles, adding markers, overlays, and annotations, and interacting with map features [18]. SQLite is a lightweight relational database management system that is integrated in the form of a library. Unlike other relational database management systems such as MySQL or PostgreSQL, SQLite does not use a server to manage connections and data storage [19]. SQLite can be used to store data such as locations, routes, and other information related to location-based applications. Additionally, use of Unified Modeling Language (UML) in system application design allows visual language for modeling object-oriented languages, all elements and diagrams are based on the object-oriented paradigm [20]. Diagrams such as use case diagrams are used to illustrate the system's functionality from the perspective of users or actors [21], activity diagrams serve as a graphical representation of the workflow sequence from the beginning to the end of a system or part of a system [22], and sequence diagrams represent interactions. These interactions can take the form of functions, procedures, or variables [23].

II. RESEARCH METHOD

In this research, researchers analyzed the need for an Android application that can create digital map markers and can be used offline and makes it possible to navigate offline and create manual routes.

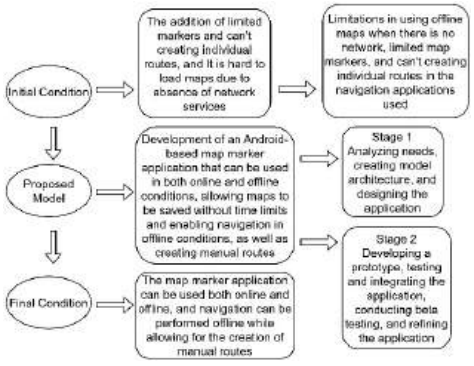

Figure 1 Research Method

A. Initial Condition

The use of the Google Maps application on mobile devices connected to the internet and GPS satellites for navigation. Users utilize mobile devices, such as smartphones or tablets, to access the navigation application. These mobile devices are connected to GPS satellites to accurately determine the user's location. Users open the Google Maps application on their mobile device to search for locations to visit, or they can use markers that have limitations to navigate to already known locations. The mobile device must be connected to the internet to access all features of Google Maps, including obtaining directions. After finding the destination, users utilize the navigation feature in Google Maps. Routes are provided from Google's servers, so users cannot create their own routes. If the mobile device loses internet connectivity, users cannot use the real-time navigation feature because Google Maps requires an internet connection to update maps and provide directions live.

B. Proposal

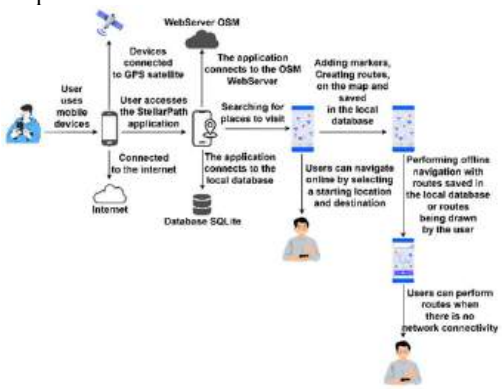

Figure 2 Architecture Model

The use of the StellarPath application on mobile devices connected to the internet and GPS satellites for navigation, with the added capability of offline navigation. Users utilize mobile devices, such as smartphones or tablets, connected to GPS satellites to accurately determine their location. Users open the StellarPath application on their mobile device to mark locations they have visited or wish to visit, and these markers are saved, allowing users to manage them; the markers are stored in the device's local storage. The mobile device must be connected to the internet for the StellarPath application to access the web server, which is necessary for logging in and registering on the app, as well as downloading maps for offline use, while the

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local SQLite database does not require internet access. The application allows users to add and manage markers, create manual routes, and save downloaded maps to local storage indefinitely, enabling users to navigate even without an internet connection based on previously drawn routes. Thus, users can continue to navigate and proceed with their journey without relying on an internet connection.

C. Proposed stage
   1. User needs analysis, This stage begins with understanding the features and experiences required in the application, both online and offline. The goal of this analysis is to ensure that the application will meet user needs under various conditions.
   2. Designing the application model architecture, After the needs have been identified, an architectural model design is created to support features such as offline map marker storage, offline navigation, and manual route creation. This design determines how each feature will work together within a single application system.
   3. Defining the application structure, At this stage, the main components of the application are established, including the integration of SQLite for local data storage, the implementation of OSM Maps, and the use of CacheManager for downloading offline maps. This is crucial to support the use of the application without an internet connection.
   4. User interface (UI/UX) design, The UI/UX is designed to make the application easy to use in various conditions, both online and offline. This design considers ease of navigation and feature usage to ensure that users remain comfortable while using the application without internet access.
   5. Developing the application prototype, Based on the design that has been created, the application prototype is developed. This prototype includes the implementation of features such as displaying maps, downloading maps, adding markers, creating manual routes, and offline as well as online navigation.
   6. Testing and integrating the application, After the prototype is completed, functional testing is conducted to ensure all features work well, especially when used without an internet connection. Integration between components is tested to minimize bugs and ensure the stability of the application.
   7. Beta testing by end users, This testing involves end users who test the application on a larger scale to gather feedback. The main goal is to ensure the application's performance and ease of use.
   8. Refining the application, Based on feedback from beta testing, the application is improved and refined. This includes fixing identified bugs, as well as adding features that users need to enhance their experience and satisfaction.

III. RESULT AND DISCUSSION

3.1. Analysis and Design

1. Functioal Requirements

   A functional mobile GIS-based digital map application requires various crucial inputs to operate. Key inputs include downloadable map data for offline use, start and end points for navigation from user-added map markers, and marker coordinates (latitude and longitude) to pinpoint marker locations on the map. Users must also input customizable route information and additional details such as name, address, category, and notes for markers. Core processes include downloading and storing maps for offline access, calculating optimal routes using a navigation algorithm, and creating manual routes. The application also manages markers with additional information. Outputs include offline maps accessible without internet connection, manual routes enabling offline navigation, and personally accessible and manageable markers with additional information, all available offline.
2. Non-functional Requirements
   a. Hardware Requirements
      1. Laptop Asus TUF Gaming F15 with Intel(R) Core(TM) i5- 10300H

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CPU @ 2.50GHz, SSD 500 GB, RAM 8.00 GB
2. Xiaomi Redmi Note 8 Android Smartphone MIUI Global 12.0.1 Android Version 10

b. Software Requirements
1. Microsoft Office
2. Google Chrome
3. Android Studio Hedgehog | 2023.1.1 Patch 2
4. XAMPP version 3.3.0
5. Android Software Development Kit (SDK)
6. Android Development Tools

3.2. Conceptual Design

1. Use Case Diagrams

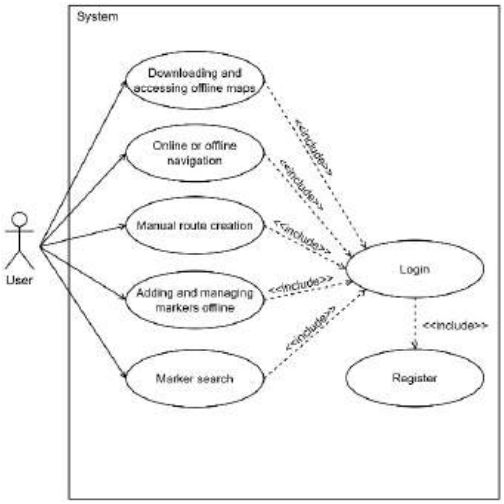

Figure 3 Use Case Diagrams

Users must register first then log in to be able to use the application. Users download maps for offline use. After the map is saved, users can open and view the map without requiring an internet connection. The user determines the starting point and destination from the saved map markers. The application provides directions from the user's location to the destination without requiring an internet connection, using previously downloaded maps. Users can draw routes manually on the map by marking the desired points. Drawn routes can be saved for later use. Users can add markers at desired locations on the map by providing details such as place name, address, category and notes. These markers can be viewed, edited, or deleted at any time. Users can search for map markers using the search feature available in the application.

2. Sequence Diagrams

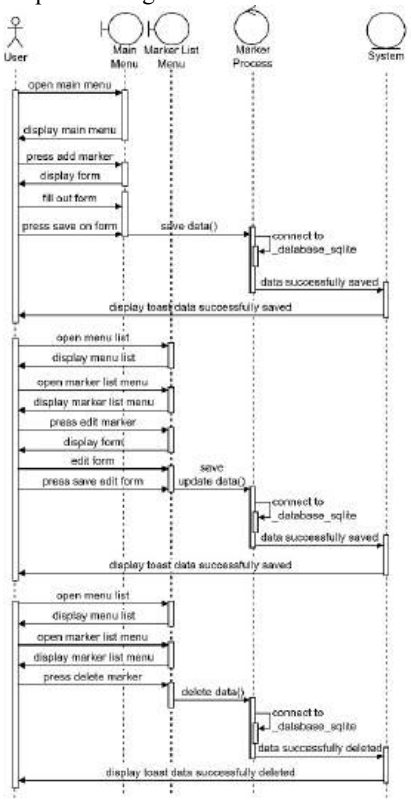

Figure 4 Sequence Diagram Adding and Managing Markers

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The user opens the main menu, and the system presents it. The user selects "Add Marker," prompting a form to appear, which the user fills out before pressing "Save." The marker data is then saved in the SQLite database, and upon successful saving, a toast notification appears. The user opens the menu list, and the system displays it. The user accesses the marker list menu, and the system shows the marker list. The user presses "Edit Marker," and the form for the marker to be edited appears. After completing the edits, the user presses "Save," and the changes to the stored data in the SQLite database are updated. If successful, a toast notification will appear. The user opens the menu list again, and the system displays it. The user accesses the marker list menu, and the system shows the marker list. The user presses "Delete Marker," and the corresponding data in the SQLite database is deleted. Upon successful deletion, a toast notification appears.

3. Activity Diagram

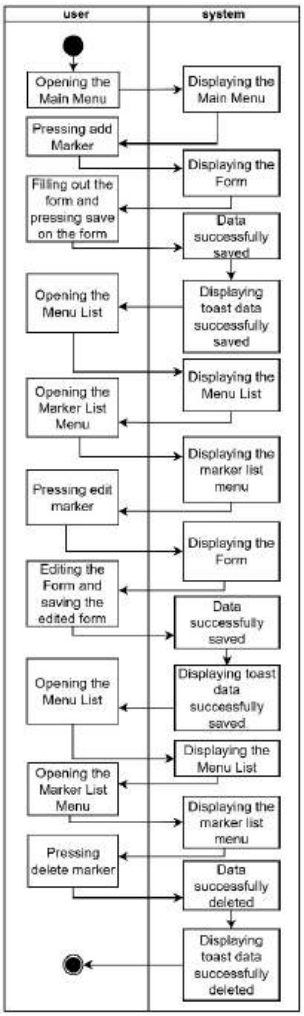

Figure 5 Activity Diagram Add and manage Markers

The user opens the main menu, and the system presents it. The user presses "Add Marker," prompting the system to show a form. The user fills in the form and presses "Save," after which the system saves the data and displays a toast indicating successful saving. The user opens the menu list, and the system displays it. The user then opens the marker list, and the system shows the marker list menu. The user presses "Edit Marker," leading the system to display the form. The user edits the form and saves the data, and the system saves it, displaying a toast that the data has been saved successfully. The user opens the menu list again, and the system displays it. The user opens the marker list, and the system shows the marker list menu. The

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user presses "Delete Marker," and the system deletes the data, displaying a toast confirming that the data has been successfully deleted.

3.3. Table Structure

This section will explain how data is stored, managed and accessed. This table structure section will make it easier to manage existing data in the system, increase efficiency in data searches, and maintain data integrity between tables. With clear primary keys, foreign keys and data types. The following are details of each table used in the system.

Table 1 User

Column	Data Type	Information
Id_name	INT (10)	Primary key, autoincrement
username	VARCHAR (255)	Unique username for users
email	VARCHAR (255)	Unique email for users
password	VARCHAR (255)	Password for users
created_at	TIMESTAMP	The time when the user was created
updated_at	TIMESTAMP	The time when the user was created

The StellarPath application's User table stores crucial user data. The `id_name` column is a unique, auto-incrementing primary key. The `username` column serves as a unique identifier for login, while the `email` column stores a unique email address for each user, usable as an alternative identifier and for communication or account recovery purposes. The `password` column stores the user's encrypted password for security. The `created_at` column records the account creation time, and `updated_at` records the last time user data was updated, helping track changes within the StellarPath application.

Table 2 Markers

Column	Data Type	Information
Id_name	INT (10)	Primary key, autoincrement
User_id	INT (10)	Foreign key to table users
title	VARCHAR (255)	Marker title
address	VARCHAR (255)	Marker address
category	VARCHAR (255)	Marker category
note	TEXT (500)	Additional notes for markers
latitude	DOUBLE	Latitude of marker
longitude	DOUBLE	Longitude of marker
created_at	TIMESTAMP	Time moment markers made
updated_at	TIMESTAMP	Time moment markers last updated

Tabel Routes in application StellarPath Stores location information marked by the user. The `id_name` column is a unique primary key, and `user_id` links the marker to the user in the `User` table. The `title` and `address` columns contain the marker's title and address, while `category` stores the location category, such as "Tourism" or "Restaurant". `note` is used for additional notes. The `latitude` and `longitude` columns store the location coordinates, while `created_at` and `updated_at` record the creation and update times of the marker.

Table 3 Routes

Column	Data Type	Information
Id_name	INT (10)	Primary key, autoincrement
User_id	INT (10)	Foreign key to table users
route_name	VARCHAR(255)	Route
route_data	TEXT	Route data in compressed format (for example, encoded)
created_at	TIMESTAMP	Time moment markers made
updated_at	TIMESTAMP	Time moment markers last updated

Tabel Routes in application StellarPath Storing user route data, with the `id_name` column as a unique, auto-incrementing primary key, and `user_id` as a foreign key linking the route to the user in the `User` table. The `route_name` column stores the route name, while `route_data` stores the route data in a compressed format (e.g., encoded). The `created_at` column records the route creation time, and `updated_at` records the

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last time the route was updated, useful for tracking data changes.

3.4. IMPLEMENTATION

1. Main Menu

Figure 6 Main Menu

The Main Menu page of the StellarPath application is designed simply to create a cleaner appearance because the main page displays a map. In the upper left corner there is a "three line" which will go to the menu list page, at the top there is also the name of the StellarPath application as a sign that the maps application used is called StellarPath, in the lower right corner there is a logo like "paper plane" and also a logo like "circle with a dot in the middle", this logo is a navigation feature and a feature for following users in the StellarPath application. At the bottom there is a column for searching for markers. In the top right corner there is a feature for adding markers, to make it clearer and easier for users, the display uses "+" which means to add and also says "Add Marker", the appearance of this main menu will make it simpler for users to utilize the StellarPath service.

2. Marker List Page

Figure 7 List Marker

The List Markers page is designed to make it easier for users to manage markers. In the top left corner there is a very clear word "List Markers" to inform that the user is now in the list markers menu. And also at the bottom of the list of markers there is the text "Last added" to notify the user of the last markers added. In the list of markers there is the name of the marker and also the address. The design is also made simple to make it easier for users, then at the bottom of each of these markers there are symbols such as "pencil" and also "trash can". These symbols are functions for editing and deleting markers, the design is made to make it simpler

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for users to utilize the StellarPath application services.

3. Download Maps Page

Figure 8 Download Maps

The Download Maps page is designed cleanly, in the top left corner there is a symbol to return to the previous page, at the bottom there is a button that says "download" which functions to start the download, the appearance of this page is quite small, not much is added.

3.5. TESTING

This process aims to evaluate and verify that a software or system works as expected. Testing is carried out to ensure that the StellarPath application is free from bugs, has good performance, and meets user needs and specifications.

Table 4 Blackbox Main Menu

No	Testing Scenario	Expected Result	Test Results	Test Results
1.	Adding Markers	Successfully added a marker to the map	Marker can added And appears on the map as well as in	Valid
2.	Displaying Marker Name	Displays marker names when the marker is tapped	The marker successfully appears when tapped	Valid
3.	Displaying Marker Details	Displays marker details when tapped	Detail from marker appears when tapped	Valid
4.	Opens Menu List	Displays a list menu application	List Menu appeared successfully	Valid
5.	Close the Menu List	The menu list is successfully closed when pressing the back button	The Menu List closes when pressing the back button	Valid
6.	Open a Manage Route option in the List Menu	Successfully opened the Manage Route option	The Manage Route option opens when tapped	Valid
7.	Open a New Route Manual option in the List Menu	Successfully opened the New Route Manual option	Option New Manual Route opens when tapped	Valid
8.	Open a Download Maps option in the List Menu	Successfully opened the Download Maps option	The Download Maps option opens when tapped	Valid
9.	Open a Manage Maps option in the List Menu	Successfully opened the Manage Maps option	The Manage Maps option opens when tapped	Valid
10.	Open a Marker List option in the List Menu	Successfully opened the Marker List option	The Marker List option opens when tapped	Valid
11.	Activate Follow Location	The map display will automatically track the user's current location.	The map display tracks the user's current location.	Valid
12.	Deactivate Following Location	The map display does not track the user's current location.	The map display does not track the user's current location.	Valid
13.	Press search marker and enter the	Successfully displays the name of the marker you	The marker name successfully appears	Valid

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	marker name registered	are looking for	when searched	
14.	Reset Map to Default View	Successfully reset the map to default view	Resetting the default view on the map was successful	Valid
15.	Open map in condition offline	Map will is displayed on application	Map succeed come on stage on application	Valid
16.	Zoom In and Zoom Out	Map zoom in and out works without errors	Zoom functionality works as expected	Valid
17.	Activate the navigation feature	Displays n toast notifications when the feature is active	A toast notification appears when the feature is activated	Valid
18.	Disable navigation features	Displays a toast notification when the feature is deactivated and the navigation route disappears	A toast notification appears when the feature is activated and the navigation route on the map is lost	
19.	Navigate the user's location to the marker	Displays user location toast notifications and marker name toasts	The user location toast notification and marker name toast successfully appear	Valid
20.	Navigate the user's location to a random destination location	Displays user location toast notifications and destination location toasts	The user location toast notification and the destination location toast notification successfully appear	Valid
21.	Marker navigation to the user's location a	Displays marker name toast notifications and user location toasts	The marker name toast notification and user location toast notification successfully appeared	Valid
22.	Marker navigation to the user's location	Displays marker name toast notifications and user location toasts	The marker name toast notification and user location toast notification successfully appeared	Valid
23.	Marker navigation to the marker	Displays notifications toasting the name of the initial marker and toasting the name of the destination marker	The initial marker name toast notification and the target marker name toast notification have successfully appeared	Valid
24.	Marker navigation to a random destination location	Displays toast notifications for marker names and destination location toasts	The marker name toast notification and destination location toast successfully appeared	Valid
25.	Navigate random starting location to marker	Displays initial location toast notification and marker name toast	The initial location toast notification and marker name toast successfully appeared	Valid
26.	Navigate from a random start location to a random destination location	Displays initial location toast notifications and destination location toasts	The initial location toast and destination location toast notifications successfully appeared	Valid

The Blackbox Main Menu table in the StellarPath application is a test of the main menu features

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including adding markers, menu list, navigation, zoom, and offline conditions.

Table 5 Blackbox Download Maps

No	Testing Scenario	Expected Result	Test Results	Test Results
1.	Downloading the Map	Map success downloaded and can be saved	Map succeed downloaded And saved successfully	Valid
2.	Zoom in dan Zoom out pada peta	Map zoom in and out works without errors	Zoom functionality works as expected	Valid
3.	Resume Map Download after Disconnect	Can continue downloading maps when the network is not connected	Downloading maps cannot continue when not connected to a network	Invalid
4.	Notifications and toast when the maps are successfully downloaded d	Displays notifications toast when maps successfully download and displays the number of tiles downloaded	Displayed successfully the toast notification and number of tiles downloaded	Valid

The Blackbox Download Maps table in the StellarPath application is a feature test when downloading Maps, including notifications and whether it is possible to continue downloading when not connected to the internet.

Table 6 Blackbox Marker List

No	Testing Scenario	Expected Result	Test Results	Test Results
1.	Editing Markers	Successfully changed the marker information in the marker list	Displays the form And users Can edit And save	Valid
2.	Edit Latitude dan Longitude	Cannot edit Latitude and Langitude	When editing Latitude and Longitude cannot be edited	Valid
3.	Deleting Markers	The success marker is deleted and does not exist on the map or marker list	The marker has been successfully deleted from the marker list or map	Valid

The Blackbox Marker List table for the StellarPath application is a test of the Marker List feature for editing and deleting markers.

Table 7 Blackbox New Route Manual

No	Testing Scenario	Expected Result	Test Results	Test Results
1.	Draw a Polyline on the map	Successfully draw a Polyline on the map	The polyline is successfully drawn by tapping on the map	Valid
2.	Save the drawn Polyline pan	Successfully save and name the polyline that has been drawn	The polyline was successfully saved and named	Valid
3.	Zoom in dan Zoom out pada peta	Map zoom in and out works without errors	Zoom functionality works as expected	Valid

The Blackbox New Route Manual table in the StellarPath application is a feature test when drawing Manual Routes with Polylines.

Table 8 Blackbox Manage Maps

No	Testing Scenario	Expected Result	Test Results	Test Results
1.	Displays a list of Maps that have been downloaded d	Displays the size and list of Maps that have been downloaded	Maps list and sizes do not appear	Invalid
2.	Delete us Maps that have been downloaded d	Successfully deleted the downloaded Maps	The downloaded maps were not successfully deleted	Invalid

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The Blackbox Manage Maps table in the StellarPath application is a feature test when managing downloaded Maps.

Table 9 Blackbox Manage Route

No	Testing Scenario	Expected Result	Test Results	Test Results
1.	Displays a list of routes that have been drawn	Successfully displays n list of drawn routes	The list of routes Drawn successfully is displayed	Valid
2.	Delete the route that has been drawn	Successfully deleted the drawn route	Route which already drawn successfully deleted	Valid

The Blackbox Manage Route table in the StellarPath application is a feature test when managing pre-drawn Routes.

IV. CONCLUSION

Based on the research on the Development of a Mobile GIS-Based Digital Map Location Marker Application for Navigational Purposes Using the Location Based Service Method. With a focus on offline capabilities, this application provides a more flexible and personalized solution for users' navigation needs. The testing of the application's features was conducted by calculating the success rate $= \left(\frac{\text{Number of Passed Tests}}{\text{Total Tests}}\right) \times 100\%$, resulting in a success rate $= \left(\frac{37}{40}\right) \times 100\% = 92.5\%$. Thus, the following conclusions can be drawn:

a. This application enables users to download maps and save them for offline use, allowing access without an internet connection. Users can also manually create their own routes and save them for offline use, however, it has drawbacks such as the inability to resume downloads when the connection is interrupted and challenges in managing downloaded maps, which can lead to the application size increasing significantly with the number of maps downloaded.
b. The application provides features that enable offline navigation with routes that can be drawn on the map, allowing users to manage those routes.
c. The application offers marker features that can be created and saved with various additional information; these markers can be stored and managed offline, making it easier for users to locate marked locations.
d. The application provides flexible navigation; users can navigate by tapping on the map, and this navigation feature can be activated and deactivated.

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Development of Paramadina Roomhub Application As Room Booking System Using Waterfall Method

Reza Arif Maulana[1*)], Muhamad Adillah Fatih[2], Lintang Arbi Suto[3], Muhammad Darwis[4]
[1234]Program Studi Teknik Informatika, Fakultas Ilmu Rekayasa, Universitas Paramadina
Email: [1]reza.maulana@students.paramadina.ac.id, [2]muhamad.fatih@students.paramadina.ac.id,
[3]lintang.suto@students.paramadina.ac.id, [4]muhammad.darwis@paramadina.ac.id

Abstract – The manual room booking process at Paramadina University faces several challenges, including inefficiencies, human errors, and communication breakdowns between applicants and facility managers. These issues often result in room booking conflicts and delays, hindering effective facility usage. The need for a more streamlined, user-friendly solution led to the development of the Roomhub Paramadina application, a web-based system designed to facilitate room bookings within the university. The objective of this research is to design and implement a digital room booking system that simplifies the current manual process. The application was developed using the Software Development Life Cycle (SDLC) with the Waterfall framework. This approach ensures structured and systematic development, enabling the team to follow sequential stages from requirements gathering to testing. The Roomhub application allows users to view available rooms, submit booking requests, and receive confirmations directly via an online platform. The system integrates with existing university infrastructure and ensures real-time room availability, reducing errors such as double bookings. Black-box testing was employed to verify the application's functionality, and the results confirmed that the system meets user needs while significantly improving booking efficiency. By automating room bookings and enhancing communication between the parties involved, this research offers a practical solution that improves operational efficiency, reduces paperwork, and minimizes scheduling conflicts, thereby benefiting the entire academic community at Paramadina University.

Keywords – Room Booking System, Web-Based Application, Software Development, Waterfall Methodology, Blackbox Testing

I. INTRODUCTION

Paramadina University is located in Jakarta, Indonesia, and was established in 1998[1]. Currently, Paramadina University has three campuses distributed across the Jabodetabek area, with one located in Cipayung, East Jakarta. The university offers a range of public facilities, including classrooms, laboratories, lecture halls, auditoriums, meeting rooms, sports fields, and other communal areas[2].

In providing its services, Paramadina University permits the Paramadina academic community to utilize these facilities for purposes other than their primary function, namely as lecture halls. The aforementioned facilities are available to all Paramadina academicians who have been granted the requisite access rights, which include students, lecturers, and university employees. To gain permission to use the facilities, individuals must submit a request for a facility booking.

Paramadina University has established a dedicated unit to oversee the utilization of public facilities within its campus. This unit is responsible for maintaining accurate records, organizing scheduling, and issuing permits for each facility. Furthermore, it provides supervisory support to ensure the safe and effective operation of these facilities. Paramadina University has established a dedicated public facility management team for each of its campuses. The Study Program Service Unit (UPPS) oversees the management of public facilities at the Cipayung Campus. Consequently, any Paramadina academic seeking to utilize public facilities on this campus must liaise with or submit a request to the relevant team via email.

To utilize campus facilities, specifically rooms, whether regular classrooms, conference rooms, lecture halls, or other such rooms, the Paramadina academic community must submit a book request to UPPS via email. Subsequently, the UPPS will process the request by forwarding it to the Directorate of Student Affairs and Business Incubator (DKI) to facilitate a follow-up response. If the request is approved, the DKI will issue a formal approval email to the UPPS, which will then process and record the request and provide relevant details to the Public Facilities Unit and the applicant. However, if the request is not approved, the DKI will issue an official rejection email, which will be subsequently conveyed to the applicant.

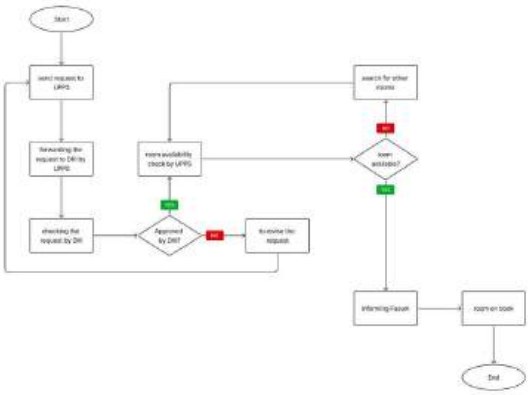

Figure 1. Room Booking Flow

It should be noted that the room identified in the booking application may not be suitable for use, despite the approval of DKI. There are several potential causes for this, such as maintenance work, the room being occupied, or it having been booked to another party. In

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such circumstances, the applicant is expected to identify an alternative room and submit a revised application, replacing the initial room specified.

Furthermore, additional factors influence the process of borrowing facilities, particularly rooms. These include the regulations that accompany the borrowing process. Based on the author's and his colleagues' direct experience of applying for a room booking, the regulations include:

1. Requests for room use must be made at least seven days before the date in question.
2. Should the room in question be used for an event, the event proposal must be approved in advance.
3. All student activities must be approved by the DKI.
4. Requests for room use must be accompanied by details of productive activities.

With such a process, and influenced by the rules in the booking process, the author considers the process inefficient. The application must pass through many stages involving many parties, so the bureaucracy is complex and time-consuming.

The conventional and manual facility booking systems and processes are susceptible to human error. There is a high probability of data loss or inadequate documentation, and communication breakdowns between applicants and room managers, which can result in erroneous information regarding space availability, double recording, potential clashes in space usage schedules, and coordination challenges[3], [4], [5]. The precise specifications, facilities/infrastructure, and status of each room are not clearly defined, making it challenging for applicants to select the optimal room[6].

With technological advances, the problems that exist in the conventional process can be avoided. Researchers take advantage of this moment to develop innovations that facilitate the process of booking facilities, especially rooms. Based on this momentum, the author conducted research with the objective of developing a web-based application designed to facilitate the management of public facilities, including the booking process. This application is designed to markedly enhance the velocity, convenience, and efficacy of public facility services, particularly in regard to rooms. The application was developed using the Software Development Life Cycle (SDLC) approach with the Waterfall Framework. The Waterfall Framework was selected for its emphasis on structured and sequential steps, which result in comprehensive and detailed documentation[7], [8]. The sequential nature of the stages facilitates comprehension of the process by team members from both technical and non-technical perspectives[9]. Allows for better project control and facilitates communication within the team.

II. RESEARCH METHODS

This research employs descriptive qualitative methods to gain a comprehensive understanding of the phenomenon through detailed descriptions, making it a suitable method for application development. In this research, application development uses the SDLC (Software Development Life Cycle) approach with a Waterfall framework. In the context of application development, the SDLC was selected as the preferred methodology due to its capacity to provide a structured framework for the effective planning, development, and management of applications. The SDLC is an economical and commonly used methodology for developing quality software. It comprises several models that facilitate a simple and systematic development process[10].

The Waterfall framework is frequently selected for its linear and sequential nature, wherein each phase must be completed before the next phase begins. The Waterfall framework is frequently selected for its linear and sequential nature, wherein each phase must be completed before the subsequent phase commences. This structured approach is well-suited to projects with clearly defined and unchanging requirements, while also reducing the likelihood of significant alterations during the development phase[11].

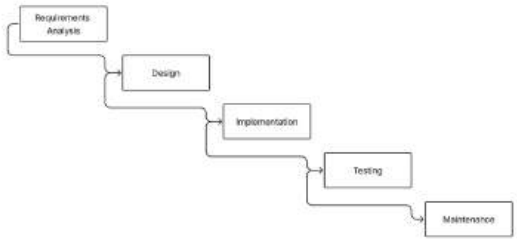

Figure 2. Waterfall Framework

The stages of the Waterfall model are as follows[12], [13]:

1. Requirement Analysis: this stage is the initial stage that serves to collect information about user needs and application requirements to be made.
2. Design: at this stage, an overall application design is made, starting from application architecture, database architecture, and user interface design.
3. Implementation: This stage involves creating an application based on the design that has been made in the previous stage.
4. Testing: at this stage, the application that has been created is then tested to ensure that the application runs well and in accordance with the application requirements.
5. Maintenance: after the application has been implemented and tested, further maintenance of the application is carried out which includes bug fixes, improving application performance, optimization, and adding new features.

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The selection of the Waterfall method over other SDLC frameworks, such as Agile or Spiral, is based on the necessity for a more structured and controlled approach to application development projects with a fixed scope. While alternative frameworks, such as Agile, are more flexible and accommodate iterative changes, the Waterfall framework provides greater stability in projects with clearly defined requirements from the outset[11].

A. Requirement Analysis

At this stage, the author collects information related to user needs and applications that will be designed and developed. This process involved interviews with the academic community of Paramadina University, including lecturers, students, and managers of campus public facilities. The interviews aimed to gain an in-depth understanding of user needs. These interviews are important in analyzing the needs of application development because they help identify features that meet user needs[14].

The objective of the interviews was to gain insight into the process of applying for a room booking. The interviews were conducted either in person or via an online platform, depending on the respondent's readiness and preference. The duration of the interviews varied, with an average time of approximately 15 to 30 minutes per session. The data obtained from the interviews were meticulously recorded and analyzed to identify common patterns related to user and system needs. The results of this analysis serve as the foundation for formulating appropriate system specifications that meet those needs.

B. Design

System design is carried out using the Unified Modelling Language (UML) modeling concept which includes structural and behavioral aspects, through use case diagrams, activity diagrams, and class diagrams. These three diagrams represent a comprehensive modeling of the system architecture of the RoomHub Paramadina application. UML is a visual modeling language used to describe the needs of software analysis and design[15]. UML has the potential to serve as a detailed and comprehensive blueprint. In this context, UML can provide detailed information about the source code, facilitating program understanding, debugging, and maintenance, and enabling the reading of program code and its conversion into diagrammatic form[16].

C. Implementation

The implementation phase entails the creation of an application that adheres to the specifications outlined in the system design. The chosen framework comprises Next.js for the client side, Express.js for the server side, Node.js as the runtime, and MongoDB as the database.

a. Next.js

Next.js is a React-based framework that enables the development of web applications with a range of features, including integrated CSS, built-in routing, layout, and image and font optimization. Next.js permits the utilization of pre-rendering and server-side rendering techniques to reduce the time required for application loading. Next.js provides efficient development support by optimizing application performance through code splitting, prefetching, and lazy loading. Additionally, Next.js offers comprehensive documentation and interactive courses to facilitate the acquisition of knowledge and proficiency in the proper use of Next.js[17].

b. Express.js

Express.js is a server-side framework for Node.js that has gained considerable popularity due to its efficacy in facilitating the development of web applications and Application Programming Interfaces (APIs). Express.js was designed to facilitate the construction of Node. js-based applications. It offers a suite of robust yet straightforward tools for the development of diverse web applications and API services. The framework is renowned for its capacity to process Hypertext Transfer Protocol (HTTP) requests, route data, utilize middleware, manage requests and responses, and provide features that expedite the development process. Additionally, Express.js enables the integration of middleware and other Node.js modules, considerably expanding its functional capabilities[18], [19].

c. Node.js

Node.js is an open-source runtime environment and cross-platform for executing JavaScript code. Node.js, released in 2009 by Ryan Dahl, enables developers to create client-side and server-side applications using JavaScript. Node.js runs using the V8 JavaScript engine, thereby enabling the execution of JavaScript code outside the browser environment. Node.js serves as the foundation for Express.js and Next.js. Express.js employs Node.js as a runtime environment for developing web applications with JavaScript. Next.js, at a more advanced level, utilizes Node.js and, on occasion, Express.js as a basis to provide a more robust set of tools for building more complex and feature-rich web applications[20], [21].

d. MongoDB

MongoDB is a document-based NoSQL database that stores data in JavaScript Object Notation (JSON) or Binary JSON (BSON) format. In contrast to relational databases such as MySQL or PostgreSQL, MongoDB is a non-relational database that permits more flexible and scalable data storage, thereby rendering MongoDB a reliable choice for storing large volumes of data[22], [23].

D. Testing

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At this stage, the system is tested using the Blackbox method to ensure that the application functions properly and meets user needs. The Blackbox testing method is an approach that tests an application without considering the internal structure and logic of the code. This approach focuses on analyzing the input and output of the application, without requiring a deep understanding of the source code or application design[24].

A number of references from various scientific journals indicate that this test is oriented toward user needs and ensures application conformance to predefined specifications. Furthermore, it is carried out without access to internal system details. For example, research conducted by Dwi et al. in the article "Testing Learning Media for English Learning Applications Using Black-Box Testing Based on Equivalence Partitions" [25] demonstrates the efficacy of black-box testing in identifying defects in English learning media applications. Other references also illustrate that black-box testing is an effective approach for detecting errors without requiring access to the internal workings or source code of an application[26], [27], [28], [29].

E. Maintenance

Although the maintenance stage represents the final phase of the Waterfall method, this research concludes at the testing stage, as the objectives of the design process for this application have been met and the issue has been resolved.

III. RESULT AND DISCUSSION

A. Requirement Analysis

The author identifies the scope of applicability based on information obtained through interviews with relevant parties. The scope of applicability is constrained by the data provided by the facility manager, which pertains to the rooms available on campus and the booking periods permitted in accordance with campus policy. This data is essential for the author to develop a room booking application.

B. Design

System design is carried out using the Unified Modelling Language (UML) modeling concept which includes structural and behavioral structures with use case diagrams, activity diagrams, and class diagrams, where the three diagrams already reflect the system architecture modeling of the RoomHub Paramadina application.

a. Use Case Diagram

A use case diagram provides an overview of the overall application, including the interactions between users (actors) and the RoomHub Paramadina application (use cases). A use case diagram comprises four principal components: actors, use cases, use case diagrams, and use case diagram scenarios. In this diagram, the author delineates the use case for each scenario and determines the interaction between the actor and the system use case. The diagram contains two cases: the Room Information case and the Room Loan use case. The design diagram that elucidates the interaction between actors and use cases is illustrated in Figure 3.

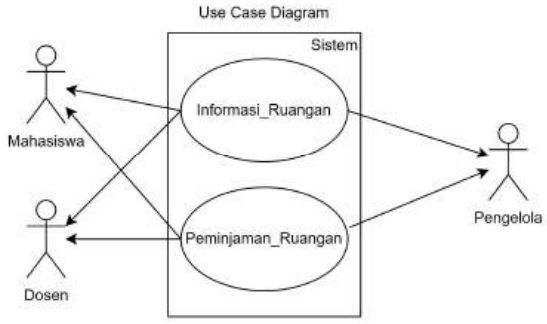

Figure 3. Use Case Diagram

b. Activity Diagram

The next diagram is the Activity Diagram. An activity diagram is a flexible instrument to describe the behavior or workings of a system and the internal logic of complex operations. This diagram helps describe in a simple way how the flow of events from the use case works. There are three Activity Diagrams shown in Figures 4, 5, and 6 to explain the behavior or workings of each use case.

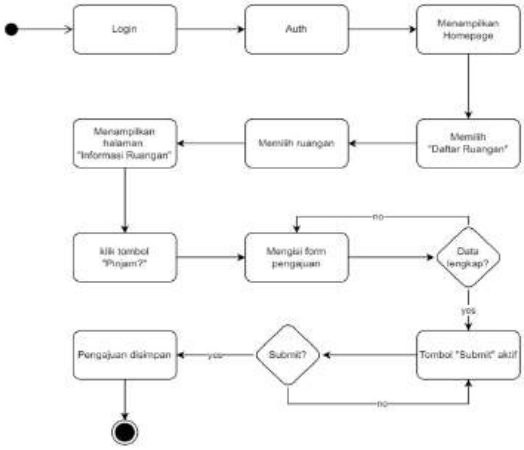

Figure 4. Activity Diagram of Room Booking

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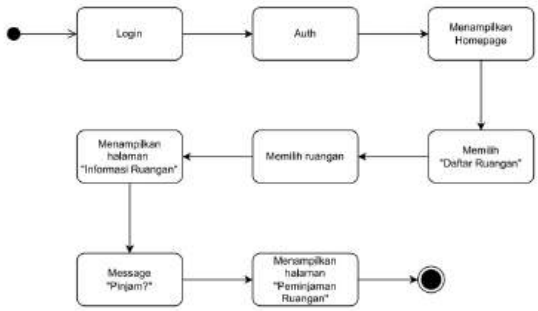

Figure 5. Activity Diagram of Room Information for Lecturers and Students

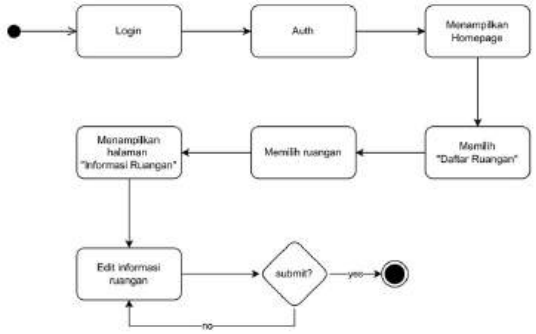

Figure 6. Activity Diagram of Room Information for Manager

c. Diagram Class

A class diagram is a UML diagram that displays the classes in software and the relationships between them[3]. The class diagram designed by the author comprises a User class that delegates its attributes and methods to the Student, Lecturer, and Manager classes, which possess a single distinctive method. Additionally, there is a Booking class and a Room class. Each class is also linked by a relation to delineate the association between classes. The class diagram for the RoomHub Paramadina application is illustrated in Figure 7.

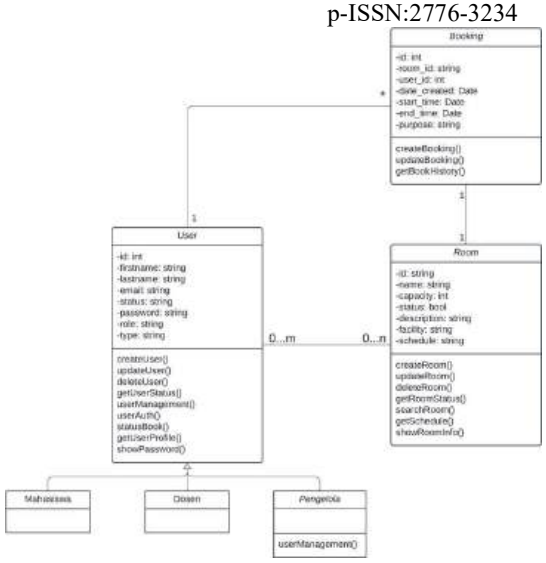

Figure 7. Class Diagram of RoomHub Paramadina

C. Implementation

The results of designing an application using the waterfall method on the RoomHub Paramadina web-based application, which produces several menus that will be utilized by the user, are presented herein. To gain access, users must first click the "Sign in with Google" button, which will prompt them to enter their Paramadina University student Google account credentials. Once the login process is complete, users are granted access to the feature that allows them to view room information and make room reservations. Once a room has been reserved, the user is able to view the booking history. Subsequently, the manager is able to modify room information, add new rooms, and delete existing rooms.

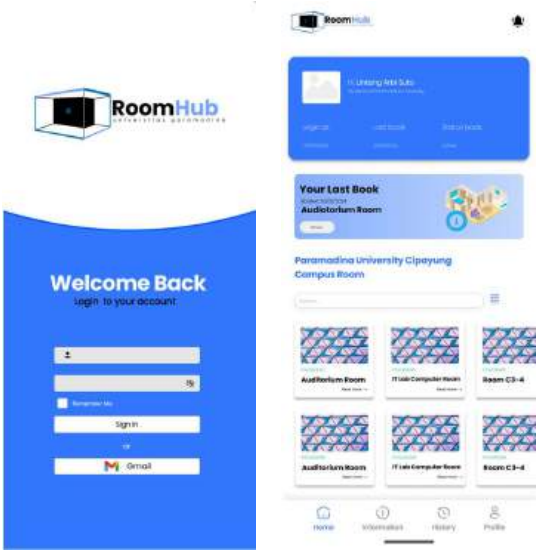

Figure 8 & 9. Login Page and Landing Page

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Figure 8 illustrates the login page. This page enables users to input the requisite account information, including the username and password. Additionally, the interface provides a button for logging in with a Google account, as well as options for password recollection and viewing. Moreover, upon successful authentication, the user is redirected to the landing page depicted in Figure 9. This page presents the user with information regarding their account, including login status, the most recent booking, and the status of any active bookings. Additionally, a list of available rooms on campus is provided, with the option of searching for specific criteria and viewing the status of room availability. The navigation bar located at the bottom of the page provides users with convenient access to the Home, Information, History, and Profile pages.

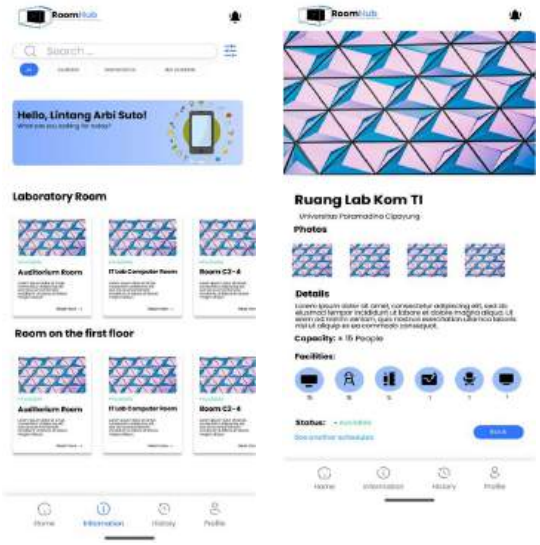

Figure 10 & 11. Room Information and Room Details page

Next one is the Room Information page, as illustrated in Figure 10, which permits users to search and filter rooms based on their availability (All, Available, Unavailable). A list of rooms is provided, with each room designated by a unique availability status, such as Room C3-4. Upon selecting a room card, the user will be redirected to the comprehensive room information displayed in Figure 11. The user is able to view photographs of the room, a succinct description, the room's capacity, the facilities that are available, and the room's current status in terms of availability. A button labeled "Book" is provided for users to reserve the room. Additionally, a navigation bar is located at the bottom of the page, allowing users to navigate between different application pages.

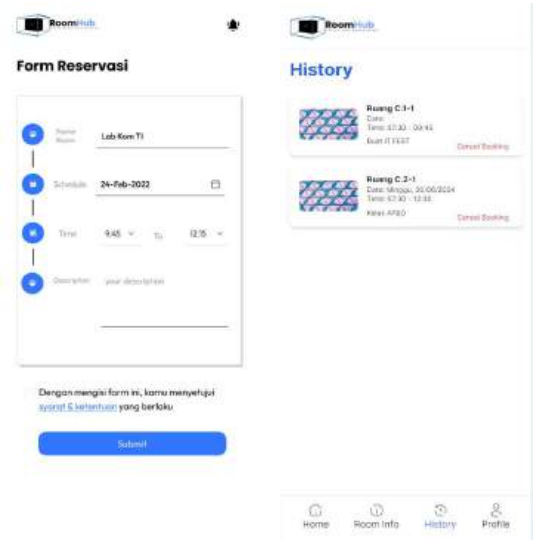

Figure 12 & 13. Room Booking Form and Room Booking History Page

Subsequently, upon clicking the "Book" button, the user will be redirected to the Booking Form page, as illustrated in Figure 12. This page allows the user to input the name of the room, the date, time, and a description of the booking. Additionally, the user must agree to the terms and conditions before proceeding. Subsequently, the user will be redirected to the History page, as illustrated in Figure 13. The History page presents a chronological record of room bookings, accompanied by pertinent details such as the time, event, and the option to cancel the reservation.

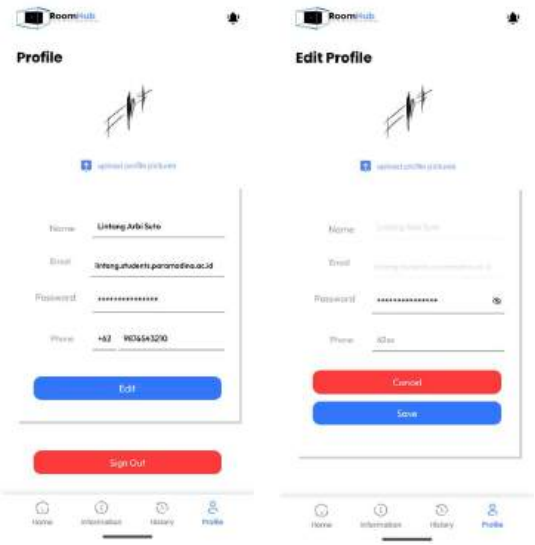

Figure 14 & 15. User Profile and Edit Profile page

Additionally, the user is able to view the account profile by navigating to the User Profile page, as illustrated in Figure 14. This section contains the user

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profile details, including the user's name, email address, and other personal information. It also includes an option to edit the profile data, should the user wish to do so. Moreover, should the user wish to modify the profile, an Edit button will direct the user to the Edit Profile page, as illustrated in Figure 15. The user is afforded the opportunity to modify the password and to add or alter the phone number. Once the requisite modifications have been made, the user may save the profile data by selecting the Save button.

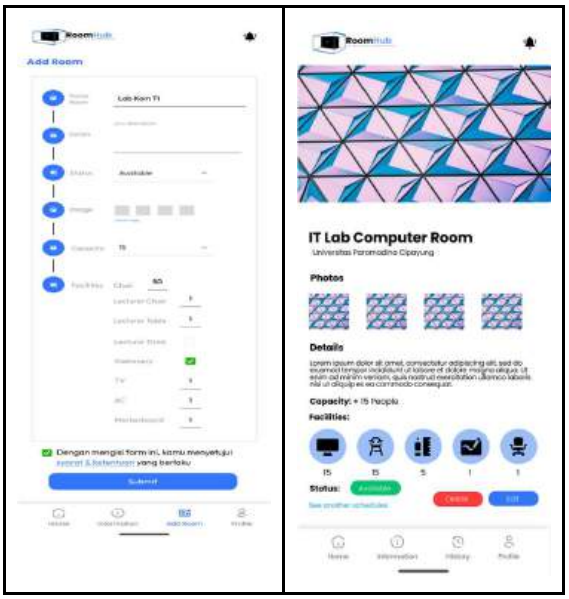

Figure 16 & 17. Room Addition and Room Information Page for Manager

Subsequently, one should proceed to the administrator or manager section, where the administrator is able to create a new room. Once the manager has successfully completed the login process, he or she will be redirected to the Admin Dashboard page. Subsequently, the manager is able to navigate to the button labelled "Add Room" in order to add a room. Figure 16 illustrates the Room Addition Page, which allows the manager to input the necessary information to add a new room to the system. This includes details such as the room name, capacity, and available facilities. To finalize the addition of the room, the manager must press the "Submit" button. Should the manager wish to modify the data pertaining to the room in question, they may navigate to the landing page, which lists all rooms. Subsequently, the manager may select a room for which they wish to modify the data, which will direct them to the Room Information page for Managers, as illustrated in Figure 17. This page enables the manager to view comprehensive details regarding the room, including capacity, facilities, and availability status, with the option to edit or manage the room information.

Figure 18. Room Information Edit Page

To modify room data, the manager must first press the "Edit" button. This action will direct the manager to the "Edit Room" page, as illustrated in Figure 18. This page enables the manager to modify room-related data, including the room name, capacity, facilities, and current availability status, which have been previously documented within the system.

D. Testing

At this stage, the author assesses the functionality of the proposed application. The objective of testing is to ascertain that the application functions in accordance with the specifications set forth in the design. The Black-box method is employed for the purpose of testing. The results of the tests are presented in tabular form.

Table 1Test Result Using Blackbox Testing Method

Test Case	Condition	Instruction	Expected Result	Test Result	Explanation
Login	Email and password	Enter a valid email and password, then click “Login”.	User successfully logs in and is	Login succeeds	The system validates the user's credentials,

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	input are correct		redirected to the main page		redirecting to the dashboard if valid.
Login	Email and password input are incorrect	Enter the wrong email or password	Displays the error message "Email or password is incorrect"	Error message displayed	The system checks the credentials, denies access and displays an error message.
Room Booking	Input of available rooms	Select an available room, fill in the data, click "Book"	The room is successfully booked and appears in the booking list	Booking successful	The system saves the booking data and updates the user's booking list.
Room Information	Display detailed room information	Select a room to see detailed information	Detail room information displayed (facilities, capacity, etc.)	Information shown	The system retrieves the room data from the database and displays it to the user.
Room Information Edit (Admin)	Admin edits the room information	Admin changes the room information, then clicks "Save"	Room information updated successfully	Information updated successfully	The system saves the changes to the room data in the database.
Delete Room (Admin)	Admin deletes a room	Admin select a room and click "Delete"	The room is successfully removed from the system	Room removed	The system deletes the room data from the database and updates the room list.
Room Search	Room search based on keywords	Enter the room name or room code in the search field	Rooms that match the keywords appear	The room appears	The system searches by keyword and displays relevant results.

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IV. CONCLUSION

The findings of the research conducted thus far indicate that the web-based RoomHub Paramadina application architecture with a mobile display has been successfully developed. The application offers the ability to view room information and make reservations for rooms at Paramadina University, particularly at the Cipayung Campus, without the necessity of direct interaction or submission of a loan letter to the Paramadina Student Council and Business Incubator (DKI) and Cipayung Campus academic services. The RoomHub Paramadina architecture has been equipped with a draft interface that can be tested at an early stage in accordance with the concept of prototyping, which allows for rapid testing to obtain an initial overview of the application. The prototyping process has only been completed once, with subsequent cycles planned to incorporate improvements. At this preliminary stage, the interface design and implementation have yielded the anticipated outcomes, yet further advancement is necessary. The Unified Modelling Language (UML) was employed as an appropriate notation to model the system architecture and provide a transparent representation of the system's operational logic.

The following recommendations are offered for consideration: System design using the object-oriented analysis and design (OOAD) method requires meticulous planning, particularly in object-based design, to ensure that the system model document is comprehensive and suitable for immediate implementation. Moreover, software development based on the prototyping paradigm necessitates the completion of several additional cycles to ensure that the resulting software is optimized to meet user needs and analysis.

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Development of a React Native-Based Mobile E-Commerce Application to Optimize Online Sales for MSMEs: A Case Study of New Delisio Bakery Cake

William Kessler Suryanto[1], Sulistyo Dwi Sancoko[2]
[1]Program Studi Informatika, Fakultas Sains dan Teknologi, Universitas Teknologi Yogyakarta
[2]Program Studi Sains Data, Fakultas Sains dan Teknologi, Universitas Teknologi Yogyakarta
Email: [1]williamksuryanto@gmail.com, [2]sulistyo.dwisancoko@staff.uty.ac.id

Abstract – The development of a mobile-based e-commerce application aims to assist MSMEs, particularly New Delisio Bakery Cake, in optimizing their online sales and expanding market reach. Currently, New Delisio operates using conventional methods that limit its customer base and overall sales potential. To address this challenge, the application was developed following the waterfall methodology, encompassing requirements analysis, design, implementation, testing, and deployment. The front-end was built using React Native, while the back-end utilized Express.js and MongoDB. A user testing phase was conducted with a sample group, providing valuable feedback on usability and functionality. The application offers a user-friendly platform for customers to browse and purchase products, while enabling the business to efficiently manage operations. The test results showed a high overall success rate of 92.52%, with 91.11% success for user interactions and 100% for admin tasks. This demonstrates the application's effectiveness in enhancing usability and functionality. By leveraging modern mobile technology, the solution enhances the store's visibility, engagement, and scalability, potentially increasing revenue. This research demonstrates the potential for MSMEs to transition into the digital market through a structured development process and iterative improvements.

Keywords – *Mobile E-Commerce, Online Sales Optimization, React Native, Waterfall Method, Market Expansion*

I. INTRODUCTION

The rapid advancement of information technology has integrated the internet into daily human life, transforming it into a dynamic medium for efficient information access and online transactions[1], [2]. Users can conveniently browse, request, and pay for products from the comfort of their homes, significantly saving time and effort. This shift has encouraged many small businesses to adopt online sales systems to increase revenue [3]. However, many micro, small, and medium enterprises (MSMEs), such as New Delisio Bakery in East Bekasi, continue to rely on conventional sales methods, which results in inefficiencies and long wait times for customers who must visit the store to place orders.

Previous studies have explored mobile applications as a solution for improving business operations. While some solutions have demonstrated success, they often lack scalability and user-friendliness, making them less effective for MSMEs [4]. For instance, many existing systems fail to cater to the specific operational challenges faced by small businesses, including inventory management and customer engagement [5]. Addressing these gaps, this research proposes the development of a mobile-based e-commerce application using React Native and Express.js with MongoDB, aimed specifically at enhancing New Delisio's operational efficiency and expanding its market reach.

The objective of this research is to create a user-friendly, scalable mobile e-commerce application that simplifies order management for New Delisio Bakery, enhances customer experience, and increases market visibility. By addressing the limitations of conventional methods and previous solutions, this study aims to provide a digital transformation model tailored to MSMEs, ultimately optimizing online sales and increasing revenue [6].

1.1 Literature Review

1. Bakery Shop

A bakery shop is a retail outlet focused on the creation and sale of a range of baked items, including bread, pastries, cakes, and cookies [7].

2. Online Sales System

The online sales system (e-commerce) designed not only aims to simplify the purchasing process for consumers, but also to provide more complete product information and increase customer satisfaction. In developing this system, needs analysis, system design, implementation, and testing are carried out to ensure that the website built can meet user needs and function optimally [8].

3. Mobile Application

A mobile application (app) is a software program designed to run on mobile devices, such as smartphones and tablets, providing users with specific functionalities or services, often enhancing user experience and accessibility[9].

4. User Interface (UI/UX)

User Interface (UI) is a communication mechanism between the user (user) and the system in a program, be it a website, mobile, or software application. User Experience (UX) refers to the overall interaction and satisfaction a user has with a program, focusing on enhancing the user's experience, unlike User Interface (UI), which centers on the design elements [10].

5. React Native

React Native is a JavaScript framework for writing real, natively rendering mobile applications for iOS and Android [11].

6. ExpressJS

Express is a Web Framework built upon Node.js. Express builds on top of its features to provide easy to use functionality that satisfies the needs of the Web Server use-case [12].

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7. MongoDB

MongoDB is a powerful, flexible, and scalable general-purpose database. It combines the ability to scale out with features such as secondary indexes, range queries, sorting, aggregations, and geospatial indexes [13].

8. Cloudinary

Cloudinary provides a secure and comprehensive API (Application Programing Interface) for users to easily upload images from the server side directly in the browser or from mobile applications [14].

9. Stripe

Stripe is a payment platform, app and services platform based on APIs that can be implemented directly in code or no-code [15].

10. Unified Modeling Language

The Unified Modeling Language (UML) is the standard modeling language for software and systems development [16].

11. Use Case Diagram

A use case is all the ways of using a system to achieve a particular goal for a particular user. Taken together the set of all the use cases gives you all the useful ways to use the system and illustrates the value that it will provide [17].

12. Entity Relationship Diagram

The ER diagram is a semantic data modeling tool that is used to accomplish the goal of abstractly describing or portraying data [18].

13. Waterfall Method

The Waterfall Model is a linear, sequential software development process where each phase must be completed before the next begins, with no overlap. It ensures project success by following a step-by-step, phase-based approach [19].

II. RESEARCH METHODOLOGY

2.1 Research Framework

The following is a phased research framework.

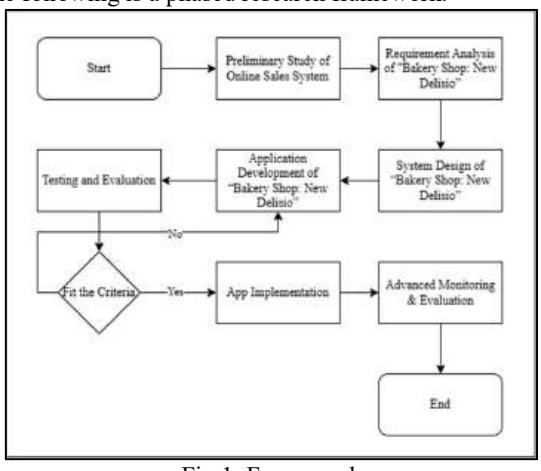

Fig 1. Framework

This research follows a phased framework illustrated in Fig 1, comprising several critical stages before deploying the application. These include a preliminary study of existing online sales systems, a needs analysis for New Delisio Bakery, system design, application development using React Native, testing and evaluation, and implementation. Post-launch, the application undergoes continuous monitoring and evaluation based on user feedback to ensure it meets the bakery's evolving needs.

2.2 Development Model

This research uses the Waterfall model. This model was chosen because it has the advantage of structuring the software development process in a linear and structured manner, allowing detailed identification of old system problems. Each stage in the Waterfall model, such as requirements analysis, system design, implementation, deployment, and maintenance, is carried out sequentially. This makes it easier to determine and identify the needs of the new system to be built more precisely and systematically. In addition, this approach minimizes the risk of errors by ensuring that each phase must be completed before moving on to the next phase, which is especially important in the development of complex e-commerce applications.

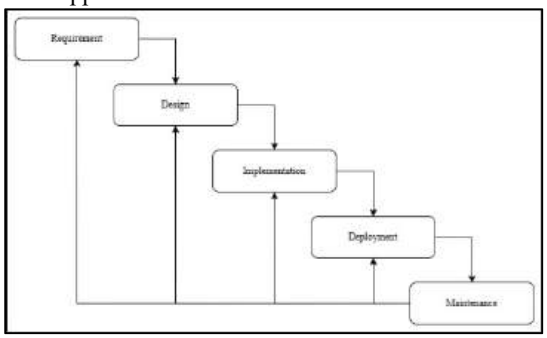

Fig 2. Waterfall Model

Each stage is described below:

2.2.1 Requirement

The system requirement analysis stage will carry out the following activities:

2.2.1.1 Analysis User Needs

The activities conducted in this research began with gathering initial information regarding the existing system to identify the problems encountered. The process of collecting primary data was carried out through surveys and direct field observations, as well as interviews with respondents, specifically the owners and managers of New Delisio Bakery. Additionally, a literature review was performed to obtain relevant information. To explore specific data, particularly concerning the challenges faced, focus group discussions were employed involving customers and bakery staff. The data collected was then analyzed to identify the needs and potential solutions for the development of this mobile e-commerce application.

2.2.1.2 Identification System

The New Delisio Bakery mobile e-commerce application is designed to enhance the efficiency of order management and improve customer engagement. The system comprises three main components: the front end, back end, and database. The front end, developed using React Native, provides an interactive user interface for customers, allowing them to browse products, place orders, and manage their accounts, as well as an admin panel for business owners. The back end, built on Express.js, handles API requests, manages user authentication, and processes data operations, ensuring secure and efficient communication between the front end and the database. For

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data management, the application utilizes MongoDB, which stores essential data such as product information, user profiles, and transaction records, providing a scalable and flexible solution [13], [20]. Additionally, the system integrates external services like Cloudinary for image management and Stripe for secure payment processing, ensuring a smooth and user-friendly experience for all users.

2.2.1.3 Identification System Needs

The New Delisio Bakery mobile e-commerce application requires specific needs to effectively serve both customers and business owners. First, it needs to support user registration and authentication, allowing customers to create accounts and securely log in. The application must also provide a robust product browsing feature, enabling users to search, filter, and view detailed product information, including images and descriptions.

Additionally, the system requires a shopping cart functionality that allows customers to add, edit, and remove items while displaying the total cost. A seamless checkout process is essential, integrating secure payment processing through Stripe and providing various payment options. The application should also include order tracking capabilities so customers can monitor the status of their purchases.

2.2.2 Design System

The system design stage aims to model the mobile e-commerce application that will be implemented for New Delisio Bakery. This stage involves two key activities: first, creating a general design of the system using UML diagrams to illustrate the various components and their interactions. This includes class diagrams that describe the processes occurring within each class, along with their attributes and relationships with other classes, specifically tailored to meet the functional and non-functional requirements identified earlier.

Second, the newly created class diagrams are analyzed and refined to define attributes that represent the identity of each entity, leading to the development of a Data Dictionary. This dictionary provides detailed descriptions of each entity's unique attributes, ensuring clarity in data management. Following this, an Entity-Relationship Diagram (E-R Diagram) is constructed to visualize the relationships between different entities in the system, such as products, users, and transactions. The E-R Diagram serves as a foundation for designing the database schema, which is then translated into structured tables within the MongoDB database, ensuring that all necessary data structures are in place for the effective functioning of the application.

2.2.3 Implementation

The implementation phase aims to build the mobile e-commerce application and its associated database according to the results of the system design. This stage involves two crucial steps following the design phase:

2.2.3.1 Developing the Application

This includes writing the code for the user interface (UI) using React Native, ensuring it provides an intuitive and engaging experience for customers and an effective admin panel for business owners. Additionally, the backend is developed using Express.js, creating the necessary API endpoints to facilitate communication between the mobile application and the MongoDB database.

2.2.3.2 Testing the Application

After the development of both the user interface and the backend, comprehensive testing is conducted. This includes functional testing of the user interface to ensure that all features work as intended, as well as testing the backend for API functionality, database integration, and payment processing with Stripe. This phase is essential to identify and rectify any issues before the application goes live, ensuring a smooth user experience and operational efficiency.

2.2.4 Deployment

Comprehensive testing was conducted to ensure functionality and accuracy using real operational data before the official launch.

2.2.5 Maintenance

Ongoing maintenance and updates were established based on user feedback to guarantee optimal performance and user satisfaction.

III. Results And Discussion

3.1 Analyze Current System Problems

The technology applied in the New Delisio Bakery mobile e-commerce application includes Stripe API for payment processing and Cloudinary for image storage. By utilizing the Stripe payment gateway, users can securely complete their transactions online, ensuring a smooth and efficient checkout experience. The integration of Stripe allows for various payment options, enhancing customer convenience and fostering trust in the payment process.

In addition to payment processing, the application leverages Cloudinary for efficient image management. This technology enables the bakery to store, optimize, and serve product images seamlessly. With Cloudinary, the application can deliver high-quality images while ensuring fast loading times, which is crucial for maintaining user engagement.

For customers browsing through the mobile application, the combination of Stripe and Cloudinary creates a cohesive and user-friendly experience. Customers can view appealing images of bakery products and complete their purchases with confidence, knowing that their payment information is securely handled. This integration not only simplifies the purchasing process but also enhances the overall functionality of the application, making it an essential aspect of the digital transformation for New Delisio Bakery.

3.2 Non-functional Requirement Analysis

The application must load quickly, targeting a response time of less than two seconds for all interactions to provide a smooth user experience. Additionally, the system should accommodate an increasing number of users and transactions without performance degradation,

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particularly during peak times. Robust security measures are crucial, including encryption for data transmission and compliance with PCI DSS standards for payment processing via the Stripe API. The user interface must be intuitive and accessible to a diverse demographic, ensuring clear navigation and responsive design. Furthermore, the system should maintain a target uptime of 99.9% to ensure high availability and minimal interruptions for users.

3.3 Functional Requirements Analysis

Functional requirements define the specific behaviors and functionalities that the New Delisio Bakery mobile e-commerce application must support.

1. The application must allow users to create accounts and securely log in using email and password. Users should have the option to reset their passwords and verify their accounts through email confirmation.
2. The system must enable administrators to add, update, and delete product listings, including descriptions, prices, and images. Products should be categorized for easy navigation.
3. Users should be able to add products to a shopping cart, view their selected items, modify quantities, and remove items before proceeding to checkout.
4. The application must facilitate the checkout process, allowing users to review their orders, and select payment methods. The system should handle order confirmations and send notifications to users upon successful purchases.
5. The application must integrate with the Stripe payment gateway to process secure online payments, including support for various payment methods (credit/debit cards, digital wallets, etc.).
6. Users should have access to their order history, including details of past purchases and current order statuses. This functionality should allow users to track their orders until delivery.
7. The application must provide a search feature that allows users to find products quickly. Filtering options should enable users to sort products by categories, price range, and popularity.
8. The application must include an admin panel for managing products, change user order status, and monitoring sales performance

3.4 Application Architecture Analysis

The physical architecture of the system is based on a two-tier application architecture model. This architecture comprises four primary components: the Client, the Application Server, the Database Server, and the Payment Gateway Server. The structure of the New Delisio application is illustrated in Fig 3 below.

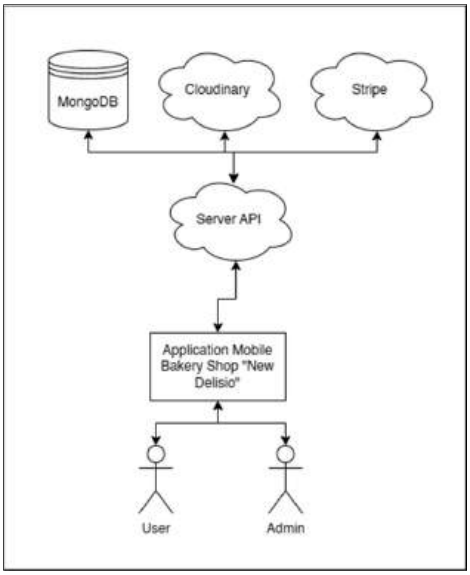

Fig 3. System Architecture

3.5 Software Features

This application includes features tailored to the roles of both the admin and the user.

3.5.1 Admin Authority

The admin has the following capabilities:

1) Manage overall product inventory.
2) Manage product categories.
3) Update order statuses.

3.5.2 User Authority

Users are granted the following functionalities:

1) Register for a new account.
2) Sign in to an existing account.
3) Change or reset their password.
4) View order history.
5) Check order status.
6) Update their profile information.
7) Change their shipping address.
8) Browse available products.
9) Search for specific products.
10) Filter products by category.
11) Add products to the shopping cart.
12) Modify the quantity of items to purchase.
13) Complete online payments.
14) Perform sign out.

3.6 Application Model

3.6.1 Use Case Diagram

The use case diagram depicts the interactions between the actors and the system. The first actor is the user of the mobile frontend application, who interacts with the app. The second actor is the admin, who engages with the admin panel via mobile application.

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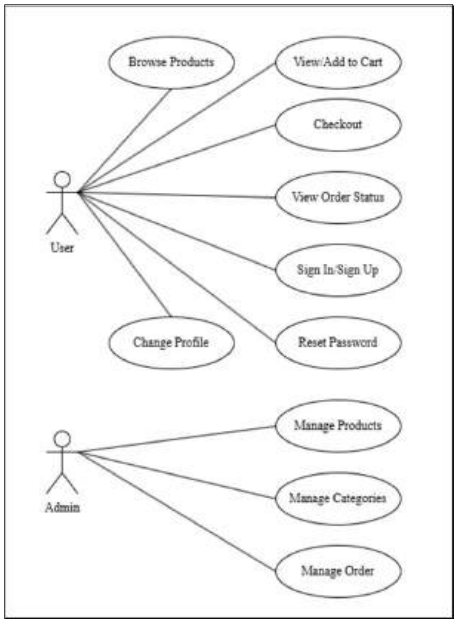

Fig 4. Use Case Diagram

3.6.2 Entity Relational Diagram

While this research uses a non-relational database (MongoDB), an ER-Diagram still provides valuable visualization of entities and their relationships within the system [18]. It outlines key collections, such as Users, Products, Transaction, Admin, and their connections, offering essential guidance for structuring data and ensuring coherent application design. The structure of the New Delisio database is illustrated in Fig 5 below.

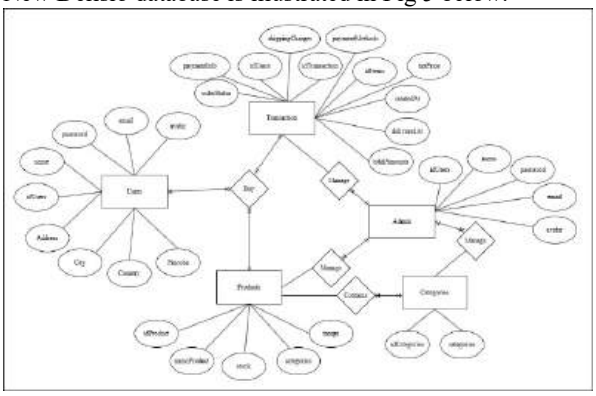

Fig 5. Entity Relational Diagram

3.6.3 Dictionary Data

This dictionary provides an outline of main attributes, data types, and descriptions for each field.

Table 1. Dictionary Data

Name Field	Type	Description
idUser	String (UUID)	Unique identifier for each user
name	String	Full name of the user
email	String	User's email address for login and contact
password	String (hashed)	Hashed password for user authentication
role	String	Role of the user
address	String	Primary address for the user
city	String	City of the user's address
country	String	Country of the user's address
pincode	Number	Postal code of the user's address
avatar	String (URL)	URL to the user's avatar image
idProduct	String (UUID)	Unique identifier for each product
nameProduct	String	Name of the product
stock	String	Available quantity of the product
imageProduct	String (URL)	URL to the product image
idCategories	String (UUID)	Unique identifier for each product category
category	String	Name of the product category
idTransaction	String (UUID)	Unique identifier for each transaction
shippingInfo	String	Shipping details and address
paymentMethod	String	Payment method used
paymentInfo	String	Additional payment information or reference
itemsPrice	Decimal	Total price of the items before tax and shipping
taxPrice	Decimal	Total tax on the items
shippingCharges	Decimal	Cost of shipping
totalAmount	Decimal	Final total amount (items + tax + shipping)
orderStatus	String	Status of the order (e.g., Pending, Completed)

3.6.4 Flowchart

The flowchart illustrates the sequential steps in the application's operation, mapping out user interactions, admin functions, and system processes. It provides a visual overview of the workflow, from user login and product selection to order processing and payment, ensuring clear and efficient functionality throughout the system.

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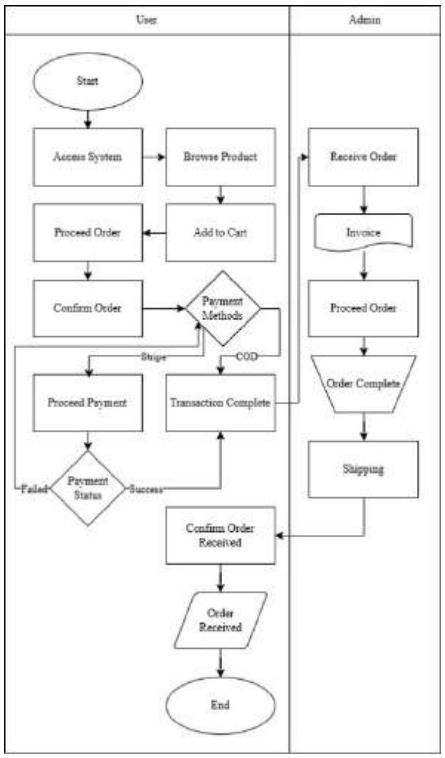

Fig 6. Flowchart

3.7 Design And Implementation User Interface

3.7.1 User Panel

3.7.1.1 Home Page

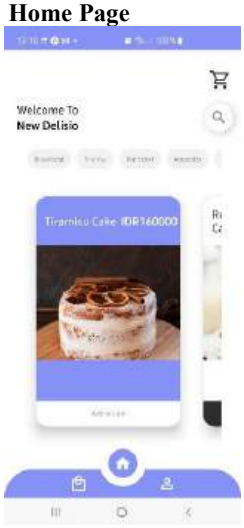

Fig 7. Home Page

The "New Delisio" app displays product categories, latest items, and a search feature for easy navigation and detailed product access.

3.7.1.2 Profile Page

Fig 8. Profile Page

The profile screen allows users to manage their account, update their profile, view orders, change passwords, and log out, all in one place for easy access.

3.7.1.3 Search Page

Fig 9. Search Page

The "New Delisio" product list displays items with images, names, and prices. Users can search for specific products or tap an item to view detailed information.

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3.7.1.4 Product Detail Page

Fig 10. Product Detail Page

The product detail screen allows users to view specific product images, select cake sizes, add custom notes, and directly add items to the cart or proceed to the cart page without returning to the home screen.

3.7.1.5 Cart Page

Fig 11. Cart Page

The cart screen displays selected products, allowing users to view and adjust product quantities directly.

3.7.1.6 Confirm Order Page

Fig 12. Confirm Order Page

The order summary screen shows selected products, total cost, tax, shipping, and the final amount. After confirming, users proceed to choose a payment method.

3.7.1.7 Payment Method Page

Fig 13. Payment Method Page

The payment method screen allows users to choose options like Cash on Delivery or Online by selecting a radio button. Users can finalize the order by tapping "Place Order."

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3.7.1.8 Stripe Payment Method Page

Fig 14. Stripe Payment Page

The payment information screen lets users enter credit or debit card details. After completing the form, users can proceed by tapping "Pay (Total Amount)."

3.7.1.9 Sign In Page

Fig 15. Sign In Page

The sign-in screen allows users to log in using their email and password.

3.7.1.10 Sign Up Page

Fig 16. Sign Up Page

The sign-up screen lets users register with their name, email, username, and password. It includes authentication to alert users if the email is already registered or if the password is less than 6 characters.

3.7.1.11 Forgot Password Page

Fig 17. Forgot Password Page

The reset password screen lets users enter their email to receive a 6-digit OTP. After entering the OTP, users can set a new password.

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3.7.1.12 Order History Page

Fig 18. Order History Page

The transaction screen displays a list of user transactions, including details like invoice, date, and order status.

3.7.1.13 Edit Profile Page

Fig 19. Edit Profile Page

The edit profile screen allows users to update their name, email, address, city, country, and postal code. Authentication alerts users if the new email is already registered.

3.7.2 Admin Panel

3.7.2.1 Admin Dashboard

Fig 20. Admin Dashboard

The Admin Panel screen in the "New Delisio" app helps admins manage product data. It displays a pie chart showing product availability (in stock vs. out of stock). Key navigation buttons include Product (for adding new products), Category (for managing categories), and All Orders (to view all listed products). A table at the bottom provides product details like image, price, name, category, and stock quantity for easy management.

3.7.2.2 Add Product Page

Fig 21. Add Product Page

The New Product page in the "New Delisio" app allows admins to add new products. Admins can enter product information such as name, description, price, stock quantity, and select a category. A camera icon at the top enables uploading product images. After filling out the details, the admin can add the product by pressing the "Create" button at the bottom.

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3.7.2.3 All Orders Page

Fig 22. All Order Page

The All Orders page allows admins to manage customer orders. It displays order details such as delivery address, order number, date, total price, shipping status, and payment method in card format. Each card includes an "Update" button to modify order status or information.

3.7.2.4 Add Category Page

Fig 23. Add Category Page

The Categories page allows admins to manage product categories. It displays existing categories like Blackforest, Tiramisu, Red Velvet, and Accessories in card format, each with a trash icon to delete unnecessary categories. At the bottom, an input form lets admins add new categories by typing a name and pressing the "Add Category" button.

3.8 Black Box Testing

The *New Delisio* application was tested by 11 respondents, including 10 end-users and 1 admin. End-users focused on features like registration, ordering, and payments, while admins tested product, category, and order management. The testing followed a black-box approach to evaluate functionality and user experience. The table below summarizes the results, highlighting successes, issues, and improvements made.

Table 2. User Testing Result

Testing Scenario	Actual Outcome	Remarks/Issues Found	Success Rate (%)
Log in with valid credentials.	9 users succeeded, 1 experienced a delay.	Delay resolved by optimizing server response.	90%
Register with valid details.	All users succeeded.	No issues found.	100%
Enter valid email to receive OTP.	8 users succeeded, 2 experienced delays in email.	Improved email server configuration.	80%
Search for a product by entering a keyword in the search bar.	3 users succeeded, 3 reported no results.	Fixed bug in search filtering logic.	70%
View details of a product by clicking on it.	All users succeeded.	No issues found.	100%
Update product quantity in the cart.	9 users succeeded, 1 reported slow UI response.	Optimized cart UI responsiveness.	90%
Review and confirm the order.	All users succeeded.	No issues found.	100%
Select a payment method (e.g., Cash on Delivery).	All users succeeded.	No issues found.	100%
Enter credit card details for payment.	9 users succeeded, 1 reported incorrect error message.	Fixed error validation for card details.	90%
Admin adds a new product.	Success	No issues found.	100%
Admin updates the status of a pending order.	Success	No issues found.	100%
Admin deletes an existing category.	Success	No issues found.	100%

The user testing results indicate a high success rate of 91.11% for user interactions and a perfect success rate of 100% for admin tasks. The overall success rate stands at 92.52%. While most features performed well, minor issues such as delays in email verification and search functionality were identified. These have been addressed to enhance the user experience, ensuring smoother operations and greater reliability moving forward.

IV. CONCLUSION

In conclusion, this research successfully developed a mobile-based e-commerce application tailored for New Delisio Bakery, enabling MSMEs to transition from conventional to digital sales operations. By leveraging React Native, Express.js, and MongoDB, the application achieves both user-friendliness and scalability, effectively enhancing customer experience and operational efficiency for the bakery. This project advances the field by providing a digital transformation model adaptable for other MSMEs

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with similar needs, especially those aiming to expand their market reach through technology.

The user testing results show a high success rate of 91.11% for user interactions and a perfect success rate of 100% for admin tasks, with an overall success rate of 92.52%. Despite this, some areas require improvement, including the accuracy of the product search feature, which experienced issues for a few users, and the email verification process. These issues have been identified and will be addressed to further enhance the application's reliability and user experience.

This application's functionality—such as product management, secure payment integration, and real-time order tracking—addresses existing limitations in MSME sales systems, positioning it as a valuable tool for small businesses seeking growth in a competitive digital landscape. Future development could expand this application with advanced analytics for customer insights and inventory management features, adding further value for users. Additionally, ongoing research could explore AI-driven recommendation engines to personalize the shopping experience, offering a broader application of the system and opening new research directions.

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Donation Raising Application Using Rapid Application Development (RAD) Method Based on Mobile Application

Aditya Bagas Nugraha [1*], Tri Widodo[2]
[1,2]Program Studi Informatika, Fakultas Sains & Teknologi, Universitas Teknologi Yogyakarta
Email: [1]Adityabagas1234567@gmail.com, [2] Triwidodo@uty.ac.id

Abstract – Indonesia is one of the countries that has a high social spirit in doing gotong royong. Its people love to help and build social welfare. There are several activities that prioritize the principle of gotong royong in society, one of which is donation-raising activities. Many institutions still collect donations in a conventional way. This can be an obstacle for donors because not all institutions or communities that collect funds are in the same area and the reach is relatively small. Lack of public trust is also a reason because of the rampant fraud on behalf of institutions and foundations, so that it can hamper the raising of donations. To overcome these problems, a new system is needed that can be applied to the community. A fundraising platform is needed to make it easier for people to donate easily and efficiently. The Rapid Application Development (RAD) method is used in its development. System development uses the Kotlin programming language and uses a realtime Firebase database to manage the data. With this system, the mobile application can facilitate and provide access to the community in making donations online without collecting manually, raising donations can also provide a wider range of donations.

Keywords – Donation Fundraising, Kotlin, Firebase, Rapid Application Development (RAD)

I. INTRODUCTION

Donation activities have been going on for a long time in Indonesia and are carried out directly through religious activities, social services, arts and sports [1]. There are many organizations and foundations that organize donation activities. Many fundraisers are also willing to take to the streets and ask for donations from people around them. The concept of fundraising with the values of mutual cooperation gave birth to a site that acts as a donation platform in Indonesia. The rapid development of the internet has given birth to a variety of diverse platforms. This can increase the effectiveness of donation raising.

The problem that often occurs when raising donations is the narrow range that inhibits donors from making donations. Not all organizations or communities that collect funds are in the same area. Lack of public trust is also a reason because of the rampant fraud on behalf of institutions and foundations, which can hinder donation raising. Sometimes there is also a lack of coordination between the government and donors in distributing aid [2]. To overcome these problems, this research was conducted in order to provide the right solution to be applied.

Some previous research is used as a literature review in this study. In research conducted by Abdul Karim, analyzing and designing mobile applications used for donations using the React Native-based Hybrid method. The waterfall method is used to develop features that have donation categories such as natural disasters, houses of worship, education, orphanages and personal [3]. The next research was conducted by Rozaliana who made a donation information system using java. The application was developed using the waterfall method and produces donation features for cash, transfers, and donations of goods [4]. Further research was conducted by Fadhillah by designing a joint venture application using Agile and Scrum methods. The resulting application is a website that can manage transactions [5]. Muhammad Alfi also conducted research by creating an android-based fundraising application and SQL Lite. The application was developed using the waterfall method which is equipped with CRUD (Create, Read, Update, and Delete) features [6]. Then in research conducted by Erika Purba in designing a donation distribution system using the prototype method. The application features a login menu, dashboard, profile, student data, donor reports, student reports and logout [7].

The research conducted focuses on system design, use of techniques and tools, and system testing. The RAD (Rapid Application Design) method is used with the aim of creating software development quickly. Designing diagrams using UML (Unified Modeling Language) to find out the flow of the system being created. While the coding process uses the Kotlin programming language and the Firebase database to manage data in real time. The finished application will be tested using several scenarios created using the black box testing method.

II. RESEARCH METHODOLOGY

The system design starts with creating an architecture model. The architecture model provides an overview of the system's performance and what tools are applied to the system. The architecture model of this system can be seen in **Figure 1** as follows

Figure 1. Architecture Model

The user inputs the donation payment into the application then the application will send it via the internet, then the internet sends it to the database and the database stores the

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data, then the system will notify that the payment was successful.

A. Rapid Application Development (RAD) Method

Rapid Application Development (RAD) is a linear sequential software development process model that emphasizes very short development cycles. RAD can be used as a reference for developing an information system that excels in terms of speed, accuracy, and lower costs [8]. The RAD method emphasizes rapid design and iterative feedback to accelerate the creation of systems with good quality. The RAD method can be seen in **Figure 2** as follows

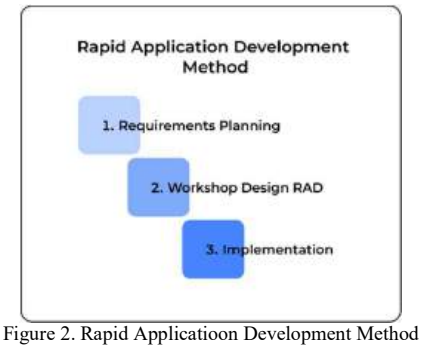

Figure 2. Rapid Applicatioon Development Method

At the Requirements Planning stage, literature data collection is carried out through literature studies. Then the RAD Design Workshop stage is carried out in the form of diagrams to determine system performance. After the application is completed, implementation is carried out.

B. Firebase

Firebase stores data online so to use firebase requires internet access. Firebase Database as a nonSQL database storage that allows for storing multiple types of data. Data in the Firebase database is stored as JSON tree objects. Unlike SQL databases, there are no tables and rows in non-SQL databases [9]. Firebase is realtime so data can be obtained quickly [10].

C. Unified Modelling Language (UML)

Unified Modeling Language (UML) is a software modeling used for visualization, specification, construction and documentation of some parts of the system. In this research, only a few types of diagrams are used such as Activity Diagram, Use Case Diagram, and Sequence Diagram [11].

D. Black Box Testing

The tests conducted focus on the functional specifications of the software [12]. Black Box testing checks every existing process whether it runs well as expected or not [13].

E. Kotlin

Kotlin was developed by JetBrains and is a functional programming language[14]. Various kinds of development can be done with kotlin, such as desktop, mobile, web, and even backend applications [15].

III. RESULTS AND DISCUSSION

A. Requirements Planning

The initial stage was carried out by identifying user needs by collecting information through interviews and surveys and literature studies. At this stage, problems were found along with application development solutions by collecting important features that must be present in the application. Documentation of the needs and solutions of these problems can be seen in the following research framework.

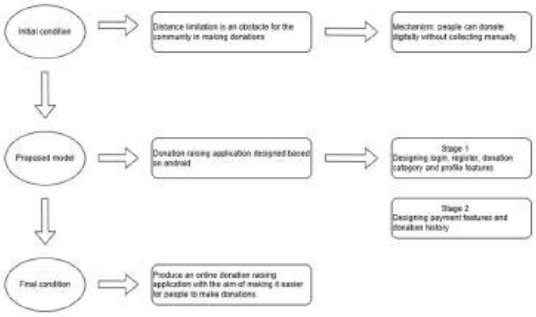

Figure 3. Requirements Planning

B. Workshop Design RAD

This stage is carried out modeling as a solution to existing problems Modeling the system using UML (Unified Modeling Language), namely use case diagrams, activity diagrams, and sequence diagrams. Use Case Diagram describes the process that occurs in the system. There is one actor, the user. Here is an image of the Use Case Diagram.

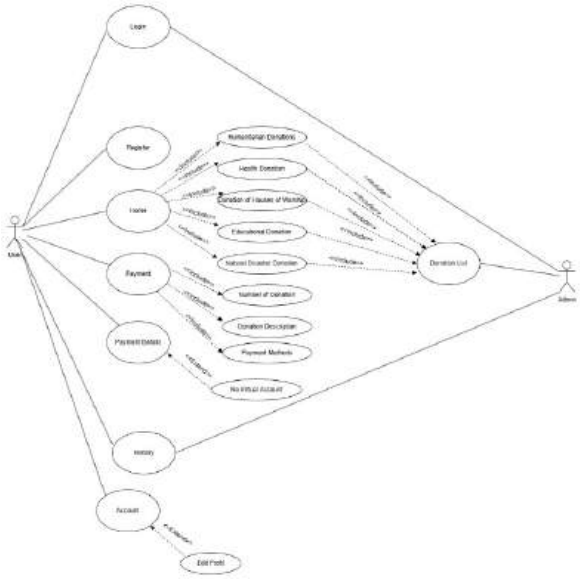

Figure 4. Use Case Diagram

Activity Diagram describes the flow of activities between users, systems and databases that have their own activities. The system as a link between the user and the database. In the login and register activity diagram, there are activities that start from the user being able to enter the application by logging in if they already have an account, but if not the user is required to register, after being validated by the system and checked by the database, the user can enter the application which displays the dashboard page. The following is an Activity Diagram **Figure 5** belows.

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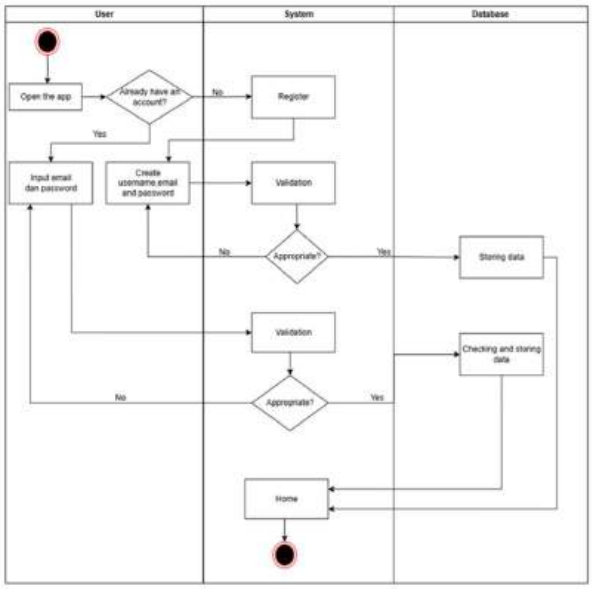
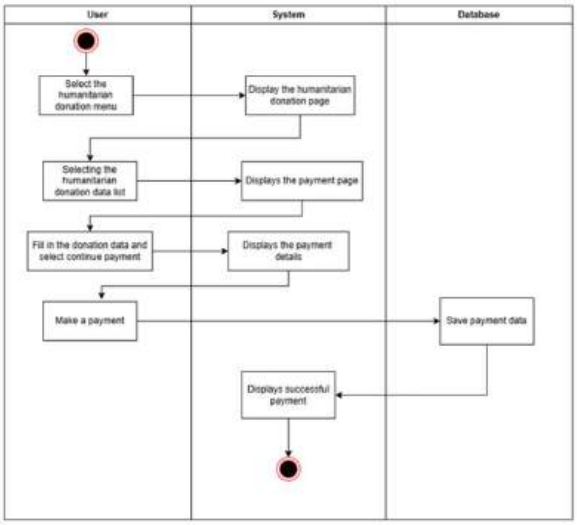


Figure 5. Login and Registration Activity Diagram

Furthermore, in the donation payment activity diagram, there are activities that start from the user selecting the donation category menu as an example of a humanitarian donation payment, the system displays the humanitarian donation page, then the user selects the humanitarian donation category, the system displays the humanitarian category, then the user selects the humanitarian donation data list and then will enter the payment page, the system displays the payment page, the user inputs the donation amount and chooses the payment method if the user has clicked the continue payment button, the system displays payment details in the form of a virtual account number if the payment is through mbanking, the user can copy the virtual account number and make a payment, then the database saves and the system displays a successful payment.



Fgure 6. Donation Payment Activity Diagram

Furthermore, in the history and delete history activity diagram, there are activities that start from the user selecting the history menu, the system displays the history menu, then the user deletes the donation history and the system confirms if yes then the database will save and delete the history otherwise it will return to the history menu.

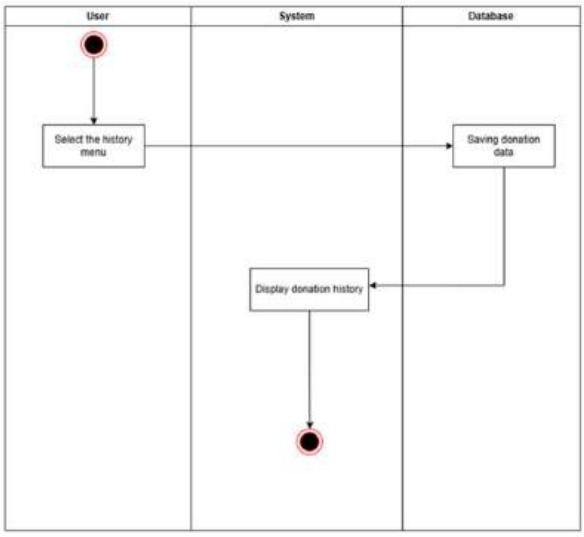


Figure 7. Activity Diagram History dan Hapus History

Activity Diagram Profile and Edit Profile starts the activity by selecting the profile menu then the system displays it, the user inputs the data that you want to change then the system will validate if yes then the database will save and update the profile, otherwise it will return to the profile menu.

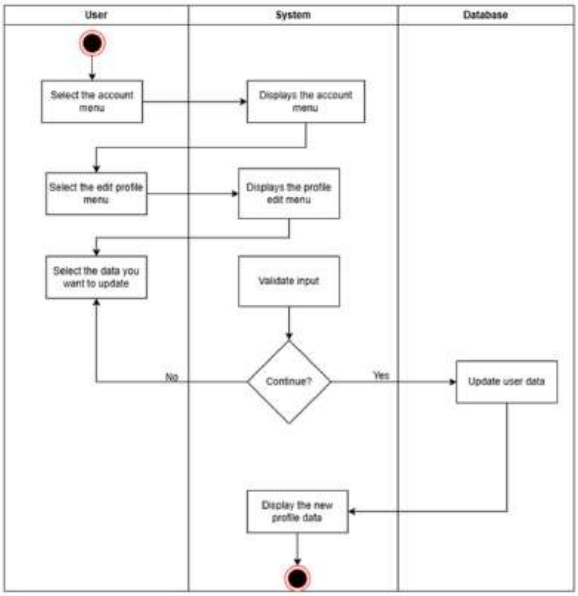


Figure 8. Activity Diagram Profile and Edit Profile

Activity Diagram Login Admin starts the activity when the admin opens the application by logging in first to be able to enter the dashboard page by entering email and password.

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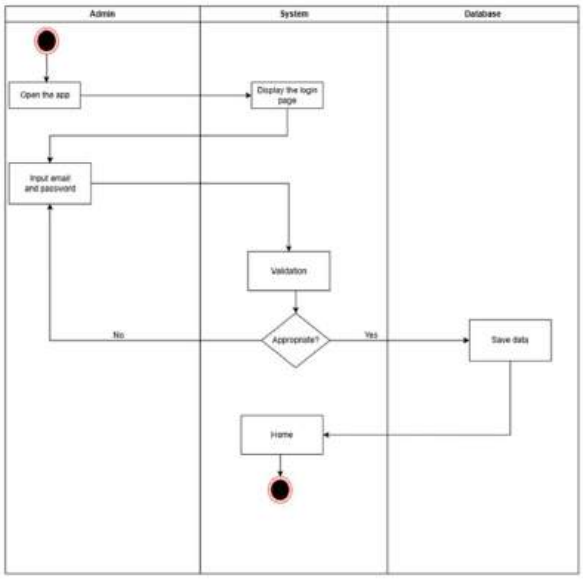

Figure 9. Activity Diagram Login Admin

Next Activity Delete Donation Data List. The activity starts when the admin chooses the donation category, the system will display it, the admin can delete the donation list data if yes then the database will delete the data, otherwise it will return to the donation data list page.

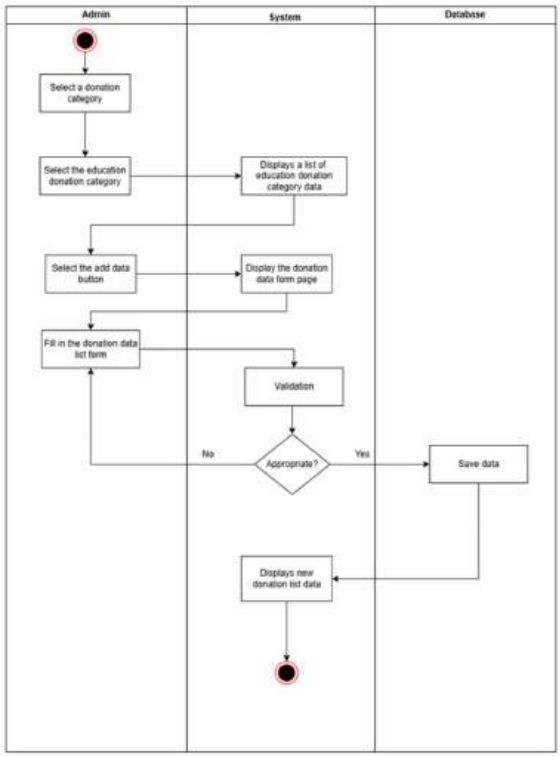

Figure 10. Activity Delete Donation Data List

Activity Diagram of Monitoring and Deleting User Donation History, starting from the admin selecting the history menu, the system displays the history menu, then the admin deletes the donation history and the system confirms if yes then the database will save and delete the history otherwise it will return to the history menu.

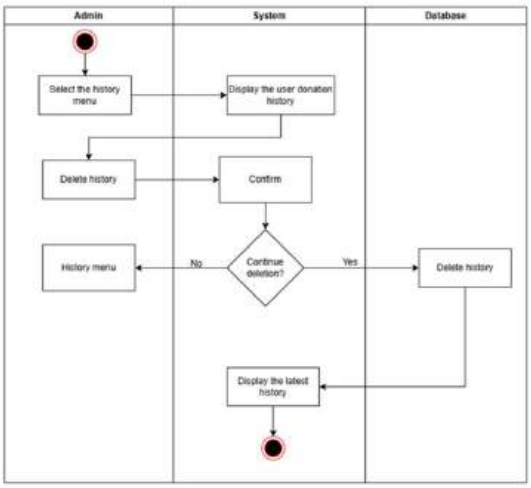

Figure 11. Activity Diagram of Monitoring and Deleting User Donation History

Sequence diagram is a diagram used to explain and display interactions between objects in a system in detail. The User Login Diagram Sequence starts when the user opens the application by logging in first to be able to enter the dashboard page by entering email and password.

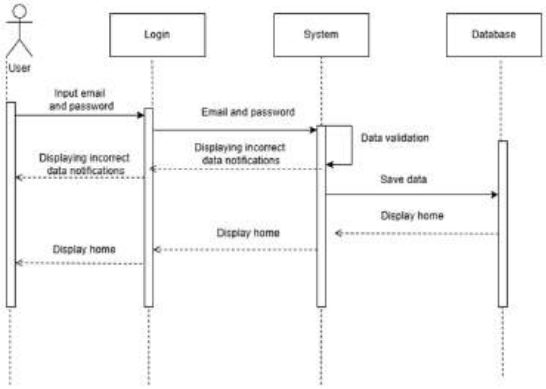

Figure 12. Sequence Diagram Login User

Furthermore, the user register sequence diagram starts from the user can enter the application by registering, by filling in the username, email and password after being validated by the system and checked by the database, then the user can enter the application which displays the dashboard page.

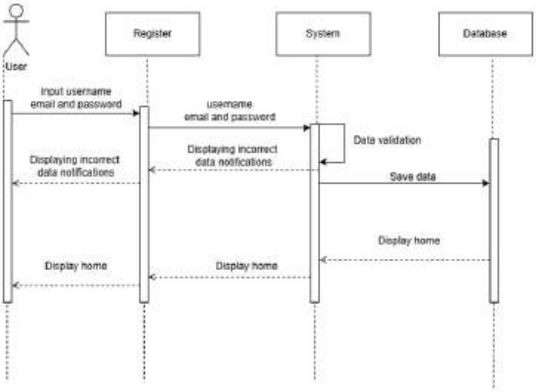

Figure 13. Sequence Diagram User Register

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Sequence Diagram History starts from the user selecting the donation category menu, then the user selects the donation category, then the user selects the donation data list, then it will enter the payment page, the user inputs the donation amount and chooses the payment method if the user has clicked the continue payment button, the system displays payment details in the form of a virtual account number if payment via mbanking can copy the virtual account number and make a payment, then the database saves and the system displays a successful payment.

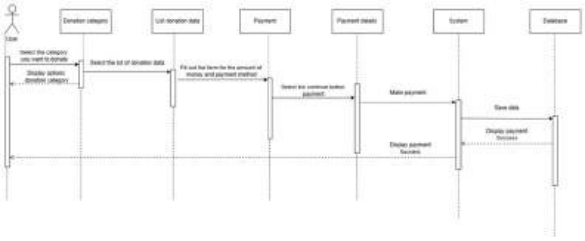

Figure 14. Sequence Diagram Payment

The User History Sequence Diagram starts when the user selects the history menu, the database will store and send the history data, then the system will display the history data.

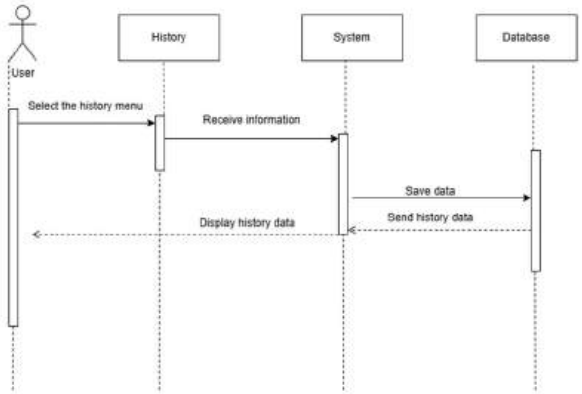

Figure 15. Sequence Diagram User History

The sequence diagram starts when the user selects the profile menu then the user inputs the data that he wants to change then the system will validate, if yes the database will save and update the profile, otherwise it will return to the profile menu.

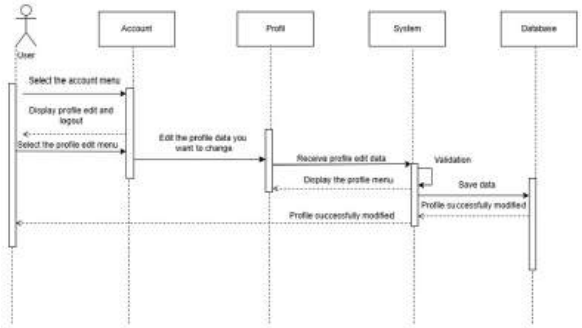

Figure 16. Account and Edit Profile Sequence Diagram

The Admin Login Diagram Sequence starts when the admin opens the application by logging in first to be able to enter the dashboard page by entering email and password.

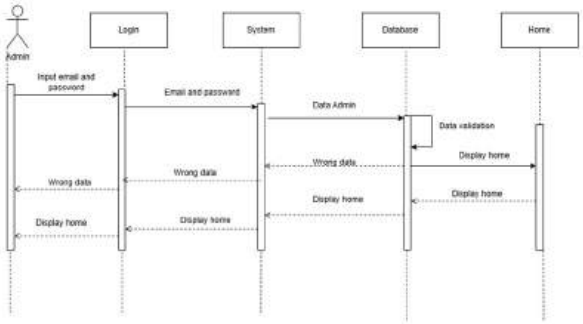

Figure 17. Sequence Diagram Admin Login

Sequence Diagram Delete Donation Data List starts when the admin enters the donation category page, then selects the list of data to be deleted, the system will validate if yes then the database will save the payment data and the system displays the data successfully deleted, otherwise it will return to the donation data list page.

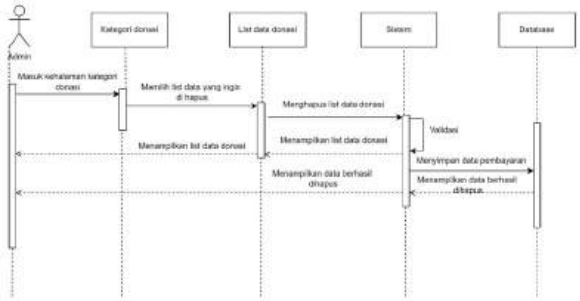

Figure 18. Sequence Diagram Delete Donation Data List

The Add Donation List Data Sequence starts when the admin enters the donation category page, then clicks the add list data button, then the admin fills in the list data form, the system will validate if yes then the database will save the payment and the system displays the data successfully deleted, otherwise it will enter the donation data form page.

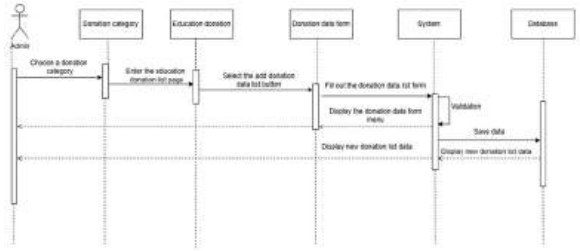

Figure 19. Sequence Diagram Add Donation List Data

Sequence diagram for Monitoring and Deleting User Donation History starts when the admin selects the history menu and deletes the user's donation history, the system will confirm the delete if yes then the database will delete and display the successful deletion, otherwise it will return to display the history menu.

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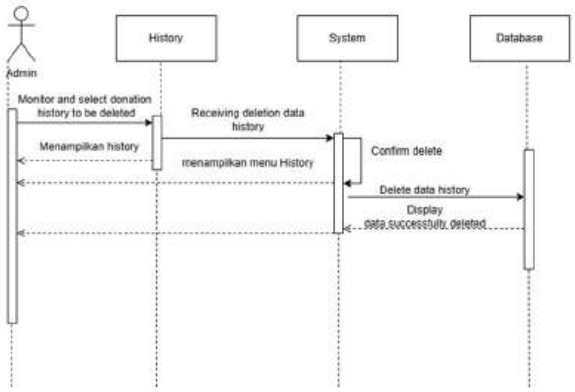

Figure 20. Sequence diagram for Monitoring and Deleting User Donation History

C. Implementation

The system created is then implemented in a mobile-based application by coding first. The implementation of the system interface can be seen as follows. Login page to log in first before entering the dashboard page. If the user does not have an account, it will be directed to register an account first.

Figure 21. Login & Register Page

After successfully logging in, users can select the category to be donated. There are five donation categories, namely health donations, natural disasters, houses of worship, humanitarian, and education.

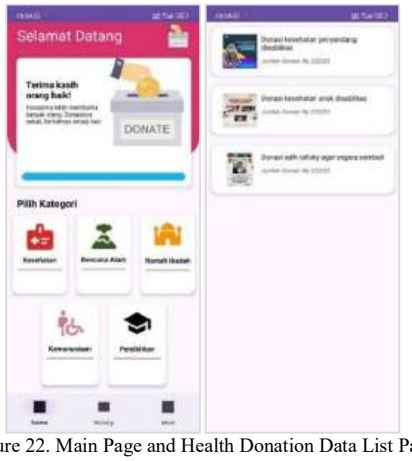

Figure 22. Main Page and Health Donation Data List Page

The next page lists the donation data. For example, from the natural disaster donation category. There is an add button that is useful for adding a list of data from natural disaster donations.

Figure 23. Health Donation Data List Page

The next is the implementation of the page of Worship Donation Data List Page and the Humanitarian Donation Data List Page.

Figure 24. Page of Worship Donation Data List Page and the Humanitarian Donation Data List Page.

Next, donation page implementation and donation history page display

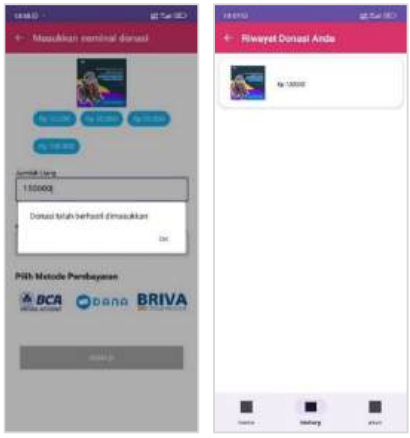

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Figure 25. Donation & Donation History Page

The account page is also equipped with a personal data editing feature.

Figure 25. Account Page & Edit Page

Photo upload page with validation after photo is successfully updated.

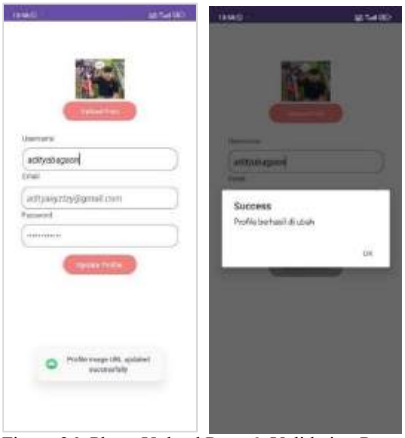

Figure 26. Photo Upload Page & Validation Page

The next stage is system testing using several scenarios created using the black box testing method. The test can be seen in the following table.

Table 1. Black Box Testing

No	Scenario	Expected Result	Status
1	Register yourself by filling in your username, email, and password, then click register.	The system will save the user data into the firebase realtime database, then the page will move to the main page.	[√]
2	Log in by filling in the correct email and password, then press login.	The system will save the user data into the firebase realtime database, then the page will move to the main page.	[√]
3	Log in by filling in the wrong email and password, then press login.	The system will refuse to enter the main page.	[√]
4	Log in without filling in your email and password, then press login.	The system will refuse to enter the main page.	[√]
5	Click the logout button.	The page will move to the login page and the user is asked to login again if they want to enter the application.	[√]
6	Select the health donation category	The page will move to the health donation data list and display the health donation data.	[√]
7	Select the natural disaster donation category	The page will move to the natural disaster donation data list and display the natural disaster donation data.	[√]
8	Select the house of worship donation category	The page will move to the list of donation data for houses of worship and display the donation data for houses of worship.	[√]
9	Select the humanitarian donation category	The page will move to the list of humanitarian donation data and display the humanitarian donation data.	[√]
10	Select the education donation category	The page will move to the education donation data list and display the education donation data.	[√]
11	The list of health donations can be entered on the payment page.	The page will move to the payment page according to the selected health donation list.	[√]
12	List data from natural disaster donations can enter the payment page	The page will move to the payment page according to the selected health donation list.	[√]
13	List data from donations to houses of worship can be entered into the payment page	The page will move to the payment page according to the selected health donation list.	[√]

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14	List data from humanitarian donations can enter the payment page	The page will move to the payment page according to the selected health donation list.	[√]
15	List data from education donations can enter the payment page	The page will move to the payment page according to the selected health donation list.	[√]
16	Click the button to select the amount of money to donate	When you click on the donation amount option, you can enter the form to fill in the amount of money.	[√]
17	Fill in the donation amount with a minimum of Rp. 10,000 and click the donate button	Firebase realtime database will save the donation data and then send it to the donation history and when clicking the donation button a pop up will appear “donation has been successfully entered”.	[√]
18	Select a payment method and click the continue payment button on the payment page.	The payment method has a spinner to select the payment method and the page will move to the transaction details.	[X]
19	Click the “<” button on the transaction details page	Return to the payment menu.	[X]
20	Click the “<” button on the payment page	Return to the donation data list menu.	[√]
21	Click the “<” button on the donation data list page	Return to the dashboard menu .	[√]
22	Click the history button and display the donation history	The page will switch to donation history and the system will display the donation history.	[√]
23	Click the account button and display the account menu	The page will move to the account page and the firebase realtime database will save the register data then the system displays the username, email and password on the account page.	[√]
24	Click the edit profile button	The page will move to the profile edit page	[√]
25	Click the photo upload button and edit the username	The page will display a choice of image sources from the camera or gallery and can upload photos and can fill in the username form.	[√]
26	Click the profile upload button	The page will issue a pop up “profile successfully changed” and move to the account page. Thedatabase will save and update the data by changing the account photo and username.	[√]
27	Click the “<” button on the profile edit page	The page will move to the account.	[√]

Based on the scenarios that have been tested, it can be seen that there are 27 scenarios tested with the results of 25 successes and 2 failures. So it can be stated that the percentage of applications running smoothly is 92.5%.

IV. CONCLUSION

This research was conducted to overcome problems related to donation money. Problems that are the reason for this research such as the lack of a trusted donation platform and to streamline donation time. To overcome this problem, a system was developed using the Rapid Application Development method which prioritizes rapid system development. Kotlin and Firebase were used in the development of the system. This research produces an application that has several excellent features. Supporting features needed are top up features that make it easy for users to make donations without opening third-party applications, the appearance of the application also affects the user experience that is more attractive and payments through virtual accounts or e-wallets that make it easier for users to donate. The system can also select institutions or foundations that have a good reputation in providing donations to people in need.

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Vehicular Ad-Hoc Networks for Intelligent Transportation System: A Brief Review of Protocols, Challenges, and Future Research

Ketut Bayu Yogha Bintoro[1]
[1]Program Studi Teknik Informatika, Fakultas Sains, Technology and Desain, Universitas Trilogi
Email: [1]ketutbayu@trilogi.ac.id

Abstract – Vehicular Ad Hoc Networks (VANET) play an essential role in the advancement of intelligent transportation systems, facilitating real-time communication between vehicles (V2V), infrastructure (V2I), and surrounding environments (V2X). This systematic review analyzes a range of VANET routing protocols, highlighting the strengths and weaknesses of topology-based, position-based, cluster-based, and hybrid methods. Additionally, this review explores core challenges in VANET, including high mobility, data security, Quality of Service (QoS) requirements, and connectivity issues in dynamic and high-density traffic environments. The paper also provides insights into simulation tools and performance metrics employed in VANET research alongside practical applications in modern transportation systems, such as autonomous driving, traffic management, and safety-related communication. Furthermore, this review emphasizes the need for ongoing research to address the identified challenges and optimize VANET performance. Integrating emerging technologies, including 5G, artificial intelligence (AI), and edge computing, offers promising avenues for enhancing system efficiency and sustainability. This review establishes a comprehensive foundation for further advancements in VANET by highlighting key findings and research gaps. Ultimately, the effective implementation of VANET has the potential to significantly improve transportation safety, efficiency, and sustainability, contributing to the realization of smart city initiatives and innovative mobility solutions. This work aims to guide future research directions, ensuring that VANET continues to evolve in alignment with the demands of modern transportation systems and the broader context of intelligent mobility.

Keywords: VANET Protocols, Vehicle-to-Everything (V2X), Intelligent Transportation Systems (ITS), DSRC Standards, Autonomous Vehicles, VANET

I. INTRODUCTION

The rapid advancement of Intelligent Transportation Systems (ITS) has significantly transformed the landscape of modern transportation[1]. This transformation requires sophisticated communication networks that facilitate real-time data exchange, ultimately enhancing safety, efficiency, and user convenience. Within this context, Vehicular Ad Hoc Networks (VANET)[2] emerge as a critical subset of Mobile Ad Hoc Networks (MANET)[3], enabling direct communication between vehicles (V2V) and between vehicles and infrastructure (V2I) without reliance on fixed infrastructure. VANET supports vital applications, including collision avoidance, emergency alerts, dynamic traffic management, and autonomous driving, establishing itself as an essential component of connected and intelligent transportation systems[4].

The architecture of VANETs is characterized by high mobility and a rapidly changing network topology, which presents significant challenges for traditional routing protocols[5]. This dynamic environment necessitates the development of specialized protocols capable of accommodating frequent network changes while satisfying the stringent quality of service (QoS) requirements associated with safety-critical applications[6]. As a result, various routing protocols have been developed for VANET, which can be categorized into topology-based[7], position-based[8], cluster-based[9], and hybrid types[10]. Each category possesses distinct strengths and limitations regarding reliability, scalability, latency, and adaptability to diverse traffic conditions.

Despite the substantial body of research dedicated to VANET protocols, several enduring challenges remain. Key issues include ensuring data security and privacy[11], maintaining stable connectivity in densely populated urban environments[12], and minimizing latency in safety-critical scenarios[13][14]. Furthermore, advancements in 5G technology[15], machine learning[16], and edge computing have generated increased interest in hybrid protocols and intelligent routing mechanisms that can bolster network resilience and efficiency in highly dynamic vehicular contexts.

This systematic review aims to comprehensively analyze existing VANET protocols, their applications, and the primary challenges encountered in VANET implementation[17]. By evaluating simulation tools, performance metrics, and emerging technologies, we intend to establish a framework for future research that addresses current limitations and explores new opportunities within transportation networks. The significance of this research lies in its potential to enhance transportation system safety and efficiency, reduce traffic congestion, and facilitate the successful integration of autonomous vehicles. A thorough understanding of the strengths and weaknesses of various VANET protocols will empower stakeholders to make informed decisions, fostering the development of more robust and adaptive communication networks that contribute to more intelligent and safer urban environments.

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The contributions of this research are multifaceted. First, it consolidates existing knowledge regarding VANET protocols, offering a clear overview of their applications and associated challenges, thereby serving as a valuable resource for researchers and practitioners. Second, by identifying gaps in the current literature, this review sets the stage for future investigations into innovative routing solutions and security measures, addressing critical issues that impede the widespread adoption of VANET technology. Finally, the findings of this research inform policy-making and strategic planning for deploying intelligent transportation systems, guiding investments and initiatives to create more efficient and safer transportation networks.

II. RESEARCH METHODOLOGY

The Systematic Literature Review (SLR) method is a structured approach for gathering and analyzing literature relevant to a specific topic, in this case, Vehicular Ad Hoc Networks (VANET) shown in Figure 1.

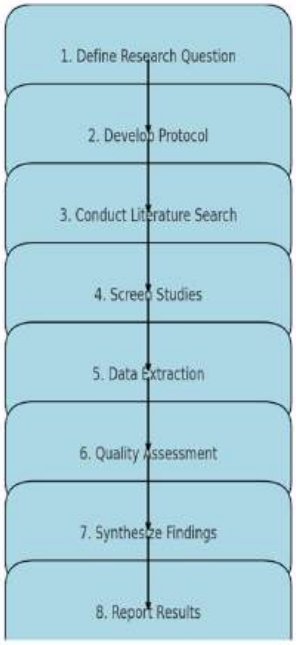

Figure 1. Systematic Literature Review Methodology[18]

In Figure 1, the process begins by formulating a specific research question to guide the literature search. Researchers then develop a protocol that outlines inclusion and exclusion criteria to ensure the selected studies are relevant and of high quality. Following this, a comprehensive search is conducted across various databases to identify pertinent studies, which are subsequently screened to filter out those not meeting the established criteria. Data from the selected studies are extracted and analyzed to uncover significant findings. Finally, the results are compiled into a report that synthesizes the findings, discusses their implications, and offers recommendations for future research. This method provides a comprehensive understanding of current developments and challenges in the VANET field.

III. VANET ARCHITECTURE AND CORE COMPONENTS

VANET form a foundational component in intelligent transportation systems, allowing real-time data exchange between vehicles and with nearby infrastructure to support efficient and safe transportation[19]. The architecture of VANET is designed to handle high mobility, rapidly changing topologies, and intermittent connectivity. This section delves into the core components of VANET, including its network structure, communication types, and standards that govern data transmission[20].

A. Network Structure

The basic architecture of VANET comprises three main elements: vehicles as mobile nodes, roadside units (RSUs), and central network elements.

Vehicles as Mobile Nodes[21]: In VANET, each vehicle acts as a mobile node equipped with communication capabilities that enable it to connect with other vehicles (Vehicle-to-Vehicle or V2V) or infrastructure (Vehicle-to-Infrastructure or V2I). These nodes move at high speeds and follow unpredictable paths, leading to frequent topology changes that require efficient and adaptive routing protocols.

Roadside Units (RSUs)[22]: RSUs are fixed infrastructure elements, often located at traffic lights, intersections, or along roadsides. They provide a stationary communication link to vehicles within a particular range. RSUs serve as intermediaries, relaying information between vehicles and sometimes providing access to the central network. They also contribute to managing data traffic, enhancing connectivity, and improving the reliability of data transmission in high-mobility scenarios.

Central Network Elements[23]: VANET may include centralized components like data servers or cloud platforms to manage, analyze, and store data collected from vehicles and RSUs. While VANET primarily operates as a decentralized network, these central elements play a role in data processing, long-term data storage, and integration with broader intelligent transportation systems.

This combination of mobile and stationary components allows VANET to dynamically adapt to the movements of vehicles, ensuring that data is shared efficiently across a vast, dispersed network.

B. Types of Communication

VANET supports several types of communication that facilitate data exchange in various scenarios, particularly regarding vehicle safety, traffic management, and efficiency:

Vehicle-to-Vehicle Communication[24] V2V communication is direct data exchange between vehicles. Through V2V, vehicles can transmit data regarding speed, position, and intent to nearby vehicles. This form of communication supports collision avoidance, lane change warnings, and cooperative driving by enabling vehicles to “see” beyond their immediate surroundings.

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V2V operates as a decentralized network where each vehicle autonomously communicates, allowing a rapid and low-latency exchange of critical information.

Vehicle-to-Infrastructure Communication[25]: V2I communication occurs between vehicles and fixed infrastructure, typically RSUs. This communication type allows vehicles to receive data from traffic management systems, such as signal timing, congestion information, or route recommendations. V2I can enhance overall traffic flow, support adaptive traffic control systems, and contribute to environmental monitoring by sharing data with city infrastructure systems.

Vehicle-to-Everything(V2X) Comunication[26]: V2X extends the scope of communication to include other surrounding entities, encompassing both V2V and V2I communications. It may involve communication with pedestrians (Vehicle-to-Pedestrian or V2P), cyclists, or devices in the surrounding environment. V2X provides a holistic approach, connecting vehicles to all relevant network elements, enhancing situational awareness, and supporting more extensive safety applications in complex traffic environments.

Together, these communication types enable VANET to act as a versatile and scalable network, capable of supporting diverse applications in urban and rural areas.

C. Protocol and Communication Standards

To support efficient and reliable communication in VANET, several protocols and standards have been established. These standards ensure interoperability, low latency, and adequate throughput in diverse environments:

IEEE 802.11p[27]: IEEE 802.11p is a modified version of the 802.11 standard for wireless access in vehicular environments (WAVE). DSRC enables short-range wireless communication, typically within a range of 300 meters. It is designed for high-speed environments, allowing vehicles to share critical safety data with minimal latency. DSRC operates in the 5.9 GHz band and supports V2V and V2I communications, making it suitable for real-time applications like collision avoidance and emergency alerts.

Dedicated Short-Range Communication (DSRC)[28]: DSRC is both a standard and a technology framework that includes IEEE 802.11p, offering secure, reliable communication in vehicular environments. DSRC is tailored for high-speed and high-mobility contexts, allowing rapid data exchange within a limited range. Its low-latency capabilities make it ideal for applications requiring instantaneous data, such as crash prevention and traffic signal communication. DSRC has been widely implemented in pilot projects and is recognized for its contributions to traffic safety applications.

LTE-V2X(Meng.et.al.,2016): LTE-V2X (Long Term Evolution for Vehicle-to-Everything) is a cellular-based V2X technology that leverages existing LTE infrastructure to provide broader coverage than DSRC. LTE-V2X supports direct communication (PC5 interface) between vehicles and infrastructure without relying on cellular networks and network-assisted communication (Uu interface) through a cellular tower. With its extensive range and support for V2V, V2I, and V2X, LTE-V2X enables applications beyond safety, including infotainment and route optimization. It also paves the way for integration with 5G, offering higher data rates, better coverage, and ultra-low latency, making it ideal for future autonomous vehicle networks.

By incorporating these standards, VANET achieves the necessary interoperability to handle complex data exchanges across different types of network environments. These standards contribute to the efficient and reliable functioning of VANET, enabling it to support diverse applications critical to the future of transportation.

III. SYSTEMATIC REVIEW OF VANET ROUTING PROTOCOLS

The effectiveness of routing protocols in Vehicular Ad Hoc Networks (VANET) significantly impacts the performance and reliability of communication among vehicles and infrastructure. This section systematically reviews various routing protocols categorized into topology-based, position-based, cluster-based, hierarchical, and hybrid protocols.

A. Topology-Based Protocols

Topology-based protocols[30] rely on the established network topology, leveraging the arrangement of nodes to facilitate data transmission. These protocols are commonly used in scenarios where the network structure remains relatively stable over short periods.

1. **AODV**[5]:
   AODV is a reactive routing protocol that establishes routes only when needed, minimizing overhead by creating routes on demand. It utilizes destination sequence numbers to maintain freshness in routes, allowing vehicles to share routing information dynamically. AODV is particularly effective in urban environments where vehicles frequently change their paths and require quick route establishment for safety messages. For instance, during peak hours in a busy city, AODV enables vehicles to communicate critical information, such as sudden stops or accidents, ensuring that other drivers can respond promptly and avoid potential collisions.
2. **DSR (Dynamic Source Routing)**[31]:
   DSR allows vehicles to discover routes by using source routing, meaning that the complete route is contained in the packet header. This protocol is especially beneficial in areas with variable traffic patterns, such as during special events that significantly alter normal traffic flow. For example, if a concert is ending and thousands of attendees are trying to leave the vicinity, DSR can efficiently route messages about congested areas or alternative routes, helping to alleviate traffic and improve overall flow.
3. **OLSR (Optimized Link State Routing)**(Priyambodo etal.,2021):

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OLSR is a proactive routing protocol that maintains up-to-date routing information by periodically exchanging link state messages. This protocol is well-suited for highways, where vehicles travel at high speeds and need constant connectivity. In such environments, OLSR's use of Multipoint Relays (MPRs) reduces the number of transmissions needed for route updates, making it efficient in dense traffic situations. For instance, on a highway where traffic conditions can change rapidly due to merging or lane changes, OLSR ensures that vehicles maintain accurate routing information, thus enhancing safety and communication.

B. Position-Based Protocols

Position-based protocols, also known as geographic routing protocols[33], utilize location information derived from Global Positioning System (GPS) to make routing decisions, enhancing efficiency and reducing overhead.

1. **GPSR (Greedy Perimeter Stateless Routing)**[34]: GPSR employs a greedy approach by forwarding packets to the neighbor closest to the destination based on their geographic location. This protocol excels in urban settings, where precise location data can guide vehicles through complex street layouts while minimizing congestion. For example, if a vehicle needs to navigate through a busy city intersection, GPSR can help it find the quickest path by routing packets to nearby vehicles, effectively creating a real-time traffic flow map that adjusts dynamically to changing conditions.
2. **GSR (Geographic Source Routing)**[35]: GSR extends the principles of geographic routing by embedding source routing information based on location data. This hybrid approach allows vehicles to navigate efficiently using available GPS coordinates, making it particularly useful in rural areas with less predictable traffic patterns. For instance, in a less populated region where road layouts may be irregular, GSR can assist vehicles in reaching their destinations by providing a reliable route that considers both geographic position and potential obstacles.

C. Cluster-Based and Hierarchical Protocols

Cluster-based and hierarchical protocols organize nodes into clusters to facilitate efficient communication and resource management, reducing overhead and improving scalability[36].

1. **COIN**:
   COIN forms clusters of vehicles that communicate within a defined range, utilizing a leader node to manage communications and routing within the cluster. This approach is particularly useful in urban traffic congestion, where localized communication can alleviate the burden on broader network communications. For example, during a traffic jam, COIN allows vehicles within the same cluster to share information about nearby obstacles or alternative routes, enabling them to coordinate their movements and reduce overall congestion.
2. **CBR(Cluster-BasedRouting)**:
   CBR organizes vehicles into clusters and selects cluster heads to facilitate communication. This method optimizes bandwidth utilization and reduces latency through localized data management. In fleet management systems, for example, CBR enables efficient communication among multiple vehicles operating in the same area, allowing for real-time coordination and resource sharing that enhances operational efficiency.

D. Hybrid and Emerging Protocols

Hybrid protocols combine features from various routing methodologies to address specific challenges and optimize performance. **LA-AODV(LearningAutomata-AODV)**[37]: LA-AODV integrates machine learning techniques into the AODV framework, allowing the protocol to adapt dynamically to changing network conditions. This adaptability is particularly valuable in high-mobility environments, such as those involving autonomous vehicles. For instance, LA-AODV can optimize relay node selection and enhance route stability based on real-time data, ensuring that autonomous vehicles can communicate effectively with each other and their surroundings, thereby enhancing safety and operational efficiency.

IV. KEY CHALLENGES IN VANET IMPLEMENTATION

One of the primary challenges in implementing Vehicular Ad Hoc Networks (VANET) is the high mobility of vehicles, which leads to frequent changes in network topology[22]. Vehicles are constantly on the move, often at high speeds, resulting in rapidly changing connections between nodes. For example, in a busy urban environment, a vehicle traveling at 60 km/h may change its neighboring vehicles every few seconds, constantly re-evaluating routing paths. This dynamic nature of the network can cause routing paths to become unstable, making it difficult to maintain continuous communication. As vehicles enter and exit communication ranges, established routes may become invalid, leading to delays in message delivery or increased packet loss. This necessitates the frequent establishment of new routes, which adds overhead and can exacerbate congestion during critical situations, such as an accident or sudden traffic jam. The ability to quickly adapt to these changes is crucial for the reliability and effectiveness of communication, particularly for safety messages that require timely dissemination. The implication is that routing protocols must be designed to efficiently handle high mobility and frequent topology changes to ensure that safety-critical information is communicated without delays.

A. Data Security and Privacy

Data security and privacy are significant concerns in VANET due to the sensitive nature of the information exchanged between vehicles and infrastructure. For instance, consider a scenario where vehicles share real-time information about their speed and location for safety

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purposes. If this data is intercepted or altered, it could mislead drivers or traffic management systems, potentially leading to accidents. The open wireless communication environment is susceptible to various security threats, including data tampering, where malicious actors may alter messages to mislead other drivers. Spoofing attacks, where an attacker impersonates a legitimate vehicle or infrastructure node, can also compromise the integrity of the network and lead to unsafe driving conditions[38].

Additionally, denial-of-service (DoS) attacks can overwhelm the network, disrupt communication, and cause traffic incidents. For example, a DoS attack on a traffic signal communication system could prevent vehicles from receiving timely updates about traffic light changes, leading to confusion and accidents. Ensuring robust security mechanisms to protect data integrity, authenticity, and confidentiality is essential to build trust in VANET systems and encourage widespread adoption**.**

B. Quality of Service (QoS) Requirements

QoS requirements in VANET are critical for ensuring effective communication, particularly for safety and time-sensitive applications. Key QoS parameters include low latency, high reliability, and stable connectivity. However, meeting these requirements in a dynamic environment is challenging. For example, during a major traffic event like a marathon, where thousands of runners and vehicles share the same roads, vehicles' rapid movement can lead to network availability fluctuations, resulting in variable latency and potential packet loss. In such scenarios, the chances of messages being delayed or lost increase, which can have dire consequences for safety-critical applications, such as alerts about road closures or accidents. Achieving a balance between QoS parameters while adapting to changing network conditions requires sophisticated routing protocols and effective resource management strategies. The implication is that protocols must prioritize timely message delivery and maintain a high level of reliability to ensure that critical information reaches drivers promptly[39].

C. Interference and Connectivity Issues

Interference and connectivity issues pose additional challenges in urban environments where VANETs are most likely to be deployed. For instance, in a densely populated city, the concentration of vehicles, buildings, and other infrastructure can lead to significant radio frequency interference, which hampers communication quality. An example is when vehicles attempt to communicate in a narrow street surrounded by tall buildings, where the signals may be obstructed, resulting in weak connectivity. Additionally, various electronic devices and competing wireless networks can exacerbate interference, leading to degraded performance. For example, Wi-Fi networks operating on similar frequencies can cause interference that disrupts VANET communications. Connectivity challenges can result in fragmented communication, where vehicles cannot maintain consistent connections with one another or infrastructure nodes. The implication is that strategies must be developed to mitigate interference and enhance signal quality, such as deploying additional relay nodes or using advanced communication technologies to ensure reliable connectivity in challenging environments[35].

V. SIMULATION TOOLS AND PERFORMANCE EVALUATION METRICS IN VANET STUDIES

Simulation platforms play a crucial role in VANET research by providing environments to model, analyze, and evaluate routing protocols under various traffic scenarios. The following are some widely-used simulation tools:

1. **NS-3 (Network Simulator 3)**: NS-3 is a discrete-event network simulator widely used in academic and industrial research. It offers advanced simulation capabilities for various network protocols, including those used in VANETs. NS-3 allows researchers to simulate complex network scenarios, implement custom protocols, and analyze network performance. For example, a study may use NS-3 to evaluate the effectiveness of a new routing protocol under different traffic densities and mobility patterns, providing insights into how the protocol performs in real-world conditions[40].
2. **SUMO (Simulation of Urban MObility)**[41]: SUMO is a microscopic traffic simulator that enables researchers to model vehicle movement in urban environments. It simulates realistic traffic scenarios, taking into account factors such as traffic lights, intersections, and vehicle behaviors. For instance, researchers might use SUMO to generate traffic patterns for a specific urban area, which can then be integrated with VANET simulations to analyze how routing protocols perform under varying traffic conditions, such as rush hour congestion.
3. **Veins**[42]: Veins is an integrated framework that combines OMNeT++ (a discrete event simulation framework) with SUMO, enabling realistic vehicular network simulations. This platform allows researchers to simulate the interaction between vehicle movements (simulated by SUMO) and communication protocols (simulated by OMNeT++). For example, a researcher could use Veins to examine how a new safety message dissemination protocol performs in a highly dynamic urban environment where vehicle speeds and densities vary significantly.

The importance of these simulation platforms lies in their ability to create controlled environments where researchers can experiment with different protocols and configurations without the limitations and risks associated with real-world testing. By providing accurate simulations of both network and traffic conditions, these tools help in understanding the implications of design choices on protocol performance.

A. Traffic and Mobility Modeling

Traffic and mobility modeling is critical in evaluating protocol performance in VANET studies. Different traffic models can simulate vehicle movement under various

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conditions, influencing the effectiveness of routing protocols[43]. Key traffic models include:

1. **Deterministic Models**: These models use fixed patterns of vehicle movement, such as constant speed and predefined routes. While they are easier to implement, they may not accurately reflect real-world conditions.
2. **Stochastic Models**: These models incorporate randomness and variability, simulating more realistic vehicle behaviors. For example, using Poisson distributions to model vehicle arrivals at an intersection can provide insights into how protocols perform under fluctuating traffic volumes.
3. **Microscopic Models**: These models focus on individual vehicle behaviors and interactions, considering factors like acceleration, lane changing, and distance to other vehicles. Tools like SUMO are essential for developing microscopic models that provide realistic traffic flow data for VANET simulations.

The choice of traffic model is vital because it directly impacts the accuracy of simulation results. Realistic traffic scenarios lead to more reliable evaluations of how routing protocols will perform in practice, ensuring that researchers can draw meaningful conclusions about their effectiveness in real-world applications.

B. Performance Metrics

Evaluating the performance of routing protocols in VANET studies involves using specific performance metrics. Key metrics include:

1. **Throughput**: This metric measures the amount of successfully transmitted data over a communication channel in a given time period, usually expressed in bits per second (bps). High throughput indicates efficient use of the network, which is crucial for applications like real-time traffic updates and safety alerts. For instance, a routing protocol that maintains high throughput during peak traffic times demonstrates its ability to handle high data volumes effectively.
2. **Packet Delivery Ratio (PDR)**: PDR quantifies the proportion of packets successfully delivered to their destination compared to the total packets sent. A high PDR is essential for ensuring reliable communication, particularly for safety-critical messages. For example, in a scenario where vehicles communicate information about accidents, a high PDR indicates that most safety messages reach their intended recipients, which can significantly enhance overall traffic safety.
3. **End-to-End Delay**: This metric measures the time taken for a packet to travel from the source to the destination. Low end-to-end delay is crucial for applications requiring real-time communication, such as collision avoidance systems. In a study evaluating a new routing protocol, researchers might find that it consistently achieves lower end-to-end delays compared to traditional protocols, demonstrating its suitability for time-sensitive applications.
4. **Jitter**: Jitter refers to the variation in packet arrival times. Low jitter is important for maintaining a smooth communication experience, especially for applications like video streaming or voice communication. In VANETs, high jitter can disrupt timely message delivery, which is critical for safety applications. An example of the impact of jitter could be in a video feed from a connected vehicle; high jitter may lead to choppy video, making it difficult for operators to react to situations effectively.
5. **Routing Overhead**: This metric measures the additional data packets generated for managing routing information compared to the actual data being transmitted. Lower routing overhead indicates a more efficient routing protocol. For example, a protocol with high routing overhead may generate excessive control packets that congest the network, reducing the effective bandwidth available for safety messages.

The importance of these performance metrics lies in their ability to provide comprehensive insights into the strengths and weaknesses of routing protocols in VANET environments. By evaluating protocols against these metrics, researchers can determine their viability for practical applications, helping to inform future developments in VANET technologies[44].

Simulation tools, traffic modeling, and performance evaluation metrics are essential components of VANET research. They allow researchers to create realistic scenarios, evaluate protocol performance under varying conditions, and understand the implications of different design choices. By leveraging these tools and metrics, the VANET community can develop more effective and reliable communication systems that enhance road safety and traffic management.

VI. APPLICATIONS OF VANET IN MODERN TRANSPORTATION SYSTEMS

Vehicular Ad Hoc Networks (VANETs) are transforming modern transportation systems by enhancing communication among vehicles and infrastructure. This section details key applications of VANET in traffic management, safety, support for autonomous vehicles, and integration into smart city ecosystems, providing examples of existing systems worldwide.

A. Traffic Management and Congestion Control

VANETs play a significant role in improving traffic management and reducing congestion through various applications:

1. **Traffic Monitoring**: By utilizing real-time data from connected vehicles, traffic monitoring systems can assess road conditions, vehicle speeds, and traffic densities. For instance, in cities like Los Angeles, traffic management systems leverage VANET data to monitor congestion levels and adjust traffic signals accordingly. This real-time data helps city planners optimize traffic flow, reducing travel times and emissions[45].

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2. **Congestion Control**: VANETs facilitate dynamic route guidance by sharing information about traffic conditions, accidents, or road closures. For example, the European project "Cooperative Intelligent Transport Systems" (C-ITS) uses VANET technology to provide drivers with alternative routes during peak traffic hours. By redirecting vehicles to less congested roads, these systems can alleviate traffic bottlenecks and improve overall flow[46].
3. **Dynamic Traffic Light Management**: VANETs enable adaptive traffic light control systems that adjust signal timings based on real-time traffic conditions. In Singapore, for instance, traffic lights are integrated with VANET technology to respond dynamically to traffic volumes, optimizing signal phases to minimize waiting times for vehicles and pedestrians[47]. This adaptive approach enhances traffic efficiency and safety at intersections.

B. Safety-Related Applications

Safety is a primary focus of VANET applications, significantly improving road safety and reducing accident rates:

1. **Collision Avoidance**[48]: VANETs enable vehicles to communicate critical information about their speed, direction, and location, allowing for timely warnings about potential collisions. The "Vehicle-to-Vehicle" (V2V) communication technology developed by organizations like the U.S. Department of Transportation is designed to alert drivers of imminent dangers, such as sudden stops or lane changes. For example, General Motors has implemented V2V communication in some of its models to enhance collision avoidance capabilities.
2. **Emergency Warning Systems**: VANETs facilitate rapid dissemination of emergency alerts, such as accidents, road hazards, or severe weather conditions[49]. The "Connected Vehicle" program in the United States includes applications that notify drivers of road hazards or emergency vehicles approaching intersections. This timely information helps drivers make informed decisions, potentially preventing accidents and enhancing overall road safety.
3. **Cooperative Driving**: In cooperative driving scenarios, vehicles work together to optimize traffic flow and enhance safety[43]. For example, the "SARTRE" (Safe Road Trains for the Environment) project in Europe demonstrated platooning, where vehicles travel closely together, reducing drag and improving fuel efficiency[50]. Through VANET technology, vehicles communicate their positions and speeds, allowing for synchronized movements that enhance safety and efficiency on the road.

C. Support for Autonomous Vehicles

VANETs are crucial for the development and operation of autonomous vehicles, providing essential data and communication capabilities:

1. **Real-Time Data**: Autonomous vehicles rely on real-time information from their surroundings to make safe driving decisions[51]. VANETs provide data on traffic conditions, road hazards, and vehicle movements, enabling autonomous vehicles to navigate complex environments effectively. For example, Waymo's autonomous vehicles use a combination of sensors and V2V communication to interpret their surroundings and make real-time driving decisions.
2. **Decision-Making Support**: By integrating VANET technology, autonomous vehicles can enhance their decision-making processes[52]. For instance, during high-traffic scenarios, connected vehicles can share information about optimal speeds and routes, allowing autonomous vehicles to adjust their behavior to improve overall traffic flow. This collaborative decision-making contributes to safer and more efficient transportation systems.

D. Integration into Smart City Ecosystems

VANETs are integral to the development of smart city initiatives, contributing to various applications that enhance urban living:

1. **Smart Parking**[53]: VANET technology can facilitate smart parking solutions by providing real-time information on available parking spaces. For example, cities like San Francisco have implemented smart parking meters that communicate with connected vehicles, directing them to the nearest available parking spot. This reduces the time spent searching for parking, decreasing congestion and emissions.
2. **Pollution Monitoring**[54]: Connected vehicles can contribute to environmental monitoring by collecting data on air quality and pollution levels. In cities like Barcelona, the integration of VANETs allows for real-time pollution tracking, helping urban planners identify pollution hotspots and implement measures to improve air quality.
3. **Fleet Management**: VANETs enhance fleet management systems by enabling real-time tracking and communication among vehicles. For instance, logistics companies like UPS utilize VANET technology to monitor vehicle locations and optimize delivery routes based on current traffic conditions[7]. This capability improves operational efficiency and reduces fuel consumption, contributing to sustainability goals.

VII. FUTURE RESEARCH DIRECTIONS AND OPPORTUNITIES IN VANET

The evolution of VANET continues to present significant research opportunities that promise to enhance transportation systems' efficiency, safety, and sustainability. One key area is the integration of Artificial Intelligence (AI) and Machine Learning (ML) in VANET, which can optimize routing, enhance anomaly detection, and facilitate predictive maintenance. For example, AI can analyze historical traffic data to predict congestion patterns,

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potentially reducing traffic delays and improving road safety. This integration can lead to safer and more efficient transportation networks if successfully implemented. Current progress in this area includes pilot projects like the Smart City initiatives in Barcelona. AI optimizes signal timings based on real-time traffic conditions, with an estimated development timeline of 3 to 5 years for broader integration.

Another significant opportunity lies in deploying 5G networks and future 6G technologies, which offer increased speed, lower latency, and more excellent connectivity range for VANET applications. These advancements support real-time data sharing and communication between vehicles and infrastructure, enhancing system responsiveness. Countries like the U.S. and South Korea are already testing 5G technologies for automotive applications, with an estimated 2 to 4 years needed for widespread adoption. Additionally, integrating edge computing within VANET can improve real-time data processing by bringing computation closer to the data source. At the same time, the Internet of Things (IoT) can enhance VANET applications by connecting a broader array of devices. Pilot projects in smart cities like Amsterdam already leverage these technologies, with a projected development timeline of 4 to 6 years for comprehensive integration.

Standardization and regulatory challenges are also critical, as establishing standardized protocols and regulatory frameworks is essential for ensuring interoperability and security across different VANET implementations. Organizations like the IEEE and ISO are actively working on standards for V2X communications, and ongoing discussions among regulatory bodies aim to create cohesive frameworks that enhance safety and public trust. This standardization could take 2 to 5 years for initial adoption. Finally, research into sustainability and green networking within VANET is crucial for aligning transportation technologies with environmental goals. This includes developing energy-efficient communication protocols. Initiatives such as the EU-funded "Green eMotion" project are already promoting sustainable mobility solutions, with an estimated timeline of 3 to 7 years for significant advancements and widespread implementation.

These future research directions offer exciting opportunities to transform VANET technology, contributing to more efficient, safe, and sustainable transportation networks. Effective collaboration among researchers, industry stakeholders, and policymakers will be crucial in realizing these advancements and their benefits.

VIII. CONCLUSION

The study's conclusion on Vehicular Ad Hoc Networks (VANET) demonstrates that this technology can transform modern transportation systems by enhancing communication between vehicles and infrastructure. With various applications ranging from traffic management to safety, VANET can reduce congestion and improve road safety through emergency warning systems and collision avoidance applications. However, the challenges faced in its implementation, such as high mobility and frequent topology changes, require effective solutions to ensure network stability and performance. Security and privacy issues are also significant, given the risks such as data tampering and denial-of-service attacks that can threaten system integrity. Quality of Service (QoS) also plays a crucial role, with the need for low latency, high reliability, and stable connectivity in dynamic environments.

Looking ahead, the integration of artificial intelligence and machine learning into VANET, as well as the deployment of 5G and 6G technologies, can offer innovative solutions to these challenges. Edge computing and IoT can also enhance real-time data processing, supporting faster and more accurate decision-making. Standardization of protocols and transparent regulatory frameworks will be necessary to ensure interoperability and security across systems while supporting efforts toward more sustainable networking.

Overall, VANET represents a promising field with many research opportunities that can enhance the efficiency, safety, and sustainability of transportation systems. Effective collaboration among researchers, industry stakeholders, and policymakers will be critical in realizing these advancements and their benefits. Systematic and comprehensive research in this area, as outlined in the literature review, will provide deeper insights into current developments and challenges and pave the way for future innovations in transportation.

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Development of a Cashier Business Transaction System using the Android Based Agile Method

David Bagus Junanda[1*)], Rodhiyah Mardhiyyah[2]
[1,2]Informatics Study Program, Faculty of Science & Technology, University Technology of Yogyakarta
Email: [1]davidsukses28@gmail.com [2]rodhiyah@staff.uty.ac.id

Abstract – The grocery retail sector in Indonesia plays an important role in meeting people's basic needs, with grocery merchants in urban and rural areas serving as the main middlemen in the distribution of staples to end consumers. Grocery merchants in Indonesia often face challenges in improving sales efficiency due to the use of conventional methods that are slow, unstructured, and prone to recording errors. These challenges can potentially lead to loss of customers, financial losses, and hinder business growth. This research aims to develop an Android-based cashier application specifically designed for grocery merchants to improve transaction efficiency and stock management. Using a qualitative approach, in-depth interviews were conducted to understand the needs and constraints faced by merchants in the transaction process. The findings were used to design the main features of the application, such as CRUD-based item management (Create, Read, Update, Delete), barcode scanning with a smartphone camera, digital receipt sending via WhatsApp, and payment support via QRIS E-wallet and cash transactions. This application is assumed to be used on Android devices with adequate internet access. The results show that this application is able to reduce recording errors, speed up transactions, and increase customer satisfaction compared to the manual method. The solution is expected to improve productivity, drive business growth, service quality and customer satisfaction as well as the competitiveness of grocers in the digital era. Future recommendations include the development of analytics features to monitor sales performance and support strategic decision-making.

Keywords – Cashier Application, Grocery Merchant, Transaction Efficiency, Stock Management, Android, Firebase

I. INTRODUCTION

In today's all-digital development of modern technology, all store management activities, such as buying and selling and transactions of physical, digital, and service products, can be done quickly, cheaply, and easily, without space and time constraints [1]. The grocery retail sector in Indonesia plays an important role in meeting people's basic needs, with grocery traders in urban and rural areas serving as the main middlemen in the distribution of staples to end consumers. Nine basic commodities or sembako is a much-needed business for the community, which requires a nearby grocery store that sells daily necessities at affordable prices, including a wide variety of food and beverages such as rice, vegetables, sugar, cooking oil, LPG gas, and other basic needs [2]. Thus, the existence of basic necessities is needed by the community to fulfill their needs [3].

Griya Sembako Abadi is a grocery store owned by Mrs. Endang Susanti located in Donokerto Village, Turi, Sleman Regency, Yogyakarta. Although this grocery store business is growing rapidly because it has an important role in the community's basic needs sector, the adoption of technology to support business efficiency is still very limited, especially among small and medium-sized traders. Toko Griya Sembako Abadi currently faces considerable challenges in its daily operations, especially in conducting transactions efficiently. Conventional methods such as manual recording make them prone to errors, such as miscalculations and stock mismatches that can lead to losing customers. Difficulties in managing stock in real-time often lead to out-of-stocks or excess items, resulting in financial losses. All of these factors hinder business adaptation to changing consumer behavior and pressure from supermarkets that have implemented advanced technology. These problems indicate that Toko Griya Sembako Abadi needs a system that can monitor stock items, calculate financial income and expenses, and make it easier for customers to make transactions and see available stock items [4]. Therefore, MSMEs must continue to be empowered even in difficult circumstances by integrating them with digital technology [5].

Based on these problems, the solution offered is to adopt technology by developing an Android-based cashier application that is easily accessible to grocery traders to improve operational efficiency, from recording transactions to managing stock items. This application is designed using Android Studio software, Android Studio is an Integrated Development Environment (IDE) which is specialized for building applications that run on the Android platform [6]. The programming language used is Kotlin, Kotlin is a Java Virtual Machine (JVM) based programming language developed by JetBrains for Android applications, combining object-oriented and functional programming, and can be integrated with Java in the same project [7]. Then the database used in designing this application is a firebase realtime database that does not have a relationship or is called NoSQL. With features such as item management, barcode scanning using a smartphone camera, and digital receipt printing that can be sent via WhatsApp, merchants can speed up the transaction process and reduce recording errors. In addition, the app also supports various payment methods, both cash and electronic through QRIS, thus providing more flexibility to customers.

To strengthen the basis of research, a literature review is needed as a literature study. In research conducted by Kurniawati and Lukman [8], the development of mobile

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technology for cashier systems using firebase and java was carried out. The system can perform total grocery calculations quickly and accurately and can display sales reports. Furthermore, the design of a sales application with a barcode scanner made by Novia [9] based on Android. The system created is able to provide information and reports on the results of sales or purchase transactions that occur in graphic form. Then in research conducted by Azhari and Linda [10] related to the design of mobile-based cashier applications using java. The resulting system can perform sales and purchase transactions. The menu provided is also complete until the addition of employees. Then in the design of the Point of Sales (POS) application conducted by Restiawan and Ramos [11] using Firebase. Android-based POS applications have succeeded in speeding up transactions, and Warkop owners find it easy to use and as needed. In research conducted by Beny and Imam [12] in designing cashier applications at Aira Motor using flutter and firebase. Android-based cashier application using Firebase Realtime Database as a solution to improve transaction services at Aira Motor Padangjaya, a trusted motorcycle workshop in Padangjaya.

This research aims to understand the challenges faced by grocery merchants in managing their business, especially regarding transaction efficiency and stock management, provide guidance for developers in designing cashier applications that can improve the efficiency of grocery store businesses, increase merchants' awareness of the importance of technology to be able to compete in the market, and contribute to the development of Android cashier applications that are relevant to the needs of merchants. In addition, this research aims to improve service quality and customer satisfaction, while driving business growth. The system is developed using the Agile Method and manages the database using firebase. By utilizing this technology, it is expected that merchants can be more competitive in the digital era, increase productivity, and strengthen relationships with customers through faster and more efficient services.

II. RESEARCH METHODOLOGY

Agile Software Development is a software development method that has various development principles that are easily adaptable to various forms of change that occur in a relatively short time [13]. The research stages in building applications using the Agile Software Development method have several stages. The following are the stages carried out in this study.

A. Planning

In this planning stage, an analysis of the current system is carried out. Through this analysis, the problems that exist in the system can be known. Planning is described in the research framework by including the initial conditions of the system with the proposed new system. The research framework can be seen as follows.

Figure 1. Research Framework

B. Design

The design is also done using Unified Modeling Language (UML) modeling because of the flexibility of many and varied diagrams [14]. The diagrams used are Use Case Diagram, Activity Diagram, and Sequence Diagram. This diagram serves to design the performance flow of the new system by identifying what activities can be performed on the system.

C. Analysis

The analysis stage is carried out by analyzing existing problems to find the right solution. System development with transaction features can be a good solution in creating shopping convenience and increasing productivity.

D. Implementation

The system design is then implemented by coding and implementing firebase as a data manager in the system. Firebase is offered by Google as a solution to simplify mobile and web application development and has a realtime database [15].

E. Testing

Testing as the final stage of development is the most important part that should not be missed. The black box testing method is used by creating several test scenarios to see the program is the same as the program task without knowing the program code used [16].

III. RESULTS AND DISCUSSION

This research shows that the Android-based grocery cashier application has been able to perform most of the main functions, including item code scanning, QRIS payment integration, and presentation of transaction reports; although there are still technical challenges such as connection stability and the need for optimisation of the barcode upload feature, these findings indicate the need for further development to enrich the user experience and add features that display transaction details to support more efficient inventory management for sellers.

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A. System Design

After conducting a sales system analysis using conventional methods, the next step is to design a proposed system by considering the shortcomings of previous sales using conventional methods. The following is the proposed system design.

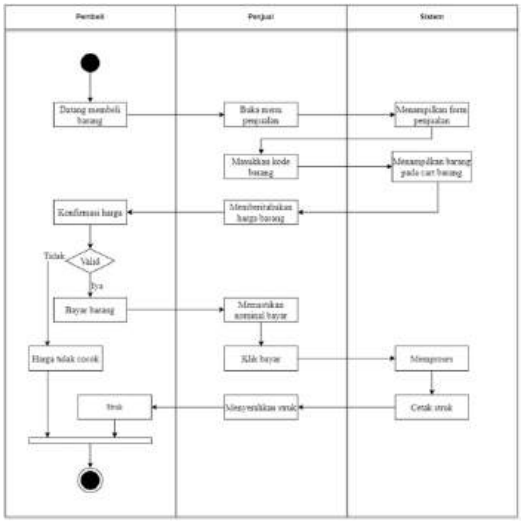

Figure 2. System Design

B. Analysis of Current System

Model architecture is used to provide a more detailed explanation of the various types of models, while designing a new model structure to address problems in the previous system, by analyzing the current system. The following image shows the sales process flow using the conventional method, depicting the current system.

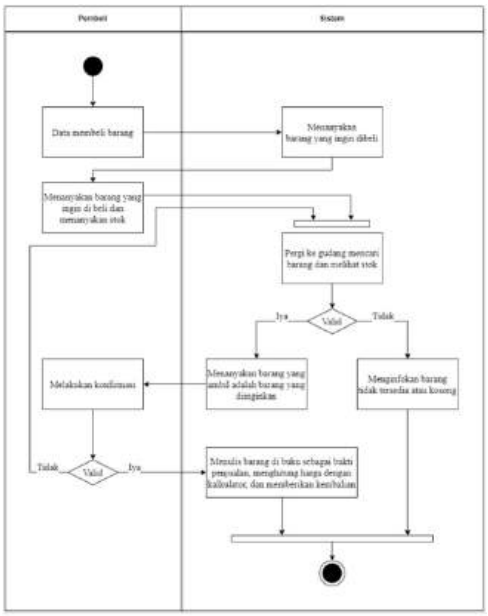

Figure 3. Analysis of Current System

C. Use Case Diagram

Here is a use case that describes the functionality performed by one actor, namely the seller. In the form of Login, Goods, Sales, Customer List, Cashier Report, Sales Report, Profile, and Logout

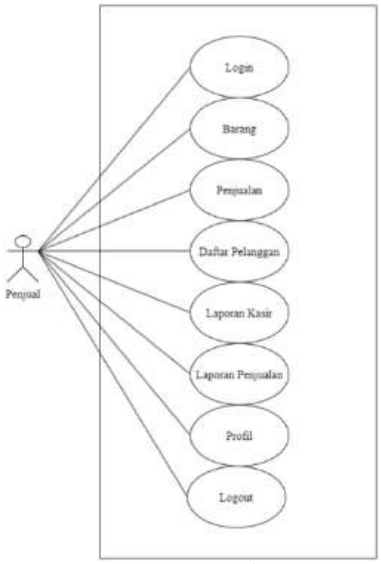

Figure 4. Use Case Diagram

D. Activity Diagram

Activity diagram is a visual representation of the workflow that occurs in a running system. Activity diagrams are used to define the display sequence of activities that occur in a system, as used in this study. In an activity diagram, components are connected using arrows, which direct the sequence of activities from start to finish. The diagram below is an activity for the login process when the user wants to enter the grocery cashier sales application.

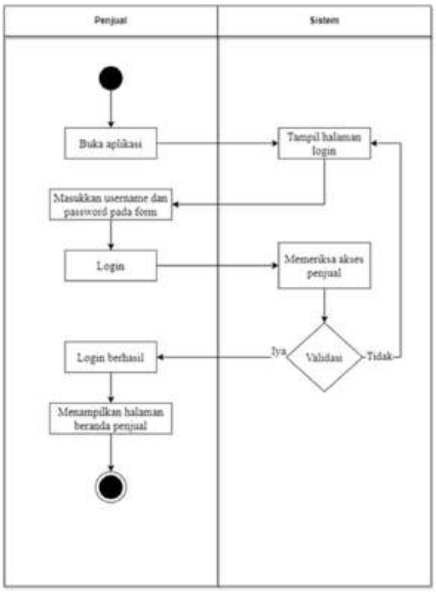

Figure 5. Login Activity Diagram

The next diagram is the item activity diagram. The diagram below is an activity that we can do to perform basic CRUD operations to make it easier to use the application.

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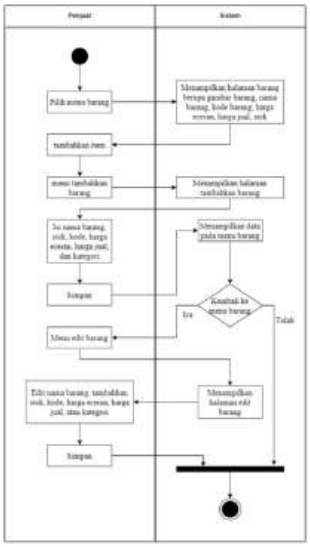

Figure 6. Item Activity Diagram

The next diagram is a sales diagram that illustrates sales activities, which include the selection of item names to the payment process.

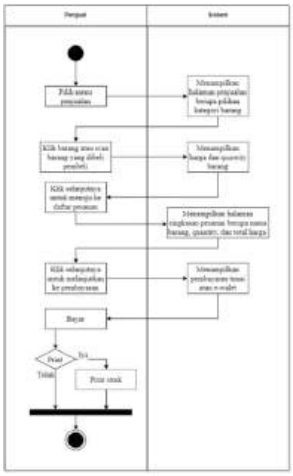

Figure 7. Sales Activity Diagram

Customer List Activity Diagram is a customer list activity in the form of customer data details to provide information if there are new products or requests for items that are not in the store.

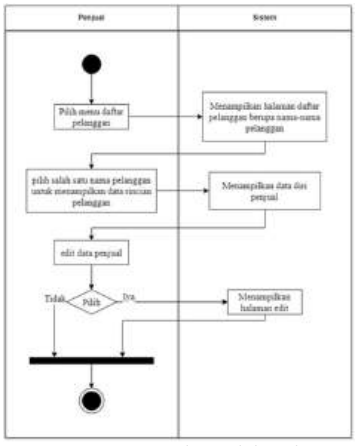

Figure 8. Customer List Activity Diagram

Cashier report activities in the form of payment data from physical money, e-wallets, and total revenue are also diagrammed as follows

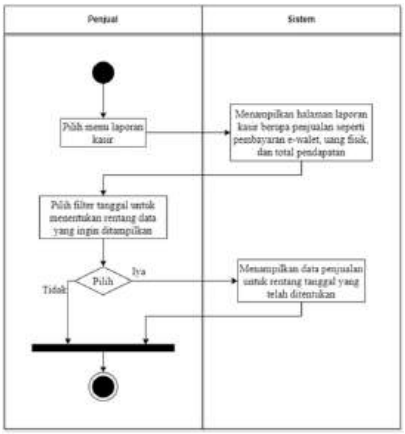

Figure 9. Cashier Report Activity Diagram

The diagram below is an activity diagram that describes the process of viewing the history of sales made in the form of total revenue and total transactions.

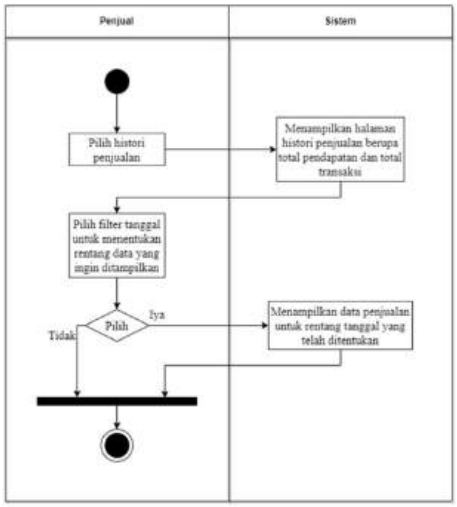

Figure 10. Sales Report Activity Diagram

The diagram below is an activity to view profile data and can also edit profiles.

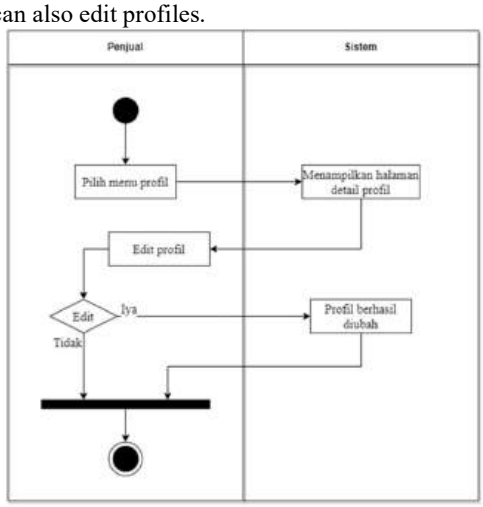

Figure 11. Profile Activity Diagram

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Furthermore, the Logout Activity Diagram describes the activity of logging out of the account.

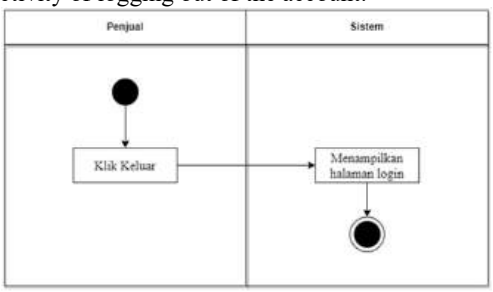

Figure 12. Logout Activity Diagram

E. Sequence Diagram

Sequence diagrams are diagrams used to explain interactions between objects in a system so that they are easier to understand. The login sequence diagram displays the process where the seller logs in and the required data is retrieved from the database. If the data is found, the user will be directed to the main page. Below are several sequence diagrams.

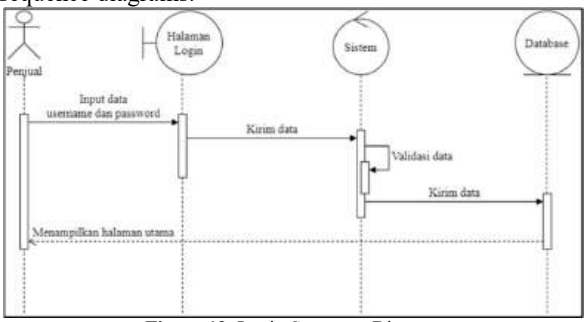

Figure 13. Login Sequence Diagram

The item sequence diagram shows the steps when the seller performs CRUD operations on the sale of goods. The seller starts by clicking on the item menu in the application, then there can edit items or add items such as item name, stock, code, retail price, selling price, and category. After that, the data entered will be stored in the database.

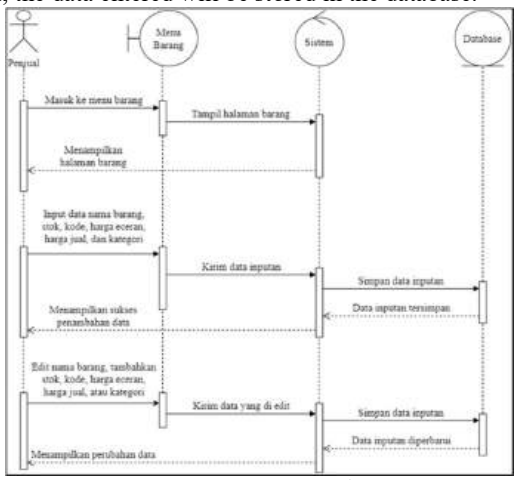

Figure 14. Item Sequence Diagram

The sequence diagram for the sales process starts when the seller inputs the goods purchased by the customer. Purchased item data is retrieved from the item database. Then display the order list to check what items are purchased. After that, choose a payment method, which can be done in cash or using an e-wallet. The payment information is then saved into the database.

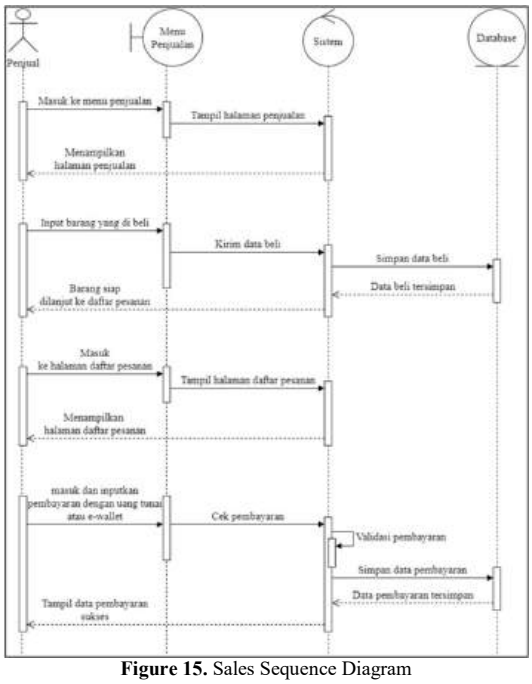

Figure 15. Sales Sequence Diagram

The sequence diagram for the customer list starts when the seller selects the customer list menu option. Customer data will be processed, retrieved from the database, and displayed to the seller.

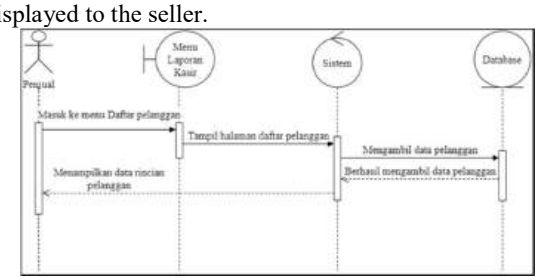

Figure 16. Customer List Sequence Diagram

The sequence diagram for the cashier's report shows that the seller can view the cashier's report which includes turnover from sales made from e-wallet payments, physical money, and total revenue.

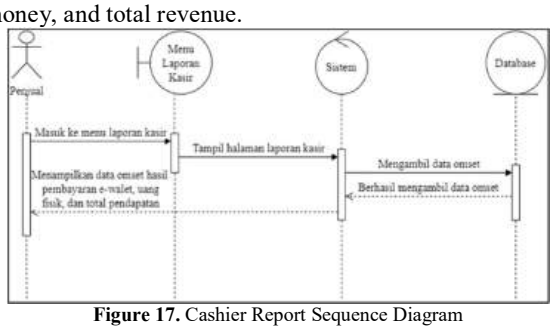

Figure 17. Cashier Report Sequence Diagram

The Sales Report Diagram illustrates the process where the seller views the sales report by retrieving data from the database, which then displays the sales report in the form of total revenue and the number of transactions that have occurred.

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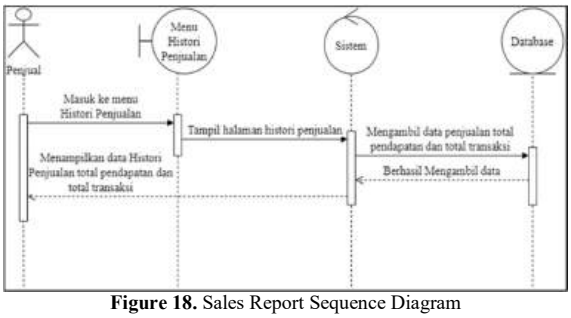

Figure 18. Sales Report Sequence Diagram

Sequence diagram for profile, where the seller enters the profile menu to edit his profile, then the data that has been changed will be saved to the database, and the results will be displayed again on the profile page.

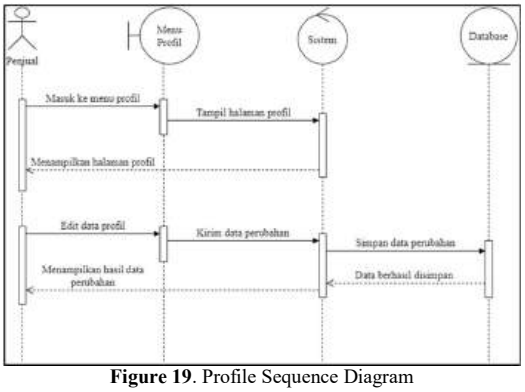

Figure 19. Profile Sequence Diagram

The sequence diagram for the logout process starts when the seller decides to exit the system. After the seller logs out, the system will respond by displaying the login page again.

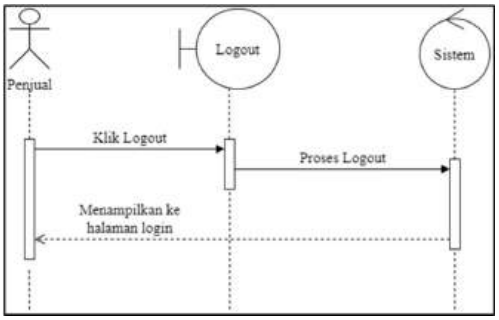

Figure 20. Logout Sequence Diagram

F. Implementation

In this phase, the system is implemented following the design specifications, with the results illustrated through application screenshots to showcase its functionality.

1. Splash Screen And Login

The splash screen page displays the logo and name of the app to give the user an initial impression, while also assisting in loading the required content, creating an engaging visual experience, as well as indicating that the app is being prepared before the user enters the main interface. Meanwhile, the login page will appear when the user has not logged into the application, where they must enter the email address and password set by the admin. After filling in the data correctly, users can press the 'login' button to access the application.

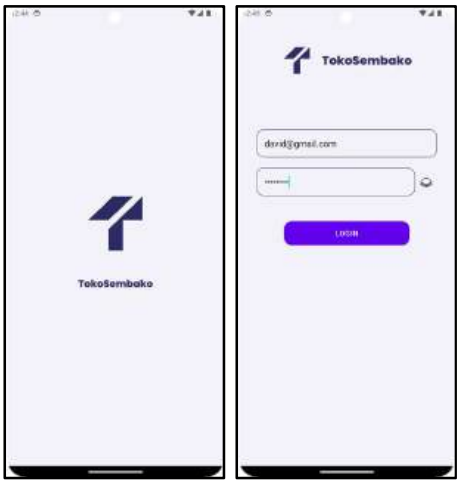

Figure 21. Splash Screen And Login

2. Home And Profile

The home page displays 3 menus, namely the goods menu containing goods management, the sales menu as sales transactions, and the customer list menu to store customer data if goods in the shop are not available. And the profile page displays store data such as store name, telephone number, and store address.

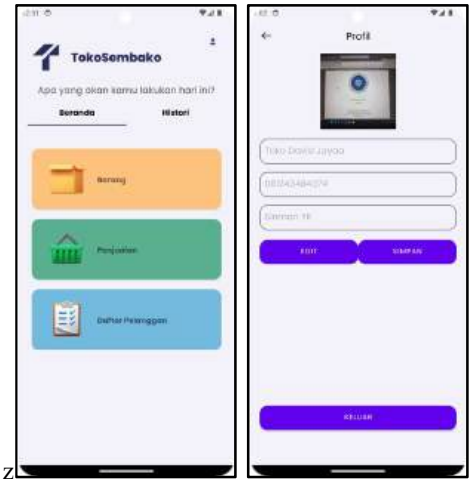

Figure 22. Home And Profile

3. Sales and Order List

The sales page displays all items for sale in terms of name, price, and stock, and displays the subtotal when selecting an item. The order list page displays details of the purchased items in the form of total items, subtotals and features for adding, reducing and deleting items if the customer reduces their order.

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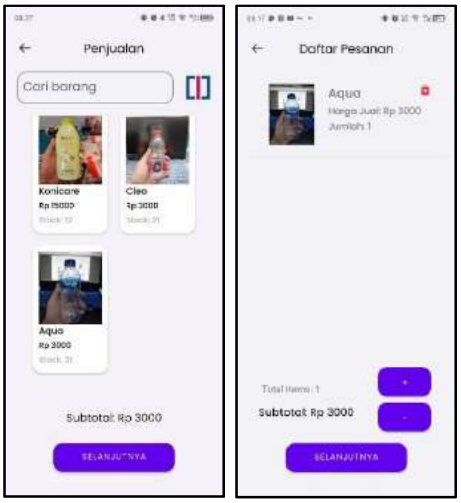

Figure 23. Penjualan And Daftar Pesanan

4. Item and Add Item

Item page as a treatment for adding items, editing, deleting, and displaying item data in the form of name, code, retail price, selling price, and item stock. The add item page consists of filling in data in the form of name, code that has been integrated with moving barcodes, retail price, selling price, stock of goods, and category choices for each item.

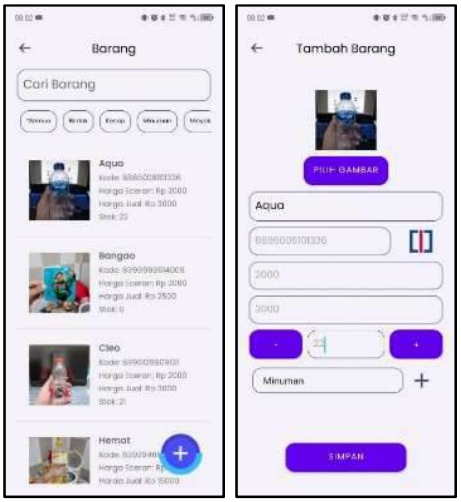

Figure 24. Barang And Tambah Barang

5. Scan Code And Customer List

The barcode scanning page appears when you click on the barcode icon, which acts as a barcode scanner for items. The customer list page displays a list of customer names in the form of names and phone numbers. Its function is to provide information to customers because the goods in the store are not yet available.

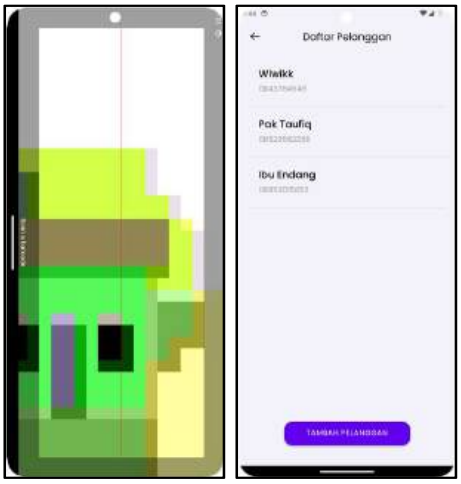

Figure 25. Pindai Kode And Daftar Pelanggan

6. Cash and Cashless Payment

The cash payment page displays the nominal input if the price is more than IDR 100,000, the nominal options start from IDR 5,000 to IDR 100,000, and item details to check the purchased items. The ewallet payment page consists of entering the QR code for all online payments, and displays the item details.

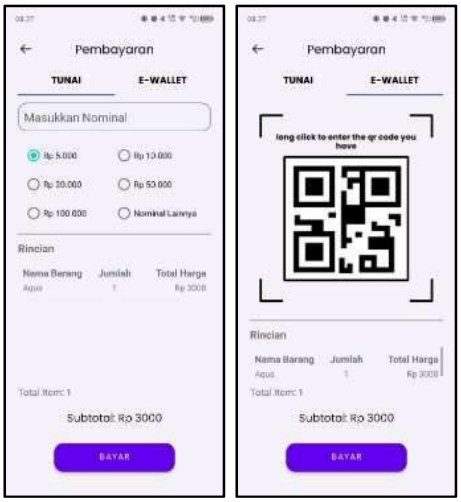

Figure 26. Pembayaran Tunai And Non Tunai

G. Testing

In this study, system testing was conducted using the blackbox method which was tested by 5 people. This approach focuses on functionality without knowing the internal structure and program code. In this blackbox testing, it is carried out critically from income calculations, input validation, data storage to the database and displaying appropriate or inappropriate results on each page. The results of testing with the blackbox method can be seen in the following table.

Table 1. Black Box Testing

Test Class	Skenario Uji	Expected Result	Conclusion
Process of Managing Goods Data	Enter item data such as image, name, code,	New item data is successfully	Succes

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	price, stock and item category. Click the add button.	added to the database.	
	Opens the goods menu that will display the goods data.	Display the item data that has been added.	Success
	Clicking on one of the items will go to the edit page and change the item, then click save.	The data is successfully updated as desired.	Success
	Clicking on one of the items will enter the edit page and click delete.	The selected item is successfully removed from the ui and database.	Success
Transaction Process	Select one of the items and the prices will be summed up immediately, then click next.	The selected item is successfully displayed on the order list along with the total price of the item.	Success
	Select the desired payment method (Cash or non-cash)	Successfully totaled the calculated groceries correctly and displayed the payment method options.	Success
	Click the pay button to complete the transaction	Cash payment will calculate the change correctly and display a successful transaction and save with payment details.	Success
Stock Items	Click on items until they exceed the stock held	Display a notification that the item is out of stock and the order quantity will stop growing	Success
Sending Via WhatsApp	On the successful transaction page, click the "Share via WhatsApp," button and enter the destination number.	The transaction details will be sent to the number in the form of a digital receipt format.	Success

Based on testing with the scenarios made, it can be concluded that the application can run well. This is because all scenarios are 100% successful.

IV. CONCLUSION

From the research and testing conducted, it was found that the system has successfully displayed transaction reports and cashier reports according to the selected date, integrating the scanning of item codes from the addition process to the display of the list of items, providing receipt options that can be shared via WhatsApp, and activating the QRIS e-wallet payment method through uploading barcodes that have been created, with automatic stock reduction when transactions occur. Although this Android-based grocery cashier application is functional and ready to use, further development is still needed to optimize application performance, for example by adding an online payment feature to facilitate transactions for buyers who are short of cash, as well as a transaction details feature that includes the number of items sold, the number of transactions, and total revenue so that sellers can recap outgoing goods data more easily.

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Long Short Term Memory For Comparison Between Bank Syariah Indonesia And PT Bank Artos Indonesia Shares

Zulfanita Dien Rizqiana[1*], Izzat Muhammad Akhsan [2], Intan Indrasara Priyanto [3] ,Aninda Sabila Maharani[4]
[1,2,3,4]Program Studi Sains Data, Fakultas Ilmu Tarbiyah, UIN Raden Mas Said Surakarta
Email: [1]zulfanita.dr@staff.uinsaid.ac.id , [2]akhsanizma@gmail.com, [3]intanindrasara02@gmail.com , [4]aninmaharani06@gmail.com

Abstract – The growth of the capital market in Indonesia has increased from year to year. Based on data from the Indonesia Central Securities Corporation (KSEI), there has been an increase in investor growth in the capital market by 2.34%, mutual funds by 2.44%, and shares by 1.34% until August 2024. The demographic of individual investors in the capital market is dominated by Generation Z who are younger than from 30 years as much as 55.07% in August 2024 (KSEI, 2024). Shares are a form of investment that has the potential for large profits but with small risks. One sector that Gen Z is interested in investing in is the financial sector. The aim of this research is to compare the share prices of Bank Syariah Indonesia and Bank PT Ban Artos Indonesia Tbk using a Neural Network with the Long Short Term Memory (LTSM) algorithm. The data used in this research is secondary data on BSI and PT Bank Artos Indonesia Tbk share prices taken from the investing.com website. The data period used is from 01 September 2021 – 01 September 2024. Based on the results of stock price forecasting using a Neural Network with the LTSM algorithm, RMSE value for both models is for BSI 75.0757 and 91.795 for PT. Bank Artos Indonesia Tbk. A comparison of the predicted share prices of PT Bank Arto Indonesia Tbk and BSI shows that BSI's share price performance is superior to that of PT Bank Arto Indonesia Tbk.

Keywords – *Financial Sector; Neural Network; Shares*

I. INTRODUCTION

The growth of the capital market in Indonesia has increased from year to year. Based on data from the Indonesian Central Securities Company (KSEI), there was an increase in investor growth in the capital market by 2.34%, mutual funds by 2.44%, and stocks by 1.34% until August 2024. The demographics of individual investors in Indonesia's capital market are dominated by Generation Z, which is less than 30 years old, totaling 55.07% in August 2024(KSEI, 2024). This shows that Generation Z is very interested in long-term investments. One of the investments that Gen Z is interested in is stocks. Stocks are a form of investment that has the potential for large profits but with little risk. Stock price risk is supported by dynamic stock price fluctuations, so it requires stock price forecasting analysis so that losses can be minimized[1].

One of the sectors that Gen Z is interested in investing in is the financial sector, especially banking stocks. Based on the KSEI 2022 press release, the stock sector that Gen Z and Millennials are most interested in is the financial sector with 209,053 and 418,197 investors. Banking dominates the financial sector because it plays an important role in the country's economy by collecting and channeling public funds [2]. Banking stocks are heavily influenced by changes in economic conditions and banking regulations, changes in interest rates, fluctuations in loan performance, and other external events may impact the movement of financial stock prices (Hijrah et al. , 2023).

This study aims to compare the stock prices of Islamic banks and conventional banks based on digital or digital banks which are useful for investors in seeing the potential movement of banking stock prices. The growth of digital banks in Indonesia continues to grow consistently. Bank Indonesia noted that the nominal digital banking transactions reached Rp. 5570.49 trillion or an increase of 10.82% on an annual basis in May 2024. Digital banking is growing positively due to several factors including data and transaction security, flexibility in accessing applications, complete application features, integration with other financial services and special promos(detikFinance.com, 2024; Purwanto & Perkasa, 2024). The growth of digital banking is driven by Gen Z, which is the largest generational group in Indonesia today. Generation Z is a generation that has grown up with access to technology and the internet since they were young, so they can play an important role in the digital economy. There are seven issuers that are purely digital banks, one of which is PT Bank Artos Indonesia Tbk. There are still few investors in the digital banking sector so this sector offers vast potential to investors[5].

Meanwhile, the growth of Islamic banking in Indonesia tends to be stable. Based on Islamic Banking Statistics, the performance of Islamic banking as seen from its capital decreased by 2.77% until July 2024 compared to 2022, and increased by 0.76% compared to 2023(Otoritas Jasa Keuangan, 2024). Although the financial performance of Islamic banking has increased and decreased every year, the banking sector in Indonesia has an important role in the economy in Indonesia. Basically, Islamic banking in Indonesia incorporates Islamic economic principles in its banking activities. One of the factors driving the development of Islamic banking in Indonesia is public awareness of sharia principles in financial activities as well as the role of government support through policies and incentives[6]. One of the Islamic banks in Indonesia is Bank Syariah Indonesia (BSI). BSI is a combination of 3 banks, namely Bank Mandiri Syariah, BRI Syariah, and BNI Syariah, which was merger on February 1, 2021. Because, the development of Islamic financial performance

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is still fluctuating, investors must understand the stock movements of this Islamic banking.

Volatile stock movements can be seen by analyzing and predicting using analysis that is in accordance with stock price data. One analysis that can be used to predict stock prices is time series analysis. Time series analysis is a statistical analysis used to analyze data based on the time period[7]. A statistical method that can be used to predict stock prices in general is ARIMA. ARIMA is considered less effective for predicting stock prices because the structure of stock prices has a complex nonlinear component [8]. One alternative method that can be used to predict stock prices is machine learning, using neural netwok algorithms. The neural network algorithm can be used to predict stock prices because this algorithm can manage complex data and has good accuracy. One of the common neural network algorithms to predict stock prices is the Long Short Term Memory (LSTM) algorithm. LSTM is well used to predict stock prices because it has the ability to understand temporal dependencies in time series data and can be used for long-term data(Cahyani et al., 2023; Mushliha, 2024).

Some research on the LSTM algorithm includes research by Khumaidi et al., (2020) regarding the prediction of air quality and temperature in Bandung City, which states that the accuracy value of the research is good.. Researched by Setiawan & Susanti (2023) The comparative analysis of stock price forecasting results using the ARIMA and LSTM models concluded that the accuracy of the LSTM model for forecasting is very accurate because it has a MAPE value of 10%. Researched by Pahlevi (2023) about bitcoin price prediction using the LSTM algorithm which produces an RMSE accuracy value of 17318.40 for training data and 27921.84 for testing data. Researched by Siregar & Widyasari (2023) regarding crude oil price forecasting using the LSTM method in a recurrent neural network produces an RMSE accuracy of 2.665 for 2018-2020 data, and an RMSE of 2.630 for 2020-2023 data. Through this research, it is hoped that readers, especially Gen Z and Milineal, can gain resources about comparison forecast shares between BSI and PT Bank Artos Tbk.

II. RESEARCH METHODOLOGY

Islamic banks are banks that use sharia principles to carry out all their activities. In general, Islamic banks are divided into two, namely Islamic Commercial Banks and Islamic People's Financing Banks. Sharia principles in Islamic bank activities are based on fatwas issued by Islamic financial institutions [14]. The following are some of the financing provided by Islamic banking, among others [15]

1. Financing is based on the principle of profit sharing
2. Financing based on the principle of equity contribution
3. Financing is based on the principle of buying and selling goods that are profitable
4. Financing of production facilities from the principle of pure lease without option
5. Transfer of ownership of leased goods based on the bank to another party.

Based on the Financial Services Authority (OJK) Regulation number 12/PJOK.02/2021, digital banks are banking institutions that provide services and carry out banking operations online without having a physical office or only a head office with limited physical offices. Digital bank services such as financial transactions, credit applications, checking account printing, etc. can be done online without direct interaction between customers and banks. One of the requirements that must be met in the OJK regulation for digital banks is a business model with a strong risk management system and innovative technology that is safe in meeting customer needs (Saputra et al., 2024).

The stock price is the market value determined by the interaction of supply and demand in the capital market. The share price is a reflection of investors' assessment of the value and potential of a company in the long term [17]. Stock price fluctuations are caused by many factors both external and internal to the company. So that companies that are able to maintain the credibility of their financial performance in increasing their share price will be the goal of investors [18].

The research method used in the study is to use the Long Short Term Memory (LSTM) algorithm with “Adam” optimization. LSTM is a type of artificial neural network in the field of Deep Learning which is a development of Recurrent Neural Network (RNN) designed to overcome vanishing gradient problems and retain important information in long sequential data sequences. LSTM has a special memory structure consisting of cells and gates that allow the network to store or ignore information as needed. LSTM was chosen because it is very effective in handling tasks involving sequential data, one of which is time series data[19].

1. Raw Data
   The data used in this study are the daily closing share prices of PT Bank Artos Indonesia Tbk and PT Bank Syariah Indonesia Tbk (BRIS) shares taken from the investing.com website, with a period of time starting from 1 September 2021 – 24 September 2024.
2. Data Preprocessing
   At this stage, unused data, namely “Open”, “High”, “Low”, “Volume” & “Change” are deleted, and only “Date” & “Close” data are used. After that, the data is normalized with an interval scale of 0-1. Furthermore, the dataset is divided into two for the training and testing process with a ratio of 80% for training data and 20% for testing data.
3. Training and Testing
   After the data preprocessing stage, the data training process is then carried out using the LSTM algorithm. The training process is carried out by training the model using training data, while the testing process is carried out by testing the training model using testing data to determine the effectiveness of the model that has been made.
   In the training and testing process, parameters are needed to get the best LSTM model. The parameters used are tested by trial and error to get the best results. In this study, the parameters used are as listed in Table 1.

Table 1 LSTM Model Parameter Combinations

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Parameter	Value
Neuron	20, 50, 70
Epoch	20, 50, 70, 100
Batch	5, 10, 30
Dropout	0.2

4. Denormalization
   After the model is applied to the training and testing data, at this denormalization stage the model output data which was previously still on a 0-1 scale is returned to its original form according to the actual value of the data, before then calculating evaluation metrics and visualization.
5. Model Evaluation
   The performance evaluation of the model that has been made is obtained using *Root Mean Squared Error* (RMSE), *Mean Absolute Error* (MAE), dan *R-squared* or R^2 [19]. RMSE measures the square root of the average of the squared differences between predicted and actual values. It provides a measure of the magnitude of errors and is sensitive to large errors.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{n}}$$

   with n is number of observation, y_i is actual value of observations, and $\hat{y}_i$ is fitted value.

   MAE represents the average absolute difference between predicted and actual values. It is less sensitive to outliers compared to RMSE and provides a straightforward measure of forecast accuracy.

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|y_i - \hat{y}_i|$$

   with n is number of observation, y_i is actual value of observations, and $\hat{y}_i$ is fitted value.

   R-squared is a statistical metric that reveals how well the machine learning model fits the data it was trained on. It represents the proportion of the variance in the dependent variable that can be explained by the independent variables.

$$R^2 = \frac{\sum_{i=1}^{n}(\hat{y} - \bar{y})^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

   with n is number of observation, y_i is actual value of observations, dan $\hat{y}_i$ is fitted value, and $\bar{y}$ is mean value of y_i.
6. Long Short Term Memory (LSTM)

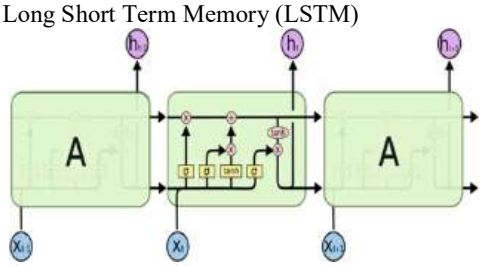

Figure. 1 LSTM Architecture

The LSTM architecture can overcome long-term memory storage because memory cells have been added, so it can overcome the vanishing gradient in RNN when processing long sequential data.
There are three gates in the LSTM architecture, namely forget gate, input gate, and output gate. Forget gate functions to remove information from the cell state. Input gate decides the new information that enters the cell state. The output gate functions to sort out useful information from the cell state and make it the output.The LSTM model can be written with the following formula

$$i_t = \sigma(W_{ii}x_t + W_{hi}h_{t-1} + b_{hi} + b_{ii})$$
$$f_t = \sigma(W_{if}x_t + W_{hf}h_{t-1} + b_{hf} + b_{if})$$
$$c_t = f_t c_{t-1} + i_t \tanh(W_{ic}x_t + W_{hc}h_{t-1} + b_{hc})$$
$$o_t = \sigma(W_{io}x_t + W_{ho}h_{t-1} + b_{io} + b_{ho})$$
$$h_t = o_t . \tanh(c_t)$$

with f, i, o, c are *forget gate*, *input gate*, *output gate*, dan *cell state*. Meanwhile σ is *sigmoid function.* x_t *and* h_{t-1} is the input at time t and the hidden state from the previous time. $W_{ii}, W_{hi}, b_{hi}, W_{if}, b_{hf}, b_{if}, W_{io}, b_{io}, b_{ho}$ are *weights* dan *biases* from LSTM unit. The LSTM architecture allows for the modeling of sequential dependencies over long time horizons, making it particularly effective for tasks such as time series prediction.

III. RESULTS AND DISCUSSION

. The following is a descriptive description of the share prices of PT Bank Artos Indonesia Tbk and BSI for the period September 2021 to September 2024.

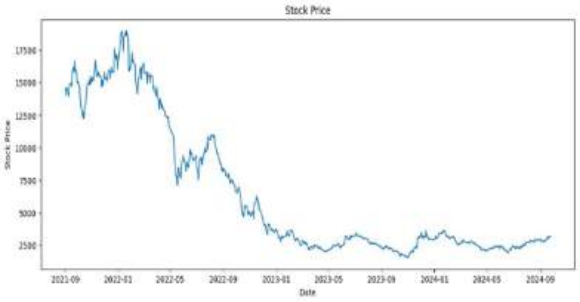

Figure.2 Stock Price of PT Bank Artos Indonesia Tbk

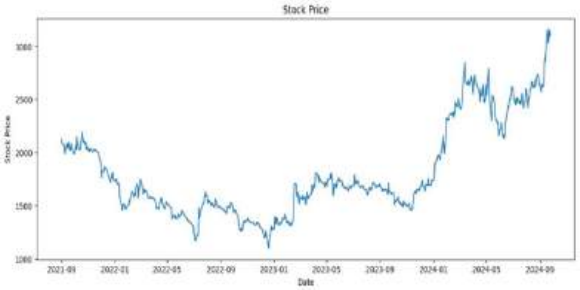

Figure.3 Stock Price of BSI

Based on Figures 2 and 3 above, it can be seen that the share price of PT Bank Artos Indonesia Tbk

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experienced a significant increase at the end of 2021 until the beginning of 2022. Then the share price of PT Bank Artos Indonesia Tbk experienced a gradual decline in mid-2024 and continued to decline until mid-2024. Although it had experienced an increase in share price at the beginning of 2024, this increase was not as significant as in 2021 and 2022. Based on the figure above, it can be seen the pattern of BSI stock movement. At the beginning of the BSI merger in 2021, BSI's share price decreased significantly from 2021 to early 2023. Although there was an increase in shares in mid-2022 and early 2023, the increase was not very significant. The increase in BSI's share price only began to show a significant increase in early 2024 to mid-2024.

The model built using the LSTM algorithm was initiated by trial and error, with a composition ratio of 80: 20 for training and testing data. The following are the results of modeling using the LSTM algorithm with various combinations of neurons, epochs, and batch sizes for PT Bank Artos Indonesia Tbk and BSI.

Table 2 Hyperparamaeter of PT Bank Artos Indonesia Tbk

Neuron	Epoch	Batch Size	MAE	RMSE	R2
20	20	5	191.45	219.64	0.424
		10	115.699	147.043	0.741
		30	162.024	190.219	0.568
	50	5	107.956	140.021	0.765
		10	202.083	239.09	0.317
		30	181.34	227.662	0.381
	70	5	101.974	128.476	0.803
		10	115.365	150.588	0.729
		30	179.683	208.104	0.483
	100	5	100.816	124.87	0.813
		10	96.98	126.113	0.81
		30	118.604	151.311	0.726
50	20	5	194.724	220.279	0.42
		10	101.251	132.723	0.789
		30	142.434	185.924	0.586
	50	5	158.009	178.84	0.618
		10	83.8	112.633	0.848
		30	106.21	136.628	0.777
	70	5	182.338	201.483	0.515
		10	107.305	132.425	0.79
		30	111.388	145.188	0.748
	100	5	78.688	98.532	0.884
		10	87.045	111.29	0.852
		30	92.119	121.453	0.824
70	20	5	92.937	120.146	0.827
		10	100.925	131.897	0.792
		30	186.857	251.583	0.445
	50	5	216.029	234.197	0.345
		10	82.709	108.104	0.86
		30	179.765	208.377	0.481
	70	5	84.159	103.474	0.872
		10	173.195	193.708	0.552
		30	88.53	117.105	0.836
	100	5	179.418	196.478	0.539
		10	**66.896**	**91.795**	**0.899**
		30	89.829	117.363	0.835

Table 3 Hyperparameter of BSI

Neuron	Epoch	Batch Size	MAE	RMSE	R2
20	20	5	78.453	106.659	0.694
		10	94.537	123.526	0.589
		30	110.014	143.761	0.444
	50	5	63.76	87.658	0.793
		10	71.209	96.708	0.748
		30	107.591	144.359	0.439
	70	5	103.964	122.763	0.594
		10	69.627	92.92	0.767
		30	97.286	123.254	0.591
	100	5	57.575	77.655	0.837
		10	78.122	97.79	0.749
		30	118.518	149.453	0.399
50	20	5	68.596	93.063	0.767
		10	91.558	118.544	0.622
		30	100.47	126.006	0.573
	50	5	65.089	86.792	0.797
		10	96.803	120.375	0.61
		30	76.587	104.003	0.709
	70	5	74.619	95.82	0.753
		10	58.695	79.862	0.828
		30	71.46	95.218	0.756
	100	**5**	**54.124**	**75.057**	**0.848**
		10	54.901	75.191	0.848
		30	68.105	92.434	0.77
70	20	5	85.326	109.728	0.676
		10	86.08	112.026	0.662
		30	137.565	159.889	0.312
	50	5	57.676	78.192	0.835
		10	63.791	86.263	0.799
		30	85.337	109.268	0.679
	70	5	54.637	75.951	0.844
		10	91.38	110.264	0.673
		30	74.305	100.549	0.728
	100	5	78.339	99.292	0.735
		10	55.031	76.022	0.844
		30	59.149	82.407	0.817

Tables 2 and 3 show various combinations of neurons, epochs, and batch size that give various values of MAE, RMSE dan R^2 differently. Based on Table 1, it can be seen that the larger the batch size will give a decreasing

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accuracy value, so the good batch size is batch size 10. Likewise, Table 3 shows that the accuracy of the model is strongly influenced by the selection of batch size, the batch size that gives the most accuracy value is 5. Based on the results of modeling using the LSTM algorithm, the best model for PT Bank Artos Indonesia Tbk is with 70 neurons, 100 epochs, and batch size 10 with MAE of 66.896, RMSE of 91.795, and R^2 sof 0.899. While the best model for BSI is with 50 neurons, epoch 100, batch size 5 with MAE of 54.124, RMSE of 75.0757, and R^2 of 0.848. Based on Figures 4 and 5, we can see the comparison between the actual value and the predicted value of stock price from both of bank.

Figure.4 Plot Actual Stock Price vs Predocted Stock Price PT Bank Artos Indonesia Tbk

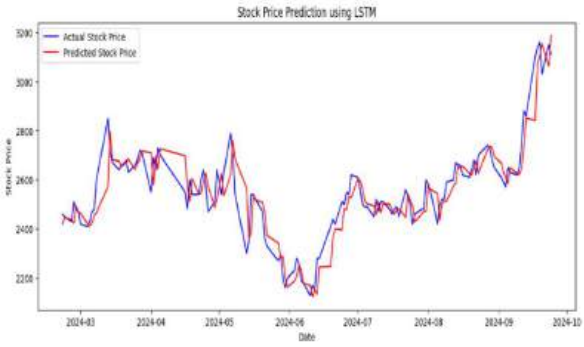

Figure.5 Plot Actual Stock Price vs Predocted Stock Price BSI

Figures 4 and 5 show the actual stock price and the predicted value obtained from the best model. Based on both Figures, the red color or predicted stock value is close to the actual stock value for both Banks, so the model that has been built is good enough with the accuracy value of the model with R^2 of 89.9% and 84.8%.

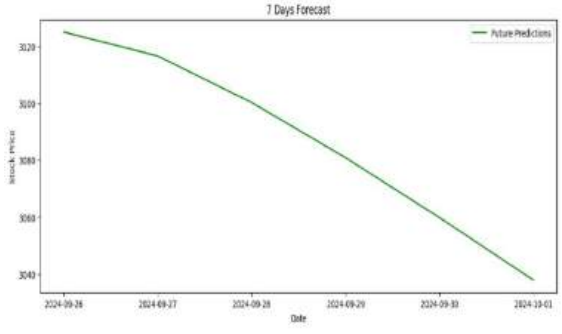

Figure 6 Plot Predicted Stock Price of PT Bank Artos Indonesia Tbk

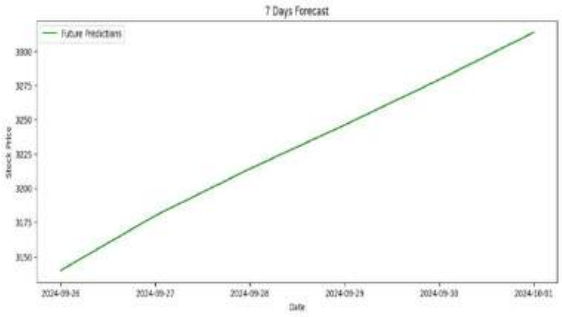

Figure.7 Plot Predicted Stock Price of BSI

Based on Figures 6 and 7 shows the predicted stock price for the next 7 days. The figure shows the predicted share price of PT Bank Artos Indonesia Tbk, which at the beginning of the week experienced an increase in share price, then in the middle and end of the week the share price will decrease. While the figure shows the predicted stock price for BSI which has increased significantly from the beginning to the end of the week. In Table 4, the predicted stock prices for PT Bank Artos Indonesia Tbk and BSI are known with an average predicted stock price for each bank of 3026.565 and 3228.703.

Table 4 Predicted Stock Price of PT Bank Artos Indonesia Tbk and BSI

Predicted Stock Price of PT Bank Artos Indonesia Tbk	Predicted Stock Price of BSI
3097.0518	3139.8188
3075.275	3179.7961
3044.7043	3214.0178
3012.4946	3245.9639
2980.5085	3279.0168
2949.354	3313.6045

Based on the results of the analysis using the Neural Network based on the LSTM algorithm, it can be seen that the predicted price of BSI shares is superior to the predicted stock price of PT Bank Artos Indonesia Tbk. This is reinforced by a descriptive analysis of the actual share price of PT Bank Artos Indonesia Tbk with BSI in 2024 where the BSI share price has increased significantly compared to PT Bank Artos Indonesia Tbk. The increase in the share price of PT Bank Artos Indonesia Tbk at the beginning of 2021-2022 was due to the large number of retail investors who purchased shares due to the public issue of digital banks. However, this did not last long, namely in mid-2022 the share price of PT Bank Artos Indonesia Tbk began to decline. This is due to the perception created by influencers who lead the opinions of retail investors, especially from millennials who have no experience without understanding the micro fundamentals of stocks based on the financial condition of a company (Asykarulloh, et. al, 2023).

Based on researched by Safira & Hidayatullah (2024) The growth of digital bank financial performance has increased and decreased every year. The financial performance of digital banks is seen from several aspects, namely the capital adequacy ratio, loan deposit ratio, operating costs to operating income, and non-performing loans. The decline in digital bank share prices is due to the lack of public knowledge about digital banks, making capital less channeled to get profits. Capital adequacy ratio is one of the indicators of financial performance by

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investors to see fluctuations in stock prices in the long term[4]. In addition, the source of digital bank income is not entirely from interest income, but comes from service products such as transactions made by customers. Lack of information about digital bank products such as online credit makes people less confident in digital banks.

While the predicted share price for BSI experienced a significant increase. Based on researched by Santoso (2023), BSI's earnings pershare experienced positive growth due to the merger so that it had a good effect on BSI's financial statements. When viewed in the descriptive analysis in Figure 1, it can be seen that the BSI share price has decreased at the end of 2022. This decline is due to the issue of the right issue until the price is approved by the company [22]. In 2023, BSI's share price experienced a significant increase despite the issue of cyber attacks that resulted in transaction paralysis. Based on researched by Solikhawati dan Samsuri (2023), After the cyber attack, BSI's share price fluctuated for 10 days. However, BSI's financial performance is still considered good enough so that it does not have a significant impact on long-term investment. This can be seen from the increasing BSI stock price in 2024 as well as the predicted BSI stock price in Figure 7.

Comparison of the predicted stock price results of the two banks can provide an overview of the predicted stock price movements of the two banks. However, the results of this analysis are not the only tool used as an investor's decision maker to invest. Investors can use fundamental analysis based on financial performance to see how the long-term stock price movements of the two banks. The results of this analysis can be used as recommendations for investors, especially gen z, millineal, and beginner investors.

IV. CONCLUSION

Based on the analysis results using the LSTM model, the best model for PT Bank Artos Indonesia Tbk is with 70 neurons, 100 epochs, and batch size 10 with MAE of 66.896, RMSE of 91.795, and R^2 sof 0.899. While the best model for BSI is with 50 neurons, epoch 100, batch size 5 with MAE of 54.124, RMSE of 75.0757, and R^2 of 0.848. A comparison of the predicted share prices of PT Bank Arto Indonesia Tbk and BSI shows that BSI's share price performance is superior to that of PT Bank Arto Indonesia Tbk.

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Bio-Inspired Algorithms in Healthcare

[1]Firdaws Rizgar Tato, Ibrahim Mahmood Ibrahim[2]
[1]Akre University for Applied Science / Technical College of Informatics – Akre / Department of Information Technology – Kurdistan Region – Iraq – firdaws.rizgar@auas.edu.krd
[2]Akre University for Applied Sciences / Technical College of Informatics-Akre / Department Computer Networks and Information Security
Email: [1]firdaws.rizgar@auas.edu.krd, [2]ibrahim.mahmood@auas.edu.krd

Abstract – Exploring hidden patterns in medical data sets is made possible by the huge potential of medical data mining. A clinical diagnosis can be made with the help of these patterns. Research on bio-inspired algorithms is a recent development. Its primary benefit is its ability to weave together social behavior, emergence, and connectionism subfields. In a nutshell, it involves modeling live phenomena using computers while studying life to make better computer applications. This chapter describes the application of five bio-inspired algorithms, including metaheuristics, to classify seven distinct real health-related information sets. While the other two of these methods rely on random population creation to create classification rules, the other two rely on the computation of similarity between the data used for training and testing. The outcomes demonstrated that bio-inspired supervised medical data classification methods were incredibly effective.

Keywords – orthogonal the local preserving projection, colony, medical the information classification, training data, testing data
.

I. INTRODUCTION

These days, cloud computing serves as the backbone of our modern economy by providing cloud clients with on-demand services via the Internet. New technologies, such as big data and Internet of Things (IoT) activities, are emerging (healthcare services, smart cities, etc.) [1], which further requires excellent data processing to process data to increase the performance and efficacy of cloud computing systems. Nevertheless, there are two issues with current big data processing methods that impair computer system performance. These issues include lengthy response times and delays brought on by the repeated movement of data from computers to the cloud and from the cloud to Internet of Things applications. IoT devices currently gather a vast variety and volume of data (known as big data), and the resulting networks are expanding at a rapid pace [2].

Data transfer is utilized in IoT-based smart cities to provide efficient big data and analytics decision-making. After data from connected gadgets on IoT networks is gathered and aggregated, it is processed and stored on cloud servers. Additionally, automatic, highly scalable internet connectivity is required to handle the massive volume of data, which can enhance system performance even more. Research has shown that when short response times as well as latency are required, current cloud-based processing platforms cannot meet the performance requirements of Internet of Things applications. Furthermore, regional data dispersion and communication breakdowns during data transfer are additional causes of a high response time and latency. Raw data from IoT devices is continuously being received by cloud computing platforms, which causes bottlenecks [3]. Thus, a new paradigm that offers a platform between computer systems and Internet of Things devices that processes user data efficiently is bioinspired technique-based big data analytics.

Artificial Neural Networks (ANNs) outperform data mining on every measure, including performance, computational speed, and complexity level [4]. Networks of basic processing components (called "neurons") that use local data and communicate with one another makeup artificial neural networks (ANNs) [5]. Many problems in the real world have been handled with the help of ANN, including predicting future trends using a company's massive data archive. Successful applications of ANN have been made in every branch of engineering, including biology, medicine, health care, manufacturing, marketing, oceanography, and decision science, to name a few [6]. To aid in predicting cardiovascular illness, this research introduces a swarm intelligence approach called particle swarm optimization (PSO) combined with a feed-forward neural network.

As Bonbeau put it, "the emergent collective intelligence of groups of simple agents" [7]. is what we mean when we talk about "swarm intelligence." A swarm consists of many similar, basic agents that interact locally with one another and their surroundings, with no overarching leadership or guidance allowing for intriguing global behavior to arise.

In recent years, a new class of population-based algorithms called swarm-based algorithms has arisen [8]. that can efficiently solve a wide variety of complicated problems with minimal resources and time investment.

Therefore, swarm intelligence (SI) may be characterized as a relatively new branch of AI that is used to represent the collective behavior of social swarms found in nature. Examples of such swarms include ant colonies, honey bee hives, and bird flocks. Individually, these agents (insects or swarm members) are not very clever or capable, but they interact in predictable ways to accomplish tasks that are essential to their survival. Individuals in a swarm may have direct or indirect social interactions with one another [9]. The following is the outline for this paper. Work in this area is discussed in Section 2. In Section 4, we explore the theoretical foundations of our methodology and the theory-driven model we developed to identify dissatisfaction. Section 5 provides a conclusion and summary of this study.

II. RESEARCH METHODOLOGY

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A. Bio-Inspired ICT for Big Data Management in Healthcare

Bio-Inspired ICT for Big Data Management in Healthcare Decisions that affect life and death will in the future depend on having access to increasingly organized and data-rich knowledge. Because this data will transcend conventional scales and dimensions, we will need to consider new approaches, including technological innovations in communication and information. Compile, arrange, and calculate all the information that is necessary for patient survival and healthcare administration. We may connect Big Data and the problems associated with data-intensive computing to the future goal of smart healthcare by adopting a bioinspired method of approaching ICT. **As** shown in Figure 1, Finding correlations and causal relationships between symptoms and patients while also taking connectivity and interpersonal transmission processes into account is made possible by the multifaceted approach to disease and the addition of a social dimension of study [9].

Figure. 1 Bio-inspired IoT applications.

B. Bio-Inspired Algorithms for Medical Data Analysis

Exploring the vast capabilities of mining medical data, the recent advancement in bio-inspired algorithm research has shown promising results in identifying patterns within medical datasets, crucial for clinical diagnosis. This interdisciplinary field merges elements of social behavior, emergent phenomena, and connectionist systems, essentially simulating living processes for enhanced computational applications. In their work, the authors illustrate the application of four distinct bio-inspired algorithms, including metaheuristics, to effectively classify various health-related data sets. Among these methods, two employ random population generation for rule creation, while the remaining focus is on analyzing similarities between test and training data. Their findings affirm the remarkable efficacy of bio-inspired algorithms in the systematic classification of medical data [44].

C. Medical data classification using bio-inspired algorithm

To help doctors with medical diagnosis, the clinical choice support structure (DSS) has become a significant field in the medical sciences in recent years. To increase the quality of DSS in healthcare, health record classifications are predicated on learning from diverse health datasets. This investigation's primary goal is to create a framework for successfully classifying health data. In medical data classification, the application of orthogonal local preservative projection (OLPP) has yielded encouraging results. This software is for high-dimensional data input. The functionality space is then shrunk without sacrificing calculation accuracy using a feature-reduction technique. The classifier that will be employed is an artificial neural network. An optimization algorithm was employed to increase productivity. A neural network employs a biobased optimization technique known as the "deliberately bee colony algorithm." The medical datasets show that the proposed system's current form has an average improvement in classification quality of 15% [18].

D. Bio-Inspired Computing: Algorithms Review, Deep Analysis, and the Scope of Applications.

The term "bio-inspired computing" refers to a broad range of recent computer science, mathematical information, and biology disciplines. A developing method called "bio-inspired computing optimization algorithms" draws inspiration and ideas from the biological evolution of nature to create innovative and resilient competing strategies. bio-inspired optimization methods have gained recognition in machine learning in recent years as the best ways to solve challenging problems in the fields of engineering and science. To identify the best solution, these issues are typically nonlinear and limited to several nonlinear constraints, which present several issues, including high dimensionality and time limitations. Recent trends have tended to utilize bio-inspired optimization algorithms, which offer a potential method for resolving complicated optimization issues, to address the shortcomings of classic optimization algorithms. the state-of-the-art nine recent bio-inspired computational methods, gap analysis, and their applications are presented in this paper. These include the following: The Artificial Algae Section (AAA), Gap Analysis, Chicken Swarm Optimization Method (CSOA), Moth The term flame Optimization (MFO), Fishes Swarm Algorithms (FSA), Cat Swarm Optimizing (the chief social officer), Algorithm (make), Genetic Beech Colony (GBC) Algorithm, Fish a Swarm Algorithm (FSA), Algae Algorithm (ESA), Moth Flame The optimization process (MFO), and the Grey Wolf Optimizing (GWO) Algorithm. The earlier, relevant works are gathered and shown from the Scopus databases. We also discuss several important problems in optimization as well as some uses for further study. We also examine in-depth talks on the fundamentals of these algorithms, their relationships to self-organization, and how they are applied in many fields of study. Consequently, certain important issues are raised by the suggested examination of these algorithms, which will need to be resolved in the future [36].

E. Bio-inspired Algorithms and Their Applications

For a very long time, scientists have looked to biology and nature to comprehend and model answers to difficult real-world issues. Numerous mathematical and algorithmic methods have been developed, along with a method of transferring knowledge from lifeforms to human technologies. The study of bionics bridges the biological structures and functions, organizational principles, and functions found in nature with our modern technologies. The results of bionics research encompass not just tangible goods but also a range of versatile optimization and

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computation techniques. 6 Four major categories of related algorithms can be distinguished: bio-inspired algorithms based on evolution, bio-inspired algorithms based on swarm intelligence, bio-inspired algorithms based on ecology, and multiple-purpose bio-inspired algorithms. With a sharp rise in the quantity of pertinent papers, bio-inspired algorithms, including neural networks, ant colony algorithms, optimization algorithms for particle swarms, and others, have been used in practically every field of research, engineering, and business management. The most recent advancements in ecology-based bioinspired algorithms, swarm intelligence-based bio-inspired algorithms, multi-objective bio-inspired algorithms, and evolutionary-based bio-inspired algorithms are reviewed in this work in a methodical, practical, and thorough manner.

Table 1. Convergence and difference between previous studies and current research

Research Title	**Bio-Inspired ICT for Big Data Management in Healthcare**	**Bio-Inspired Algorithms for Medical Data Analysis**	**MEDICAL DATA CLASSIFICATION USING BIO-INSPIRED ALGORITHM**	**Bio-Inspired Computing: Algorithms Review, Deep Analysis, and the Scope of Applications**	**Bio-inspired Algorithms and Their Applications**
Research Methodology	Descriptive analytical approach	Descriptive analytical approach	Descriptive analytical approach	Descriptive analytical approach	Descriptive analytical approach
Data used	Following a biologically inspired approach to ICT, we can weave big data and data-intensive computing issues into the future vision of smart healthcare.	Medical data has great potential for investigating hidden patterns in medical domain datasets. These patterns can be used for clinical diagnosis.	The classification of health records is based on learning from different health data sets to improve the better quality of DSS in health care. The main objective of this study is to establish a system for successful classification of health data	a, biologically inspired optimization algorithms in machine learning are known to solve optimal solutions to complex problems in science and engineering. However, these curves are usually nonlinear and constrained	The output of bionics research includes not only physical products, but also various computational methods of optimization that can be applied in different fields
data analysis	Tough a program spss	Tough a program spss	Tough a program spss	Tough a program Chart or table analaysis i	Tough a program spss
Results	Collecting, organizing, and calculating every aspect will be crucial for patient retention and for healthcare management. By following a biologically inspired approach to ICT, we can integrate big data and data-intensive computing issues into the future vision of smart healthcare.	The authors present the application of four biologically inspired algorithms and meta-heuristics to classify seven different real medical data sets. Two of these algorithms are based on calculating similarity between training and testing data while the other two are based on random generation of populations to construct classification rules.	In classifying medical information. This is a high-dimensional data input package. A feature reduction tool is then used to reduce the functional space without compromising the computational accuracy. Artificial neural networks be used as a classifier. We used an optimization algorithm to enhance performance.	use biologically inspired optimization algorithms that represent a promising approach to solving complex optimization problems. This paper presents the state of the art of nine of the recent bio-inspired algorithms, gap analysis, and its applications including; Bee Colony Genetic Algorithm (GBC), Fish Swarm Algorithm (FSA), Cat Swarm Optimization (CSO),	A systematic, pragmatic, and comprehensive review of the latest developments in evolutionary-based biologically inspired algorithms, swarm intelligence-based biologically inspired algorithms,
Similarities in research	descriptive and analytical approach	descriptive and analytical approach	descriptive and analytical approach	descriptive and analytical approach	descriptive and analytical approach
Differences in research	Time, place, sample Kuait	Time, place, sample Lebnce	Time, place, sample malysia	Time, place, sample gujrat	Time, place, sample Swayamsiddha
	Discover associations and causal relationships between	The results showed a very good performance of biologica	The “artificial bee colony algorithm” is a bio-based	We analyze in-depth discussions where the essence of these	It offers ecology-based biologically inspired algorithms and

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personal opinion	diseases and patients by considering the processes of communication and social infection. Thus, we achieve an evolution from data to multi-agent by introducing personalized medicine in a multi-layered architecture.	lly inspired algorithms for supervised classification of medical data.	optimization algorithm used by a neural network. The medical dataset represents an average improvement in the classification quality of the proposed system with the current form, about 15%.	algorithms and their relevance to customization and applications in various fields of research are presented. Consequently, the proposed analysis of these algorithms leads to some key problems that must be addressed in the future.	multi-objective biologically inspired algorithms.

III. BIO-INSPIRED ALGORITHMS HEALTHCARE

Suggested a data-aware family scheduling method for big data analytics based on genetic algorithms (GAs), with an emphasis on data dependencies, computational power, and bandwidth usage. Additionally, the GA algorithm separates data, and cloud-based computing services are offered. The outcomes show that because the method used by GA handles data using parallel processing, it produces effective results when speaking of turnaround periods. [10] presented a huge data mining method based on the multiobjective genetic modeling (GP) algorithm. This method is utilized to create the concrete creep model, which yields objective and precise predictions. The GP model operates at both standard and high strengths. suggested a large data analytics method based on the differential evolve (DE) algorithm that makes use of local search to boost the DE algorithm's exploitation potential. Although it takes a long time to compute, this method optimizes the huge amount of data from the 2015 benchmark challenges in both multi- и single-objective tasks. [11] presented a big data processing technique based on the adaptive approach (ES) algorithm that uses parallel scheduling utilizing cloud resources to handle data reliably and effectively. Additionally, the ES algorithm reduces the amount of time it takes to perform a set of jobs by dividing them into fragmented sets, each of which is executed by the same resources.

Suggested a huge data optimization technique based on the simulated annealing (SA) algorithm. This technique leverages a WOA to design several feature selections approaches, thereby reducing the modification by probing those that are most capable regions. The suggested method chooses the most beneficial elements for categorization tasks while also assisting in increasing classification accuracy. Additionally, [12] presented the SA algorithm-based selection of features (SAFS) method for computer vision and big data learning. The SAFS algorithm is primarily suitable for big data learning because it gradually reduces the issue size over iterations by eliminating variables and tightening a sparsity constraint based on a criterion. A big analysis of data based on the FSO and SA-based hybridized (FSOSAH) technique was developed by 8 Tayal and Singh [13] as an effective solution for a multiobjective issue based on stochastic dynamic facility layout. [14] suggested using the big data analytics crow search optimization (CO) method to cluster data. Additionally, many datasets through the Machine Learning Repository at the University of California, Irvine, are taken into consideration to validate the CO approach through research results, and these datasets exhibit superior convergence stability and computing efficiency.

A. Cellular Automata

Cellular automata (CA), an early example of bio-inspired computing, are mentioned as reference [40]. These are discrete systems, self-replicating in nature, composed of finitestate machines, or cells, arrayed in a network. Each cell is locally connected to others, leading to a complex global behavior emerging from these interactions [15]. The state of each cell synchronously alters based on its current state and the states of adjacent cells from the previous time step. A uniform local update rule is applied across all cells, establishing a homogeneous system [16]. The paper introduces Tumor-Cut [17], a method using a CA model that integrates gradient magnitude as the local transition rule, equating to the shortest path algorithm as indicated in [18]. Similarly, GTVCUT, a CAbased method for segmenting brain tumors in MRI images for neuro-radiosurgery planning, is cited as [19]. This semi-automatic technique involves adaptive initialization of foreground and background seeds through a simple draggable rectangle that encompasses the area of interest [20].

B. Membrane Computing Membrane Computing

Is an unconventional model of computation that assumes the functioning of the cells as an information processing system? In particular, this model formalizes the flow of metabolites among cells of a living tissue or the organelles in an eucaryotic cell. More specifically, the computational devices in membrane computing are called P systems [21]. This model can be effi-ciently implemented on parallel architectures [22] and has been applied to image segmentation [23]. P systems were efficiently applied to edge detection and multi-level thresholding in [24].

IV. SWARM-BASED ALGORITHMS

Suggested a massive data management strategy based on the synthetic colony of bees (ABC) algorithm, which finds the optimal cluster and optimizes it for varying dataset sizes. The implementation is done in a MapReduce-based Hadoop system, and the results show that, in terms of execution time, the ABC method produces a better result

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when compared to differential evolution with the particle swarm optimization approach (PSO). [27] presented a large data analytics technique called Firefly Swarm Optimization (FSO) for creating new connections on social media sites and determining whether a social network can survive. This method lowers the cost of handling large quantities of data by introducing a mathematical model to verify the social network's stability. To concentrate on six multiobjective issues [28]. suggested an FSO algorithm-based hybrid (FSOH) strategy for large data optimization. Although it has a high computational time complexity, it lowers execution costs. suggested a big data optimization strategy based on the PSO algorithm to enhance online lexicon learning and presented a dictionary-learning model that makes use of the auto updating stage. The PSO method increases accuracy while reducing computationally demanding tasks [29]. suggested a big data-driven program composition method based on the parallel clustered PSO method (PCPSO). Massive volumes of heterogeneous data are handled using the PCPSO algorithm, which uses MapReduce for parallel processing on the Hadoop platform [30]. presented a big data classification method based on the cat swarm optimization (social organizations) algorithm to choose features for text categorization in big data analytics

The phrase frequency-inverse document occurrence is used by the CSO algorithm to increase feature selection accuracy. For the economic carry dispatch problem [31]. suggested a big data analytics strategy based on the swarm intelligence (SI) algorithm. The SI algorithm processes high-dimensional data, which increases the accuracy of the data processing [32]. suggested utilizing rough sets to offer the ant colony optimum (ACO) algorithm-based strategy for mobile big data. Big data via social networks is managed more successfully when the ACO algorithm is used to choose the best feature for resolved judgments (tweets and posts). suggested the big data analytical technique for managing medical data, including patient and operation data, that is based on the improved ACO protocol (IACO) [33]. This approach aids physicians in promptly obtaining the necessary data. suggested using shuffled frog flying (SFL) to choose the characteristic for enhanced high-dimensional biological data. The SFL method maximizes the predicting accuracy for enhanced high-dimensional biomedical data by reducing irrelevant features and obtaining the group of characteristics by exploring the space containing probable subsets. The Fish Swarm Optimize (FSW) technique was proposed by [34]. for deciding on features in huge data. The FSO algorithm uses the behavior of fish swarming to simplify combinatorial problems, and it works well for a variety of applications. Fish movements in their quest for food have been used to construct social interactions among huge amounts of data. Effective outputs in terms of data correctness and fault tolerance are produced by this method. To efficiently manage large amounts of data [35]. suggested the intelligent droplets of water (IWD) method for workflow scheduling. The efficacy of the IWD-based strategy is tested using workflow simulation tools. The results demonstrate that, in comparison to the FCFS, Round-Round, and PSO algorithms, the IWD-based approach performs satisfactorily concerning cost and makespan.

V. ECOLOGICAL ALGORITHMS

Suggested a large data optimization strategy based on the invasive weed optimization (IWO) algorithm to handle the multiobjective portfolio allocation problem. Moreover, the multiobjective choice of the portfolio model is converted to the single-objective programming system using the uniform design and imprecise normalization technique. Big data is managed faster using the IWO method than PSO [36]. tackled the problem of huge data processing and analysis by presenting a hybrid biogeographybased optimum (BBO) methodology for multilayer perceptron training. According to experimental results, BBO outperforms GA and PSO algorithms in terms of velocity and is useful for training multilayer perceptrons [37]. suggested using the multispecies optimizer (PS2O) algorithm to choose characteristics for large data stream mining. The PS2O algorithm classifies the gathered data streams related to big data using an incremental classification technique, which improves the analytical accuracy with an acceptable amount of processing time [38].

VI. BIO-INSPIRED ALGORITHMS

Phonetic-based methods and large-vocabulary continuous speech recognition (LVCSR). To transliterate the audio's spoken content, LVCSR first indexes the data before looking for an index phrase. Phonetic indexing searching is handled via the phonetic-based approach, which works with phonemes or sounds. Video streams, such as CCTV footage and live streaming sports events, can have valuable information visualized, examined, and extracted through the use of video analytics. Video analytics can be run on centralized systems (servers) or end devices (edges) [39]. The study of social media analytics involves analyzing both structured and unstructured data from websites that facilitate user-to-user communication, such as Facebook, Twitter, and others. Two categories of online analytics exist: First, content-based (user-posted data) based on structure (combining the structural elements). Predictive analytics is a technique that makes use of both historical and present data to forecast future results. It can be applied to heterogeneity (data from multiple sources), spurious correlation (uncorrelated variables due to large dataset size), noise accumulation (an error of estimation during data interpretation), or incidental endogeneity (indications or variables that explain results that are independent of the leftovers term) [40].

The ability of an infrastructure to scale up or down its nodes in response to the volume of data being transferred for analytics is known as scalability. Large amounts of storage space are needed by big data analytics approaches to store all of the data needed to run the various analytics and extract the necessary information. The capacity of a system to process user data in the allotted amount of time is known as tolerance [41]. Agility-based big data analysis approaches are necessary to analyze user data in the necessary format since the type of information that needs

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analytics is always changing. To build virtual computers for remote user data processing, cloud-based systems need to apply the virtualization technique [42]. The big data analytics execution cost represents the amount of work needed to complete the task. The mechanism that indicates how simple it is to utilize the system to execute big data analytics is known as ease of use. The comparison of bio-inspired methods for large amounts of information analytics based on various parameters is covered in the section on data management [43].

VII. RESULTS

Enables the reader to select the best bio-inspired algorithm by comparing bioinspired big data analytics algorithms according to several criteria. As of right now, cloud computing has become the fifth computing utility and is attracting a lot of interest from academics and industry for the analysis of big data. With the ongoing advancement of virtualization technology, new models, procedures, and strategies for the efficient use of cloud infrastructure in big data management are appearing. Fog computing provides cloud services with the least amount of network latency and reaction time by utilizing mobile base stations, switches, routers, and gateways. As a result, big data analytics can also be carried out at the fog or edge device rather than at a distributed database or server.

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