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Analysis of the Shortest Route from Cikampek to Purwokerto using Ant Colony Algorithm

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Abstract – Finding the shortest path sometimes makes most people confused in choosing a path, especially if there are many paths that must be taken to reach one destination. Tracing various routes from Cikampek to Purwokerto is a challenge, with the risk of spending excessive time and money. To solve this problem, this research uses the Ant Colony Algorithm to determine the most efficient path. One of the problems that often arises is that the Cikampek area has 3 routes that can be used to reach Purwokerto, namely the Cikampek - Indramayu (Patrol), Cikampek - Subang, and Cikampek - Bandung routes. The purpose of determining the shortest path is to provide the shortest path solution to users so that they can reach their destination faster and save time and costs. In this study, we use Ant Algorithm because the route from Cikampek to Purwokerto depends on many road factors and other conditions that could change from time to time. For example, traffic congestion and road repairs are major factors. The ant algorithm has strong customization capabilities to determine the shortest path based on the pheromone trails left by ants during exploration. This means that the ant algorithm can work optimally even if there are many factors in road conditions. In addition, the ant algorithm has the ability to handle problems with a large number of nodes, so it can explore various possibilities efficiently. The ant algorithm is an appropriate choice for finding the shortest path in a journey involving complex and diverse routes. There are six steps required to complete the ant algorithm. The first step is initialization, the second step is path selection, and the third step is setting the ant trail and communication between the ants hit by the trail in path selection. The fourth step is to look for visibility, the fifth step is to stop the criterion until it reaches a certain condition, and the last step is to determine the path by calculating probabilities. The results of this study indicate that the ant algorithm can be used to determine the shortest path which is then displayed. This research aims to assist the community in making decisions and determining the location of the city that must be passed. This study took 8 location points with starting point A and destination point H. Based on the results of the discussion it can be concluded that the shortest route from Cikampek to Purwokerto is with 3 routes, namely first (A → D → E → F → H) with a distance of 355 KM, second (A → D → G → F → H) with a distance of 431 KM and the third (A → D → E →H) with a distance of 317 KM.

Keywords: Shortest Route, Ant Algorithm, Map

I. INTRODUCTION

The growth of road and transportation infrastructure has had a positive impact on connections between various cities and regions. However, the reality that must be faced is the many paths available to achieve certain goals. This can cause confusion and doubt for road users, which ultimately affects the effectiveness and efficiency of travel, especially on the Cikampek route to Purwokerto. In this case study we took the Cikampek to Purwokerto route because Cikampek has 3 different routes that we can take to Purwokerto, namely the Cikampek - Indramayu (Patrol), Cikampek - Subang, and Cikampek - Bandung routes. Many people have difficulty in determining the shortest path to reach Purwokerto. The purpose of determining the shortest path is to provide users with the shortest path solution so that they can reach their destination faster and save time and money.Therefore, there is an urgent need to have a method that can assist road users in choosing the shortest path.

One algorithm that has been widely used to address this problem is the Ant Colony Algorithm. The ant colony algorithm is a paradigm for designing metaheuristic algorithms for combination optimization problems. The essence of the ant colony algorithm is the combination of information about the structure of the promised solution with information about the structure of the previously obtained good solution [1]. The study used sample data taken from Google Maps to calculate the fastest path. By utilizing Google Maps data, researchers can obtain accurate and up-to-date information about traffic conditions, toll roads, congestion, and alternative routes that can be considered by ant algorithms [2].

The main objective of this research is to provide practical solutions for those users who are often faced with confusion in choosing the fastest and most efficient path to achieve their goals. The Cikampek area is an interesting example for the shortest route analysis, because of the limited literature discussing the Cikampek to Purwokerto route that we can see digitally has branch lines passed. Therefore, to make it easier for readers to know which path is efficient from using the ant algorithm without having to go through all existing paths. So that being able to determine the most optimal route can save travel time and costs.

Through this research, it is hoped that readers will gain a better understanding of how the Ant Colony Algorithm can be applied in solving the shortest route determination problem and provide useful guidance for users in choosing the best path to reach their destination.

II. RESEARCH METHODS

The following is a framework of the stages of research carried out.

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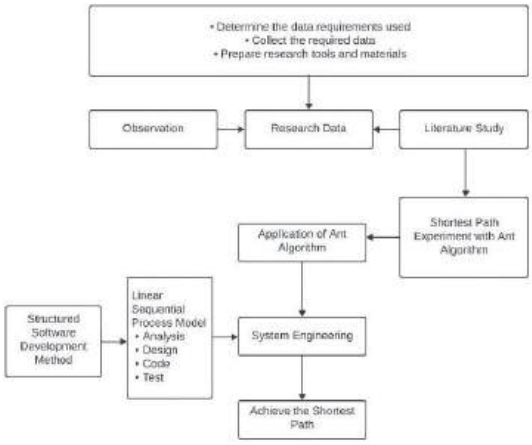

Fig 1. Frame of mind

There are several things that must be done before collecting research data, including determining data needs, collecting data, and preparing tools and materials. If the research data has been obtained, it is necessary to conduct observations and literature studies. Then the ant algorithm can be applied using existing methods to get the shortest path.

2.1 Artificial Intelligence

Artificial Intelligence is a machine that is implanted with human intelligence and programmed so that the machine can think like humans. So, without human power or intelligence the work that is usually done by humans can be completed with computers [3]. The ant algorithm is one of the artificial intelligences, namely computational intelligence.

2.2 Basic Theory of Graphs

A graph is a collection of points connected by lines/sides [4]. Dots on graphs can be used as signs for place names, the names of objects and so on which are usually numbered or letters in the dot. G=(V,E) notation is a notation usually used for Graph, the empty set of vertices that are V and the side set that makes a pair of connected vertices namely E (Munir, 2005) [5]. If the node and the v node are connected by a side that is e then e=(u,v) (Figure 2).

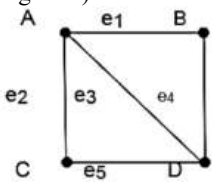

Fig2. Graphs G (4,5)

The graph with the V knot repertoire and the E side group is G (4,5) is:
V = { A, B, C, D }
E = { (A, B), (A, C), (A, D), (B,D), (C, D) }
= {e1, e2, e3, e4, 35}

2.3 Shortest Path

There are two commonly used methods for determining the shortest path. The first is applied by ordinary mathematical calculations, namely conventional algorithm methods, while the second is by calculating artificial intelligence and determining the knowledge base and calculations are heuristic methods [6].

a. Conventional methods for determining the shortest path of the Djikstra, Floyd-Warshall, and Bellman-Ford algorithms. It is common to use this conventional method and this method tends to be easier to understand.
b. Heuristic methods are methods that are actually more difficult to understand than conventional but the results obtained are more varied and the time for calculation is shorter, one example is the ant algorithm.

2.4 Application of the Ant Algorithm

There are several problems that can be solved using ant algorithms to solve problems in finding the shortest path in everyday life (Triandi, 2012) [7]. Among them: Quadratic Assignment Problem (QAP), Job-shop Scheduling Problem (JSP), Vehicle Routing Problem (VRP) and Traveling Salesman Problem (TSP).

2.5 Ant Algorithm

This ant algorithm is taken from the example of ant colonies that work to find food sources where ants can find the shortest route naturally. Because when looking for food sources, ants leave pheromones so that other ants know that the path has been passed, therefore it can happen. The more pheromones left by the ants that have passed by, the clearer the footprints left behind. So that the longer it will increase the density of ants passing through the road, or even all ants will follow to pass the path (Ambarsari 2017) [8]. Here is an illustration of an ant's journey in finding a feeding source (Figure 3).

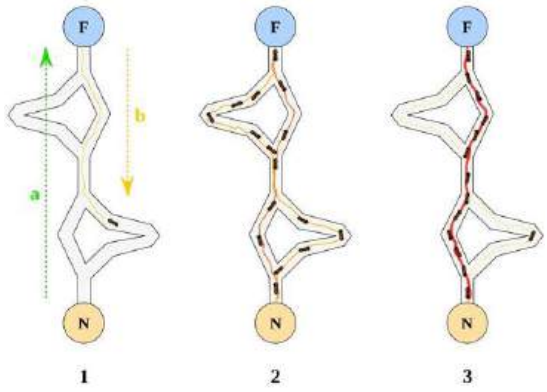

Fig 3. Ants travel in search of food sources

Steps to Solve the Ant Algorithm in the US The steps are (Bronson, 1882 Zukhri, 2005):
Step 1:

a. The price of the parameters of the algorithm is initialized.
b. The first city of each ant is given a name or initial.

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Step 2: The first city is put on the taboo list.
Step 3: The route of each ant's visit to each city is drawn up.
Step 4:
a. The route of each ant is calculated in length.
b. Shortest route search.
c. The price of the intensity of intercity ant footprints is calculated.
Step 5:
a. The price of the intensity of intercity ant footprints for the next cycle is calculated.
b. Repetition or reset of prices changes the intensity of ant footprints between cities.
Step 6: The taboo list is cleared, and step 2 is repeated if necessary.

III. RESULTS AND DISCUSSION

In this study, researchers obtained 8 (eight) location points that were passed to travel from the city of Cikampek to Purwokerto, each point representing the city passed. The selection of location points is determined directly by researchers as many as 8 (eight) points by considering the path that can be passed. Each point is stored at each intersection where point A is the starting point and point H is the destination point. Here are some points that can be passed on the Cikampek route to Purwokerto, namely:

A = Cikampek E = Cirebon
B = Patrol F = Kuningan
C = Bandung G = Tasikmalaya
D = Subang H = Purwokerto

Where the site map of the path passed from Cikampek to Purwokerto can be shown in figure 4 below:

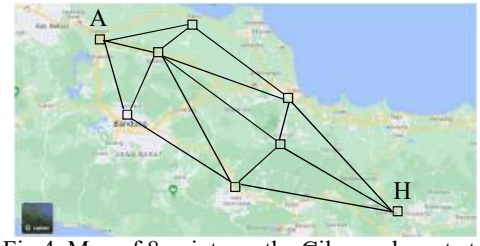

Fig 4. Map of 8 points on the Cikampek route to Purwokerto.

The initial stage in solving this problem is to describe the points passed on the Cikampek to Purwokerto route into points contained in the graph, then the weight of the side in the graph is the distance between the location points between the routes (Figure 6).

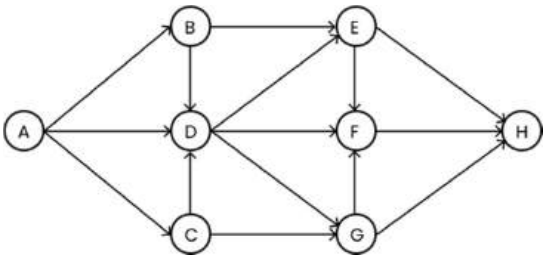

Fig 5. Complete graph of 8 points of destination location

Based on the data obtained, the route distance from Cikampek to Purwokerto can be arranged in kilometers (Km) from each point in table 1 as follows:

Table 1. Route distance from Cikampek to Purwokerto (Km) 8 points

Distance (Km)	A	B	C	D	E	F	G	H
A	0	67	92	55				
B	67	0		47	93			
C	92		0	59			109	
D	55	47	59	0	119	140	151	
E		93		119	0	35		143
F				140	35	0	79	146
G			109	151		79	0	143
H					143	146	143	0

Based on table 1, the graph in figure 6 can be valued according to the distance listed in table 1 using the graph model in figure 7 as follows:

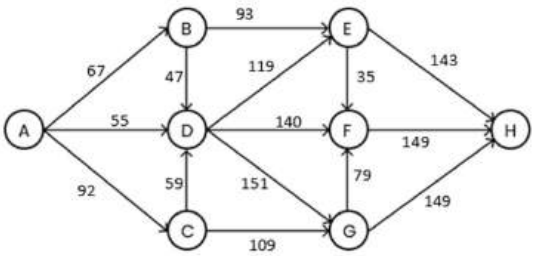

Fig 6. Distance at each point of the graph

Next, the application of the ant algorithm to obtain the shortest (optimal) route. The first step is to set the initial values of the algorithm parameters. The parameters used are:
β = 1,00
α = 1,00
ṗ = 1.00
Many ants (k) = 8
The initial pheromone can be calculated using the formula:

$$\tau ij = \tau 0 = \frac{k}{c\ greedy} \quad (1)$$

Calculations using greedy algorithms are:
a. Determine the starting point that is point A
b. Point A has a route at B each with a distance (67). Furthermore, the smallest or shortest distance is taken so that the selected one is B so that the first route is A→B
c. Perform an action similar to the second step where starting from the selected point i.e. B. B has routes in D and E with distances (47) and (93) respectively. Furthermore, the selected point is E, because if you go to point E, it will increase the final value of the resulting distance so that a second route is obtained namely A→B→E

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d. Perform an action similar to the third step where starting from the selected point that is E. E has routes in D, F and H with distances of (119), (35) and (143) respectively. Furthermore, the selected point is H, because if you go to point F, it will increase the final value of the resulting distance so that a third route is obtained namely A→B→E→H
e. Furthermore, because there are no other points, the last point is H so that the path A→B→E→H is obtained. Thus, obtained minimum distance Cgreedy = 67 + 93 + 143 = 303

Then, proceed from the Greedy algorithm above to get the initial pheromone:

$$\tau ij = \tau 0 = \frac{k}{c\,greedy} = \frac{8}{303} = 0{,}0264026403$$

The second step is to find the visibility value between points by using formula(2):

$$\varphi ij = \frac{1}{dij} \quad (2)$$

Where φij is the distance between known points. Sehingga didapatkan :

$$\varphi ij\ A,B = \frac{1}{dA,B} = \frac{1}{67} = 0.014925373$$
$$\varphi ij\ A,C = \frac{1}{dA,C} = \frac{1}{92} = 0.010869565$$
$$\varphi ij\ A,D = \frac{1}{dA,D} = \frac{1}{55} = 0.018181818$$
$$\varphi ij\ B,A = \frac{1}{dB,A} = \frac{1}{67} = 0.014925373$$
$$\varphi ij\ B,D = \frac{1}{dB,D} = \frac{1}{47} = 0.021276596$$
$$\varphi ij\ B,E = \frac{1}{dB,E} = \frac{1}{93} = 0.010752688$$

In the same way obtained visibility values between points in Table 2 below:

Table 2. Visibility between points

φij	A	B	C	D	E	F	G	H
A	0	0,01493	0,01087	0,01818	0	0	0	0
B	0,01492	0	0	0,02128	0,01075	0	0	0
C	0,01087	0	0	0,01695	0	0	0,00917	0
D	0,01818	0,02128	0,01695	0	0,00840	0,00714	0,00662	0
E	0	0,01075	0	0,00840	0	0,02857	0	0,00699
F	0	0	0	0	0,02857	0	0,01265	0,00685
G	0	0	0,00917	0	0	0,01266	0	0,00699
H	0	0	0	0	0,00699	0,00685	0,00699	0

The next step involves drawing up travel routes to each location point. In this context, researchers use the term "ant" to refer to the method used in finding the shortest route from Cikampek to Purwokerto. In this scenario, ants scattered throughout the point of location will travel from the starting point of each as the point of origin to another point as the destination point. After this stage, the ants will travel randomly, taking into account not visiting the path that has been traveled before. The ant's journey will continue until all points have been visited, forming a complete path. Below is a probability calculation that applies to the first cycle (NC=1).

B. 1st cycle (NC=1)

1st ant(k1)
Taboo list = A

$$p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tab_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} \quad (3)$$

To $j \in \{N - tabu_k\}$

$p\frac{k}{ij} = 0$, for the other j with i as the origin city index and j as the destination city index.

$\sum_{k' \in \{N - tab_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta} =$
$= (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}014925373)^1 + (0{,}0264)^1 * (0{,}010869565)^1 + (0{,}0264)^1 * (0{,}018181818)^1$
$= 0.001160986$

$$\text{city A} = p\frac{k}{ij} = 0$$

$$\text{city B} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}014925373)^{1.00}}{0.001160986} = 0{,}3393$$

$$\text{city C} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}010869565)^{1.00}}{0.001160986} = 0.2471$$

$$\text{city D} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}018181818)^{1.00}}{0.001160986} = 0.4134$$

$$\text{city E} = p\frac{k}{ij} = 0$$

$$\text{city F} = p\frac{k}{ij} = 0$$

$$\text{city G} = p\frac{k}{ij} = 0$$

$$\text{city H} = p\frac{k}{ij} = 0$$

Table 3. 1st ant probability between point A to another

Ket	A	B	C	D
A	0	0.3393	0.2471	0.4134
Cumulative	0	0,339	0.586	1

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Ket	E	F	G	H
A	0	0	0	0
Cumulative	1	1	1	1

Number of random numbers raised between 0-1 by using the function in Excel, namely Rand(), then 0.406 is selected so that the selected city is city D so that the taboo list becomes A = > D.

2nd ant(k1)
Taboo list = B

$$p\frac{k}{ij} = \frac{[\tau i\ ]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} \quad (4)$$

Untuk $j \in \{N - tabu_k\}$

$p\frac{k}{ij} = 0$, for the other j with i as the origin city index and j as the destination city index.

$\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta} =$

$= (0{,}0264)^1 * (0{,}0149)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}0212)^1 + (0{,}0264)^1 * (0{,}01075)^1$

$= 0.001239603$

$$\text{city A} = p\frac{k}{ij} = \frac{[\tau i\ ]^{\alpha} * [\tau i\ ]^{\beta}}{\sum_{k' \in \{N-tab\ k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}014925373)^{1.00}}{0.001239603} = 0{,}3178$$

$$\text{city B} = p\frac{k}{ij} = 0$$

$$\text{city C} = p\frac{k}{ij} = 0$$

$$\text{city D} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}021276596)^{1.00}}{0.001239603} = 0{,}4531$$

$$\text{city E} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}010752688)^{1.00}}{0.001239603} = 0.2290$$

$$\text{city F} = p\frac{k}{ij} = 0$$

$$\text{city G} = p\frac{k}{ij} = 0$$

$$\text{city H} = p\frac{k}{ij} = 0$$

Table 4. 2nd ant probability between point B to another point

Ket	A	B	C	D
B	0,317	0	0	0,453
Cumulative	0,317	0,317	0,317	0,770

Ket	E	F	G	H
B	0,229	0	0	0
Cumulative	1	1	1	1

A random number generated between 0-1 using a function in Excel is Rand(), then 0.586 is chosen so that the selected city is city D so that the taboo list becomes B = > D.

3rd ant(k1)
Taboo list = C

$$p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} \quad (5)$$

Untuk $j \in \{N - tabu_k\}$

$p\frac{k}{ij} = 0$, for the other j with i as the origin city index and j as the destination city index.

$\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta} =$

$= (0{,}0264)^1 * (0{,}010869565)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}016949153)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}009174312)^1$

$= 0.000976616$

$$\text{city A} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}010869565)^{1.00}}{0.000976616} = 0{,}2938$$

$$\text{city B} = p\frac{k}{ij} = 0$$

$$\text{city C} = p\frac{k}{ij} = 0$$

$$\text{city D} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}016949153)^{1.00}}{0.000976616} = 0{,}4581$$

$$\text{city E} = p\frac{k}{ij} = 0$$

$$\text{city F} = p\frac{k}{ij} = 0$$

$$\text{city G} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}009174312)^{1.00}}{0.000976616} = 0.2480$$

$$\text{city H} = p\frac{k}{ij} = 0$$

Table 5. 3rd ant probability between point C to another point

Ket	A	B	C	D
C	0,293	0	0	0.458
Cumulative	0.293	0.293	0.293	0,751

Ket	E	F	G	H
C	0	0	0,248	0
Cumulative	0,751	0,751	1	1

Random numbers that are generated between 0-1 using functions in Excel are Rand(), then 0.155 is chosen so that the selected city is city G so that the taboo list becomes C = > G.

4th ant(k1)
Taboo list = D

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$$p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} \quad (6)$$

To $j \in \{N - tabu_k\}$

$p\frac{k}{ij} = 0$, for the other j with i as the origin city index and j as the destination city index.

$\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta} =$

$= (0{,}0264)^1 * (0{,}018181818)^1 + (0{,}0264)^1 * (0{,}021276596)^1 + (0{,}0264)^1 * (0{,}016949153)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}008403361)^1 + (0{,}0264)^1 * (0{,}0071422857)^1 + (0{,}0264)^1 * (0{,}006622517)^1$

$= 0.020744144$

$\text{city A} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}018181818)^{1.00}}{0.020744144} = 0{,}2313$

$\text{city B} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}021276596)^{1.00}}{0.020744144} = 0{,}2707$

$\text{city C} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau i\ ]^{\beta}}{\sum_{k' \in \{N - tab\ k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}016949153)^{1.00}}{0.020744144} = 0{,}2157$

$\text{city D} = p\frac{k}{ij} = 0$

$\text{city E} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}008403361)^{1.00}}{0.020744144} = 0{,}1069$

$\text{city F} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}0071422857)^{1.00}}{0.020744144} = 0{,}0909$

$\text{city G} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}006622517)^{1.00}}{0.020744144} = 0.0842$

$city = p\frac{k}{ij} = 0$

Table 6. 4th ant probability between point D to another point

Ket	A	B	C	D
D	0,231	0,270	0,215	0
Cumulative	0,231	0.502	0.717	0,717

Ket	E	F	G	H
D	0,106	0	0,090	0
Cumulative	0,824	0,915	1	1

A random number generated between 0-1 using a function in Excel is Rand(), then 0.065 is chosen so that the selected city is city G so that the taboo list becomes D = > G.

5th ant(k1)
Taboo list = E

$$p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} \quad (7)$$

Untuk $j \in \{N - tabu_k\}$

$p\frac{k}{ij} = 0$, for the other j with i as the origin city index and j as the destination city index.

$\sum_{k' \in \{N - tab\ k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta} =$

$= (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}010752688)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}008403361)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}028571429)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}006993007)^1$

$= 0.014446208$

$city\ A = p\frac{k}{ij} = 0$

$city\ B = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}010752688)^{1.00}}{0.014446208} = 0{,}1965$

$city\ C = p\frac{k}{ij} = 0$

$city\ D = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}008403361)^{1.00}}{0.014446208} = 0{,}1535$

$city\ E = p\frac{k}{ij} = 0$

$city\ F = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}028571429)^{1.00}}{0.014446208} = 0{,}5221$

$city\ G = p\frac{k}{ij} = 0$

$city\ H = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}006993007)^{1.00}}{0.014446208} = 0.1277$

Table 7. 5th ant probability between point E to another point

Ket	A	B	C	D
E	0	0,196	0	0,153
Cumulative	0,00	0,196	0,196	0,35

Ket	E	F	G	H
E	0	0,522	0	0,127
Cumulative	0,35	0,872	0,872	1

A random number generated between 0-1 using a function in Excel is Rand(), then 0.524 is chosen so that the selected city is city F so that the taboo list becomes E = > F.

6th ant(k1)
Taboo list = F

$$p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tab\ k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} \quad (8)$$

To $j \in \{N - tabu_k\}$

$p\frac{k}{ij} = 0$, for the other j with i as the origin city index and j as the destination city index.

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$\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta} =$

= $(0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}007142857)^1 + (0{,}0264)^1 * (0{,}028571429)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}012658228)^1 + (0{,}0264)^1 * (0{,}006849315)^1$

= 0.014578563

$city\ A = p\frac{k}{ij} = 0$

$city\ B = p\frac{k}{ij} = 0$

$city\ C = p\frac{k}{ij} = 0$

$city\ D = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau i\ \ ]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}007142857)^{1.00}}{0.014578563} = 0{,}1293$

$city\ E = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau i\ \ ]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}028571429)^{1.00}}{0.014578563} = 0{,}5173$

$city\ F = p\frac{k}{ij} = 0$

$city\ G = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tab\ \ k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}012658228)^{1.00}}{0.014578563} = 0{,}2292$

$city\ H = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}006849315)^{1.00}}{0.014578563} = 0{,}1240$

Table 8. 6th ant probability between point F to another point

Ket	A	B	C	D
F	0	0	0	0,129
Cumulative	0,00	0,00	0,00	0,129

Ket	E	F	G	H
F	0,517	0	0,229	0,124
Cumulative	0,646	0,646	0,875	1

Random numbers that are generated between 0-1 using functions in Excel are Rand(), then 0.05 is chosen so that the selected city is city H so that the taboo list becomes F = > H.

7th ant(k1)

Taboo list = G

$$p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} \quad (9)$$

To $j \in \{N - tabu_k\}$

$p\frac{k}{ij} = 0$, for the other j with i as the origin city index and j as the destination city index.

$\sum_{k' \in \{N-tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta} =$

= $(0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}009174312)^1 + (0{,}0264)^1 * (0{,}006622517)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}012658228)^1 + (0{,}0264)^1 * (0)^1 + (0{,}0264)^1 * (0{,}006993007)^1$

= 0.009358289

$city\ A = p\frac{k}{ij} = 0$

$city\ B = p\frac{k}{ij} = 0$

$city\ C = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}009174312)^{1.00}}{0.009358289} = 0{,}2588$

$city\ D = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}006622517)^{1.00}}{0.009358289} = 0{,}1868$

$city\ E = p\frac{k}{ij} = 0$

$city\ F = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tab\ \ k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}012658228)^{1.00}}{0.009358289} = 0{,}3570$

$city\ G = p\frac{k}{ij} = 0$

$city\ H = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N-tabu_k\}} [\tau ik\prime]^{\alpha} * [\tau ik\prime]^{\beta}} = \frac{(0{,}0264)^{1.00} * (0{,}006993007)^{1.00}}{0.009358289} = 0.1972$

Table 9. 7th ant probability between point G to another point

Ket	A	B	C	D
G	0	0	0,258	0,186
Cumulative	0,00	0,00	0,258	0,445

Ket	E	F	G	H
G	0	0,357	0	0,197
Cumulative	0,445	0,802	0,802	1

A random number generated between 0-1 using a function in Excel is Rand(), then 0.398 is chosen so that the selected city is city F so that the taboo list becomes G = > F.

In this case, not all routes can be used as optimal path solutions, there are several routes that can be used as optimal path solutions, namely:

1) A => D => E => F => H
2) A => D => G => F => H
3) A => D => E => H

C. 2nd Cycle (NC=2)

1. 1st ant(k1)

β = 1,00

α = 1,00

ṗ = 1,00

Taboo list = D

Then perform the local pheromone() update processτ.

$\tau ij(baru) = (1 - \dot{p})\tau ij + \Delta\tau i\ jk$

= (1–0,01) * (0,2313) + ((0,01) * (1/0,2313))

= 0,27222

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$$p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} \quad (10)$$

To $j \in \{N - tabu_k\}$

$p\frac{k}{ij} = 0$, for the other j with i as the origin city index and j as the destination city index.

$\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta} =$

$= (0{,}27222)^1 * (0{,}01818)^1 + (0{,}27222)^1 * (0{,}2128)^1 + (0{,}27222)^1 * (0{,}01695)^1 + (0{,}27222)^1 * (0)^1 + (0{,}27222)^1 * (0{,}00840)^1 + (0{,}27222)^1 * (0{,}00714)^1 + (0{,}27222)^1 * (0{,}00662)^1$

$= 0{,}021390$

$$city\ A = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}27222)^{1.00} * (0{,}018181818)^{1.00}}{0{,}021390041} = 0{,}231$$

$$city\ B = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}27222)^{1.00} * (0{,}21276596)^{1.00}}{0{,}021390041} = 0{,}2707$$

$$\text{city } C = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}27222)^{1.00} * (0{,}016949153)^{1.00}}{0{,}021390041} = 0{,}2157$$

Table 10. The journey of ants in the first cycle

Ant	Point Beginning	Probabilitas								Selected Point	Taboo List
		A	B	C	D	E	F	G	H		
K1	A	0	0,3393	0,2472	0,4134	0	0	0	0	D	A → D
K2	B	0.3179	0	0	0,4531	0,229	0	0	0	D	B → D
K3	C	0,2938	0	0	0,4581	0	0	0,2480	0	G	C → G
K4	D	0.2314	0,2708	0,2157	0	0,1069	0,0909	0,0842	0	G	D → G
K5	E	0	0,1965	0	0,1536	0	0,5221	0	0,1278	F	E → F
K6	F	0	0	0	0,1293	0,5174	0	0,2292	0,1240	H	F → H
K7	G	0	0	0,2589	0,1868	0	0,3570	0	0,1972	F	G → F

$$city\ D = p\frac{k}{ij} = 0$$

$$city\ E = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}27222)^{1.00} * (0{,}008403361)^{1.00}}{0{,}021390041} = 0{,}1069$$

$$city\ F = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}27222)^{1.00} * (0{,}007142857)^{1.00}}{0{,}021390041} = 0{,}0909$$

$$city\ G = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}27222)^{1.00} * (0{,}006622517)^{1.00}}{0{,}021390041} = 0{,}0842$$

$$city\ H = p\frac{k}{ij} = 0$$

Table 11. 1st ant probability between point D to another point

Ket	A	B	C	D
D	0,231	0,2707	0,2157	0
Cumulative	0,231	0,5021	0,717	0,717

Ket	E	F	G	H
D	0,1069	0,0909	0,0842	0
Cumulative	0,824	0,915	1	1

A random number generated between 0-1 using the Excel function Rand() is chosen 0.1067 so that the selected city is city E. So the Taboo list becomes A = > D = > E.

1. 1st ant(k5)

Taboo list = E

$$p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} \quad (11)$$

to $j \in \{N - tabu_k\}$

$p\frac{k}{ij} = 0$, for the other j with i as the origin city index and j as the destination city index.

$\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta} =$

$= (0{,}27222)^1 * (0)^1 + (0{,}27222)^1 * (0{,}010752688)^1 + (0{,}27222)^1 * (0)^1 + (0{,}27222)^1 * (0{,}008403361)^1 + (0{,}27222)^1 * (0)^1 + (0{,}27222)^1 * (0{,}028571429)^1 + (0{,}27222)^1 * (0)^1 + (0{,}27222)^1 * (0{,}006993007)^1$

$= 0{,}01489601$

$$city\ A = p\frac{k}{ij} = 0$$

$$city\ B = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}27222)^{1.00} * (0{,}010752688)^{1.00}}{0{,}01489601} = 0{,}1965$$

$$\text{city C} = p\frac{k}{ij} = 0$$

$$\text{city D} = p\frac{k}{ij} = \frac{[\tau i]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}27222)^{1.00} * (0{,}008403361)^{1.00}}{0{,}01489601} = 0{,}153$$

$$\text{city E} = p\frac{k}{ij} = 0$$

$$\text{city F} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau i]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}27222)^{1.00} * (0{,}028571429)^{1.00}}{0{,}01489601} = 0{,}522$$

$$\text{city G} = p\frac{k}{ij} = 0$$

$$\text{city H} = p\frac{k}{ij} = \frac{[\tau ij]^{\alpha} * [\tau ij]^{\beta}}{\sum_{k' \in \{N - tabu_k\}} [\tau ik']^{\alpha} * [\tau ik']^{\beta}} = \frac{(0{,}27222)^{1.00} * (0{,}006993007)^{1.00}}{0{,}01489601} = 0{,}127$$

Table 12. 1st ant probability between point D to another point

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Ket	A	B	C	D
E	0	0,1965	0	0,153
Cumulative	0	0,196	0,196	0,350

Ket	E	F	G	H
E	0	0,522	0	0,127
Cumulative	0,350	0,872	0,872	1

Random numbers that are generated between 0-1 using the Excel function, namely Rand(), then **0.057** is chosen so that the selected city is city H. So that the Taboo list becomes **A = > D = > E = > H.**

The first cycle has been completed and pheromone renewal is obtained, the next step is to find a better route in the second cycle. If there is a better route than the first cycle in this case it has a smaller route length then the pheromone will be renewed again, but when the second cycle is not better than the first cycle then what is taken is the route in the first cycle. Likewise for the third, fourth and so on cycles until it reaches NC max or the specified iteration limit. In manual searches, it is only limited to the first cycle or first iteration (NC = 1) so that the shortest route is obtained on the Cikampek to Purwokerto route with 3 routes 1). A→D→E→F→H with a distance obtained on the route of 355 Km; 2). A→D→G→F→H with the distance obtained on the route which is 431 Km; 3). A→D→E→H with the distance obtained on the route which is 317 Km.

IV. CONCLUSION

This study confirms the effectiveness of the ant colony algorithm in finding the shortest route between Cikampek and Purwokerto. The algorithm models the behavior of ants in search of food and applies this concept to finding the shortest route on the road network.

Through the application of an ant colony algorithm, this study succeeded in finding the shortest path connecting Cikampek and Purwokerto. This has the potential to provide efficient solutions to route planning problems in a variety of contexts, such as transportation and logistics.

From the search for the shortest path from Cikampek city to Purwokerto using the ant algorithm, the shortest path was found through two cycles, namely cycles A and N. This path only passes the shortest route on line 3, which includes points (A→D→E→H), with a total length of 317 Km. In its implementation with cities that have been analyzed, the path formed is through Cikampek → Subang→ Cirebon → Purwokerto. Thus, the ant algorithm is effective in finding the shortest path to travel from Cikampek to Purwokerto through these important points.

The weakness of this research is that it is only limited to finding the shortest route, it cannot determine the fastest time on the path traveled. Because in reality there are several factors on each path traveled.

This research still has a lot to be improved, it is hoped that there will be further research to find out the efficiency of finding the shortest path using the ant algorithm. It is hoped that there will be research that can compare the ant algorithm with other methods/algorithms.

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Comparative Analysis of Sorting Algorithms: TimSort Python and Classical Sorting Methods

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Abstract – The sorted() function within the Python programming language has emerged as the primary choice among developers for sorting operations. Consequently, this study offers a comparative analysis of various classical sorting algorithms and Python's built-in sorting mechanisms, with the objective of identifying the most time-efficient sorting algorithm. The analysis involves assessing the time complexity of each algorithm while handling data arrays ranging from 10 to 1,000,000 elements using Python. These arrays are populated with randomly generated numeric values falling within the range of 1 to 1000. The benchmark algorithms utilized encompass Heap Sort, Shell Sort, Quick Sort, and Merge Sort. A looping mechanism is applied to each algorithm, and their execution speeds are gauged utilizing the Python 'time.perf_counter()' library. The findings of this study collectively indicate that Python's standard algorithm, surpasses classic sorting algorithms, including Heapsort, Shellsort, Quicksort, and Mergesort, in terms of execution.

Keywords – Quicksort, Mergesort, Timsort, Heapsort, Shellsort

I. INTRODUCTION

The development of science and technology allows humans to create increasingly developed and complex works, even though computers can perform calculations faster than humans in general, computers cannot simply solve problems on their own without teaching humans through sequences or steps. The steps mentioned here can be called an algorithm. There are many definitions of what an algorithm actually is. According to Sismoro (2005), an algorithm is a set of instructions or steps written systematically and used to solve logical and mathematical problems/issues with the help of a computer [1]. According to Kani (2020), an algorithm is an effort with a series of operations arranged logistically and systematically to solve a problem to produce a certain output [2]. Informally, an algorithm is any well-defined computational procedure that takes some value, or set of values, as input and produces some value, or set of values, as output [3]. Some of the understanding obtained by researchers shows that an algorithm is a systematic process for solving a problem, and a sorting algorithm is an example that can show that a problem can be solved with a systematic process.

A sorting algorithm in general is a process for rearranging a collection of objects or data using certain rules. In programming, sorting data is important because the time required for the sorting process must be taken into account. Sequencing is also used in compiling computer programs and has an important role in increasing the efficiency of processing data that needs to be repeated. The type and amount of data that needs to be sorted varies greatly. Additionally, determining the right algorithm for a particular situation can be a difficult task because there are various factors that influence its effectiveness. There are several methods that can be used to carry out the sorting process, including Quick Sort, Merge Sort, Bubble Sort, Insertion Sort, and many more. Sorting algorithms have their respective advantages and disadvantages which depend on the amount of data. Efficiency in an algorithm is very important, according to Anggraini Kusumaningrum (2010) a good algorithm is an efficient algorithm where the algorithm is said to be good because it is assessed from the aspect of short time requirements [4].

Time complexity is a measure of the computational effort required for an algorithm to complete its task, expressed as a function of the size of its input. It quantifies how the algorithm's execution time adapts to the size of the input data and characterizes the efficiency of the algorithm by analyzing the number of basic operations it performs. Along with current technological developments, sorting algorithms have also been applied to programming languages, in this case Python. Sorting in the Python programming language uses the sort() function or what is called Timsort. Timsort is a Merge Sort (hybrid) algorithm derived from Merge Sort and insertion sort, which is designed to handle sorting on many types of data so that it can work well (Tim Peters, 2002) [5]. Timsort was created by Tim Peters in 2002 for use in the Python programming language. The algorithm finds sub-sequences of data that are already running and uses them to sort the rest more efficiently. According to Auger Nicolas et al, this is done by combining processes until certain criteria are met. Timsort has been Python's standard sorting algorithm since version 2.3.

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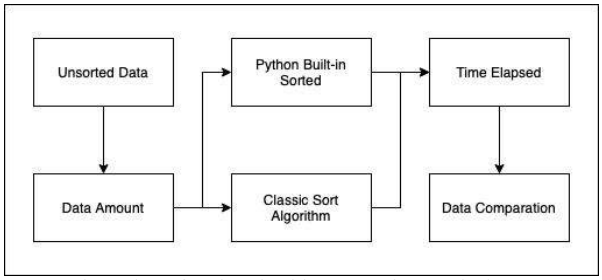

Fig 1. Flow of sorting algorithm comparison methods

done by combining runs until certain criteria are met. Timsort has been Python's standard sorting algorithm since version 2.3.

In several studies obtained from several references, like comes from Yolanda Rumapea (2017) found that the Quick Sort and Merge Sort algorithms each have advantages and disadvantages in computing time and number of steps [7]. Many factors influence this, one of which is a big factor. the size of the data input, the type of data input, and determining the pivot value (specifically in the Quick Sort algorithm).

Other studies from Oladipupo Esau Taiwo et al (2020) state that quick-sort is indeed faster, although merge-sort is stated to be better for organizing larger amounts of data/arrays [8]. In the same study, the author also stated that in terms of stability, Quick Sort is also more stable than merge-sort, also the performance of Merge Sort is indeed good, but the need to allocate memory used for sorting makes it less preferable when compared to the Quick Sort algorithm for application use where good cache locality allocation is the main thing.

In a study from S. Mansoor Sarwar et al (1993) comparing quick-sort, shell-sort and merge-sort, this study showed that shell-sort behaved better than merge-sort by $1000 < N < 150{,}000$ [9]. However, Merge Sort outperformsShell Sort for $N > 150{,}000$, then apart from these 2 algorithms, Quick Sort turns out to be better than Shell Sort and Merge Sort for all values of $N > 1000$.

Several studies tried to enhance sorting algorithms in order to efficiency. Like a study by Abu Sara et al (2020) [10], Enhanced Merge-Sort (EMS) has been carried out, experimental results show that EMS provides better sorting efficiency in terms of running speed than classic merge-sort. Another comparative study comes from Khalid Alkharabsheh discusses a comparison between the new suggested sorting algorithm (GCS) and selection sort, Insertion sort, merge sort, and quick sort. and bubble sort. It analyzes the performance of these algorithms for the same number of elements (10000, 20000, 30000) [11]. For small input, the performance for the six techniques is all nearest, but for the large input Quick sort is the fastest and the selection sort the slowest.

Opeyemi Adesina (2013) evaluated the performance of median, heap, and quick-sort techniques using CPU time and memory space as performance indexes [12]. The results obtained show that in the majority of the cases considered, the heap sort technique is faster and requires less space than median and quick sort algorithms in sorting data of any input data size.

Apart from that, there is research from Muhammad Ezar Al Rivan (2017) which tries to connect several classical sorting algorithms. The combination of the Quick-Insertion Sort algorithm has better performance compared to Quick Sort itself and Merge-Insertion Sort has better performance compared to classic merge sort and classic quick sort itself [13], Quick-Insertion Sort is 15% faster compared to Quick Sort with a limit of 16. Merge-Insertion Sort is 34.8% faster than Merge Sort with a limit of 16. After comparing several sorting algorithms from various studies above, we chose heap, shell, merge, and quick sort as a comparison method Python's built-in sorting

The aim of this research is to present a comparative study of several classical sorting algorithms and Python's built-in sorting methods with the aim of showing the time complexity of the most efficient sorting algorithms. In this case the researcher tries to prove the sorting process because each programming language creates a different sorting function. Functions such as Python build in sorted(), namely Timsort, are considered more frequently used, because classical sorting algorithms are rarely used to implement sorting.

II. RESEARCH METHODOLOGY

In this study, we aim to compare the efficiency of classical sorting algorithms with Python's built-in algorithm, known as timsort. The process flow carried out for this research is illustrated in Figure 1. The initial step involves determining the data size (denoted by 'n') to assess the real-time speed of each algorithm. To achieve this, researchers used loop functions to determine the desired data size for the execution of each algorithm examined. The data size used is randomly generated by the Python library, generating random numbers ranging from 1 to 1000. Next, these randomly generated numbers are sorted based on each selected algorithm.

Since each sorting algorithm is encapsulated in a function, the process of measuring its execution speed becomes easier. To perform these time calculations, the Python library 'time.perf_counter' will be used. Start the timing process by recording the start time before the sorting operation and conclude it by recording the end time. The difference between the final and initial values is calculated, providing the execution time for each algorithm. Next, we will describe the various algorithms used for benchmarking and comparative analysis in this research.

A. Heap Sort

Heap sort is a sorting technique that utilizes a binary tree structure to arrange elements in an array. This approach involves transforming the array into a binary tree, where the values contained in the individual array indices are then sorted. In the following section, we present a brief explanation of the heap sort method accompanied by a representative example, as illustrated in Figure 2. It is important to emphasize the heap construction of the provided array and its subsequent transformation into a maximal heap, as depicted in Figure 3. After this conversion process, the elements making up the array reach the configuration shown in Figure 4.

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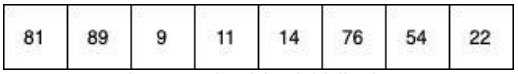

Fig 2. Unordered data initialization

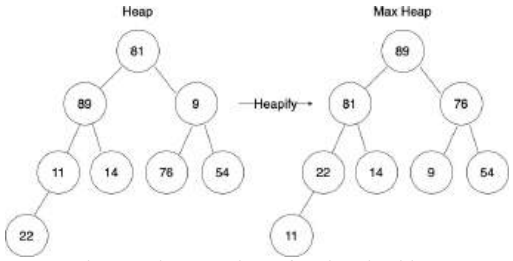

Fig 3. Study comparison of sorting algorithms

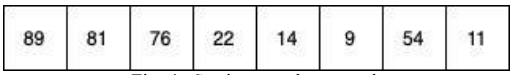

Fig. 4. Sorting max heap result

After swapping the array element 89 with 11, and converting the heap into max-heap, the elements of the array are Figure 6. The process is looping until the data is sorted properly.

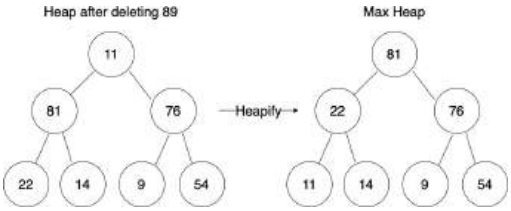

Figure. 5. Next step of erasing highest heap

Fig 6. Heap sort loop and result

In heap sort there are 3 parts, namely Node, Edge, and Leaf where the node is each index in the array, the edge is the line that connects each node and the leaf is each node that does not have a child node (child node). Apart from that, there is also something called root, which is the initial node in a heap. Max heapify has complexity O(logN), build Maxheap has complexity O(N) and we run Max heapify **N−1** times in heap_sort function, therefore the complexity of heap_sort function is O(NlogN)

B. Shell Sort

This sorting technique, commonly referred to as the "diminishing increment method," is frequently denoted as the "Shell Sort Method." Its inception can be attributed to Donald L. Shell in 1959 [17], hence the nomenclature. This method orchestrates the sorting of data by scrutinizing each data element in relation to other elements situated at specific intervals, effecting exchanges where deemed necessary. The sorting process using the Shell method can be explained as follows:

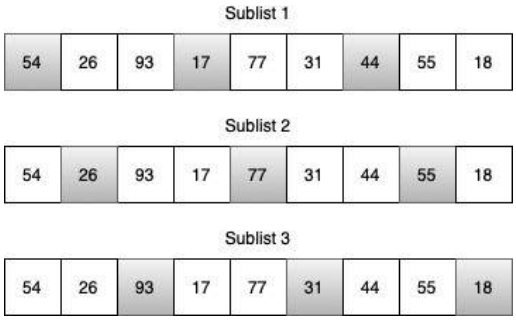

Fig 7. Initial sublist of Shell Sort

We can observe this in Figure. 7, where there are nine items in the list. By employing an increment of three, the list is divided into three sublists, each of which can be individually sorted using insertion sort.

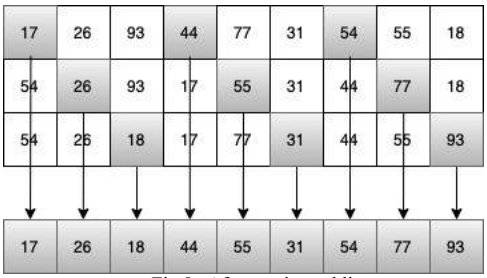

Fig 8. After sorting sublist

Once these individual sorts are finished, you'll notice the resulting list in Figure. 8. While it may not be entirely sorted, an intriguing transformation has occurred. Sorting the sublists has brought the items closer to their respective correct positions within the list.

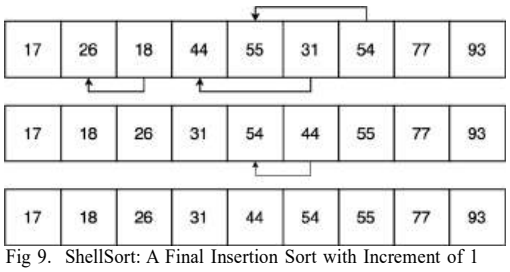

Fig 9. ShellSort: A Final Insertion Sort with Increment of 1

In Figure. 9, you can observe the last step of the insertion sort, which uses an increment of one, essentially representing a traditional insertion sort. It's worth noting that the previous sorting of sublists has effectively minimized the total number of required shifting operations to arrange the list in its correct order. In this particular instance, only four additional shifts are needed to finalize the sorting process.

C. Merge Sort

The Merge Sort algorithm uses the divide and conquer concept. The Merge Sort algorithm is an algorithm that performs sorting by dividing data into small parts. Then these small parts are divided into small sub-parts until one element is obtained. Sorting is done simultaneously with merging. One element is combined with another element by

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directly sorting it. This combination of elements is then combined again with other combinations of elements. The time complexity of the Average Case and Worst Case is [5].

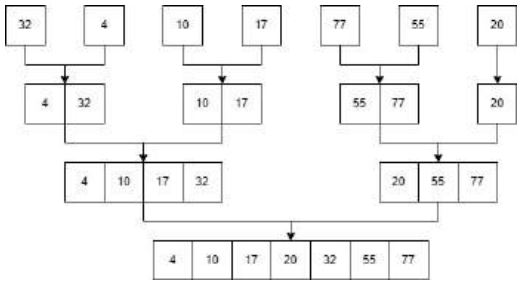

Fig 10. Merge Sort algorithm workflow

Briefly, Merge Sort can be explained as follows (Figure 10). Initially, the array will be divided into two almost equal parts. This is done by finding the midpoint of the array. This process repeats recursively until each subarray has only one element. This is the basic step (base case). Next, the two sorted subarrays are merged into one sorted subarray. When performing a merge, it compares the elements of the two subarrays and places them in thecorrect order. Next, the division and merge steps are repeated for each subarray until the entire array is sorted. The base case of recursion is when the subarray contains only one element or is empty. When that happens, the subarray is considered sorted and no longer needs to be sorted.

D. Quick Sort

Quick Sort method is also often called the Partition Exchange Sort method. This method was introduced by C.A.R. Hoare. To increase its effectiveness, in this method the distance between the two elements whose value will be exchanged is determined to be quite far. The Quick Sort sorting method can be implemented in non-recursive and recursive forms [7].

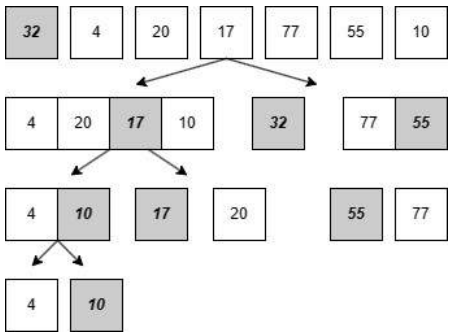

Fig 11. Quick Sort algorithm process flow

The sorting process is carried out by breaking the data set into two parts based on the selected pivot value. In principle, the selected pivot value will be placed in position at the end of each partition process. After the partition process is complete and the pivot is placed in the right position, the sorting process continues recursively to sort the data on the left pivot side and the right pivot side. In general, the Quick Sort sorting process can be explained in the following image, Figure 11.

E. Python Built-in Sort (Timsort)

Timsort is designed to take advantage of running sequential elements that already exist in most real-world data. This repeats the data collection elements into the process and simultaneously places the process in the stack. Whenever runs in the stack match the Merge Sort criteria, they will be merged. This goes on until all data has been passed, then all processes are merged two at a time and only one sorted process remains. The advantage of merging run sequences over merging fixed-sized sub-lists (as classical Merge Sort does) is that it reduces the total number of comparisons required to sort the entire list [19]. Each process has a minimum size, which is based on the input size and is determined at the beginning of the algorithm. If the process is smaller than this minimum process size, the insert type is used to add more elements to the process until the minimum process size is reached.

Timsort is a stable sorting algorithm (the order of elements with the same key is maintained) and attempts to perform a balanced merge (the merge combines its size) [5].

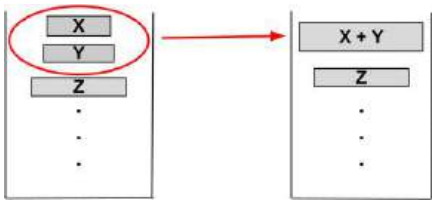

Fig 12. Magnetization as a function of applied

If | Z | | Y | + | X |, then X and Y are combined and replaced on the stack. In this way, the merge continues until all runs satisfy it. | Z | > | Y | + | X | and ii. | Y | > | X | [16].

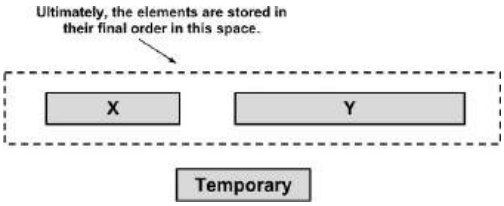

Fig 13. Python Built-in Flow

To merge, Timsort copies the elements of the smaller array (X in this illustration) to temporary memory, then sorts and fills the elements in final order into the combined space of X and Y Figure 13. Elements (indicated by blue arrows) are compared and smaller elements are moved to their final positions (indicated by red arrows) Fig. 14. All red elements are smaller than blue (here, 21). Thus, they can be moved in chunks to the final array of Figure 15.

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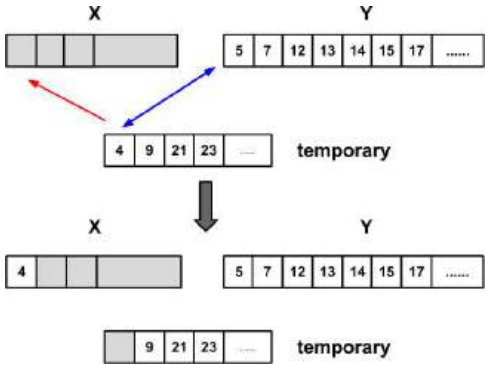

Fig 14. Element and final position

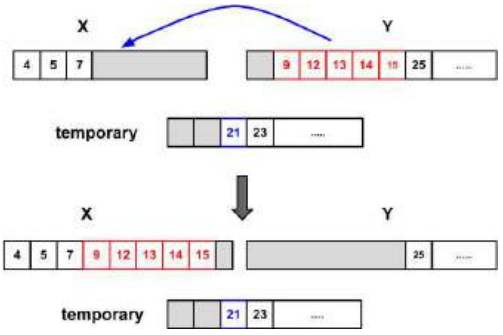

Fig 15. Element configuration

The Timsort algorithm looks for a sequence of minimum size, min runs, to perform the sorting. Because merging is most efficient when the number of runs is equal to, or slightly less than, a power of two, and notably less efficient when the number of runs is slightly more than a power of two, Timsort chooses minrun to try to ensure the former condition.

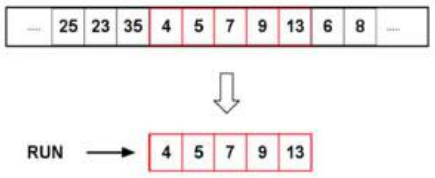

Fig 16. Timsort algorithm searches for minimum-size

III. RESULTS AND DISCUSSION

The average time complexity of the classic sorting algorithm heap, shell, merge, quick sort is O(n log(n)), which is the same as Python built-in (Timsort)t. Additionally, the best and worst case time complexity of merge sort is also O(n log(n)), which is the also same as quicksort and heap sort. As a result, the classical merge sort is generally unaffected by factors in the initial array.

However, classical merge sort uses O(n) space, since additional memory is required when merging. Quicksort also has this space complexity, while heap sort takes O(1) space since it is an in-place method with no other memory requirements.

A summary overall of the complexity time is shown in Table 1. The results of the comparison method produced first are data comparisons (n), namely 10 to 100 unsorted data. The comparison results are shown in Table 2.

Table 2. Time elapsed for each algorithm (10 - 100)

Heap (ms)	Shell (ms)	Merge (ms)	Quick (ms)	Timsort (ms)	Data Amount
0.04	0.01	0.02	0.02	0.01	10
0.03	0.02	0.04	0.03	0.01	20
0.04	0.03	0.05	0.05	0.02	30
0.06	0.04	0.06	0.06	0.02	40
0.08	0.06	0.07	0.08	0.02	50
0.16	0.05	0.08	0.09	0.03	60
0.11	0.07	0.1	0.12	0.04	70
0.13	0.08	0.12	0.13	0.04	80
0.14	0.09	0.14	0.15	0.05	90
0.18	0.11	0.17	0.2	0.05	100

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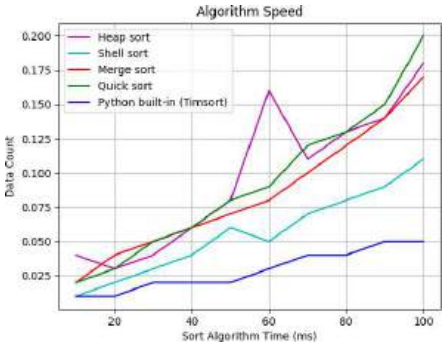

Figure 16. Time Complexity (10-100)

As the result from 10-100 sorting data Fig. 16, we found Quick sort and Python Sort appear to be the fastest sorting algorithms across all data sizes, consistently taking the least amount of time.

Table 3. Time elapsed for each algorithm (100 - 1.000).

Heap (ms)	Shell (ms)	Merge (ms)	Quick (ms)	Timsort (ms)	Data Amount
0.18	0.11	0.17	0.2	0.05	100
0.48	0.23	0.33	0.33	0.1	200
0.66	0.38	0.49	0.49	0.15	300
0.81	0.6	0.68	0.75	0.22	400
1.07	1.01	0.94	0.93	0.32	500
1.65	0.97	1.49	1.01	0.31	600
1.55	1.12	1.26	1.38	0.38	700
1.85	1.5	1.75	1.58	0.41	800
2.09	1.73	1.64	1.49	0.46	900
2.41	1.84	1.89	1.71	0.51	1000

Heap Sort, Shell Sort, and Merge Sort tend to take more time as the data size grows, and their execution times are relatively close to each other. The Python Sort (built-in) consistently outperforms the custom sorting algorithms in terms of speed (Table 2).

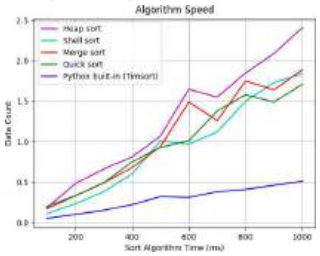

Fig 17. Time Complexity (100-1,000)

As we can see (Table 3), Quick Sort and Python Sort are consistently faster across all data sizes. Quick Sort, in particular, maintains its efficiency even as the data size grows. Heap Sort, Shell Sort, and Merge Sort exhibit longer execution times as the data size increases, with Heap Sort being the slowest among the custom sorting algorithms Fig. 17.

Table 4. Time elapsed for each algorithm (1.000 - 10.000).

Heap (ms)	Shell (ms)	Merge (ms)	Quick (ms)	Python built-in (ms)	Data Amount
2.41	1.84	1.89	1.71	0.51	1000
6.02	4.34	3.86	3.12	1.01	2000
8.51	6.53	6.13	4.3	1.54	3000
11.72	8.94	8.38	5.69	2	4000
14.8	12.79	10.91	7.09	2.55	5000
18.11	14.33	13.21	9.13	3.19	6000
21.9	16.94	15.38	9.35	3.7	7000
25.36	21.11	17.81	10.75	4.28	8000
29.41	24.11	20.24	11.58	5.15	9000
32.02	27.53	22.47	13.34	5.25	10000

Heap Sort and Shell Sort show the highest percentage increases in execution time, indicating that they become significantly slower as the data size grows (Table 4 & Fig. 18).

Quick Sort exhibits a lower percentage increase compared to the custom sorting algorithms, making it more efficient for larger data sets. Python Sort remains a robust choice, with its execution time increasing by less than 1000% over the data size range, suggesting its consistent efficiency.

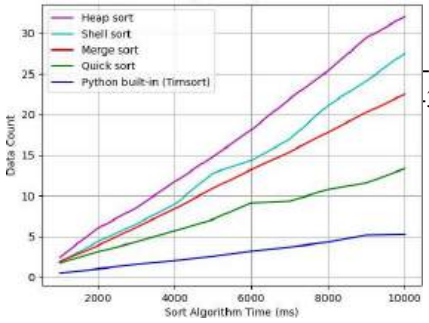

Fig 18. Time Complexity (1,000-10,000) Table 5.

Time elapsed for each algorithm (10.000 - 100.000).

Heap (ms)	Shell (ms)	Merge (ms)	Quick (ms)	Python built-in (ms)	Data Amount
32.02	27.53	22.47	13.34	5.25	10000
71.64	68.98	52.12	29.7	12.4	20000
123.65	104.99	79.05	39.74	17.68	30000
159.55	146.2	109.02	53.99	22.99	40000
203.19	190.69	145.88	67.79	28.91	50000
245.93	244.8	168.6	93.34	35.06	60000
307.37	296.3	196	90.99	40.58	70000
356.79	329.69	235.7	108.01	46.77	80000
408.63	404.4	314.56	132.6	51.35	90000
435.74	494.3	371.57	197.26	57.13	100000

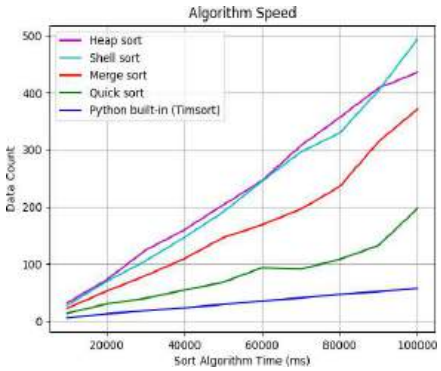

Fig 19. Time Complexity (10,000-100,000)

As data size reaches 100,000 elements, the execution times vary significantly between sorting algorithms, with Quick Sort and Python Sort maintaining their efficiency, while the other algorithms experience more substantial increases in execution time. Heap Sort, Shell Sort, and Merge Sort become increasingly slower as the data size grows. Heap Sort is notably slower for larger datasets.

Table 6. Time elapsed for each algorithm (100.000 - 1.000.000).

Heap (ms)	Shell (ms)	Merge (ms)	Quick (ms)	Timsort (ms)	Data Amount
419.13	494.3	371.57	197.26	55.16	100000
919.21	1399.76	593.99	284.13	125.2	200000
1477.77	1580.54	918.64	441.91	170.65	300000
2165.92	2286.17	1298.11	810.55	684.66	400000

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2875.81	3181.02	1621.98	813.99	289.56	500000
3176.95	3522.2	1982.79	1023.11	355.8	600000
3917.22	4109.59	2332.34	1266.21	408.73	700000
4420.99	5341.38	2689.28	1477.53	469.31	800000
5263.96	5474.57	3061.3	1680.99	541.9	900000
5700.81	6999	3450.7	2011.64	596.34	1000000

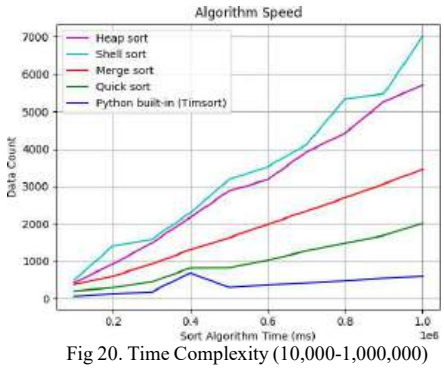

Fig 20. Time Complexity (10,000-1,000,000)

Same as described above, for the largest dataset with 1,000,000 elements (Table 6), the differences in execution times among the sorting algorithms are pronounced, with Quick Sort and Python Sort being significantly more efficient than the others (Fig. 20).

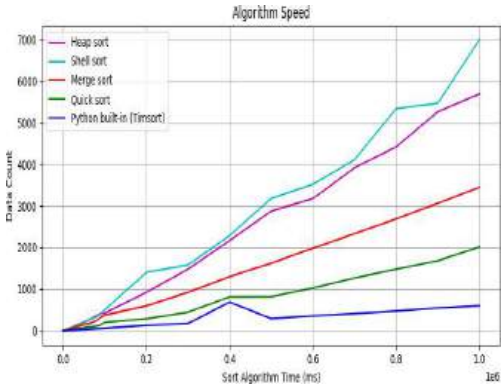

Fig 21. Overal Time Complexity (10-1,000,000

Python Sort (Python's built-in sorting function) is the second most efficient sorting algorithm (Fig. 21), closely following Quick Sort. Heap Sort, Shell Sort, and Merge Sort tend to become slower as data size increases, with Heap Sort being the slowest among these three custom sorting algorithms. For the largest dataset with 1,000,000 elements, the differences in execution times among the sorting algorithms are pronounced, with Quick Sort and Python Sort being significantly more efficient than the others. As data size reaches 1,000,000 elements, the execution times vary widely among the sorting algorithms, reflecting the importance of choosing the right sorting algorithm for specific use cases.

For data sizes of 100,000 or more, the differences in execution times among sorting algorithms become even more pronounced, with Python Sort consistently demonstrating its efficiency. Heap Sort exhibits the longest execution times for large datasets, making it less practical for very large datasets

IV. CONCLUSION

The dataset consists of execution times (in milliseconds) for various sorting algorithms on different data sizes ('data_count'). This research includes five classical sorting algorithms: Heap Sort, Shell Sort, Merge Sort, and Quick Sort compared with Python Built-in Sort (Timsort), with data sizes ranging from 10 to 1,000,000 elements. As the data size increases, the execution time for all sorting algorithms generally increases, following the expected trend.

Python Sort (Python's built-in sorting function) consistently shows the fastest execution times across all data sizes, maintaining its efficiency and scalability. Quick Sort is the second most efficient sorting algorithm. Heap Sort, Shell Sort, and Merge Sort tend to get slower as data size increases, with Heap Sort being the slowest of these three specific sorting algorithms.

For the largest data sets with 1,000,000 elements, the difference in execution time between the sorting algorithms is apparent, with Quick Sort and Python Sort being much more efficient than the others. When data sizes reach 1,000,000 elements, execution times vary greatly between sorting algorithms, highlighting the importance of choosing the right sorting algorithm for a particular use case.

Other classical algorithms are still reliable for use in small data sets (1000 elements and below) but in very large data sets (100,000 elements and above), Quick Sort and Python Sort are the most efficient sorting algorithms. When choosing a sorting algorithm, we need to consider factors such as worst-case time complexity, memory usage, and specific application requirements.

Data set analysis highlights the variation in performance of different sorting algorithms as the data size increases. Quick Sort and Python Sort consistently stand out as efficient options for sorting small and very large data sets, making them the preferred choice for most practical applications. However, the choice should be aligned with your application's specific needs, taking into account factors other than execution time, such as memory usage.

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Expert System for Diagnosing Covid-19 Disease Using Method Forward Chaining

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Abstract – December 2019 was the beginning of cases that hit the Wuhan area, increasing cases of Covid-19 in China every day and increasing from January to February 2020. Initially reports came from the Hubei area and surrounding provinces, and the reports that came increased to the provinces around China, there were 86 other cases reported from various parts of the country, including Indonesia. Indonesia's first Covid-19 disease reportedly entered on March 2, 2020, there were two cases. The latest information is published on the official WHO website (World Health Organization) it was recorded that from January 3, 2020 to March 18, 2022 in Indonesia, there were 5,948,610 people who were recorded as positive for Covid-19 and 153,411 people were confirmed to have died. Diagnosing Covid-19 is the job of experts or specialists who have experience and knowledge in this field. An alternative that can help people who are not experts in diagnosing Covid-19 is an expert system. The forward chaining method was chosen because it is a forward tracking technique that is sorted according to the number of facts and ends with a conclusion. Forward Chaining is a method inference engine where this method compares facts and statements and will start from the left first (IF). Where, reasoning will start from the facts and then test the validation of the hypothesis (THEN). This research was conducted to make it easier for non-experts to diagnose Covid-19 with this expert system, and to be able to provide solutions after a successful diagnosis.

Keywords - Covid-19, Diagnosis, Expert Systems, Methode Certainty Factor, Method Forward Chaining.

I. INTRODUCTION

December 2019 was the beginning of cases that hit the Wuhan area, increasing cases of Covid-19 in China every day and increasing from January to February 2020. Initially reports came from the Hubei area and surrounding provinces, and the reports that came increased to other provinces around China, there were 86 cases others were reported from various countries such as Taiwan, India, South Korea, the Philippines, Australia, Canada, Finland, Nepal, Sri Lanka, Thailand, Vietnam, Malaysia, Cambodia, Japan, Singapore, Saudi Arabia, France and Germany [1]. Indonesia's first Covid-19 disease reportedly entered on March 2, 2020, there were two cases. The latest information published on the official WHO website (World Health Organization) it was recorded that from January 3, 2020 to March 18, 2022 in Indonesia, there were 5,948,610 people who were recorded as positive for Covid-19 and 153,411 people were confirmed to have died [2].

Diagnosing Covid-19 is the job of an expert who has knowledge and experience. The limitations of someone who is not an expert in diagnosing Covid-19 disease are often wrong, due to lack of knowledge and experience. An expert system can be an alternative that can help people diagnose the Covid-19 disease. Expert systems can be defined as applications of artificial intelligence where the system contains knowledge from one or more related experts in a particular field [3]. Many methods can be used to build expert systems, such as Forward Chaining, Certainty Factor, Backward Chaining, Depth First Search, and others [4]. The expert system built is widely used to help everyday life. One of them is to diagnose a disease [5]. Forward Chaining is a method inference engine where this method compares facts and statements and will start from the left first (IF) [6]. This expert system can identify user problems related to dementia disease. Its use is similar to query tracing using the forward-chaining method used to draw conclusions based on conclusions drawn from answers to various questions asked by users [7]. The forward chaining method performs processing starting from a set of symptoms, which are then carried out in inference to produce a diagnosis The data used for research consists of 30 symptoms and 10 eye diseases [8]. Where, reasoning will start from the facts first in testing the validation of the hypothesis (THEN) [9].

This method is a form of strategy to get results or certainty that starts from looking for facts in an expert system. This process is carried out by providing data in a working memory, then this process is repeated until a goal or result is found [10]. Concepts that have been tested for truth are based on research results related to the author's research topic using the method Forward Chaining for early diagnosis of a disease is the result of research conducted by Aggy Pramana Gusman, Dian Maulida and Eva Rianti in 2019 entitled “Expert System for Diagnosis of Ovarian Cyst Disease using the Forward Chaining Method” [11]. Similar research also uses Methods Forward Chaining carried out by Ranti Eka Putri, Kriscillia Molly Morita and Yanti Yusman in their journal entitled “Application of the MethodForward Chaining in Expert Systems to Know Someone's Personality” [12].

This research was conducted to make it easier for non-experts to diagnose Covid-19 using an expert system method Forward Chaining, and can provide solutions after successful diagnosis. Apart from that, even though Covid-19 will be declared endemic, it is hoped that this method can help in diagnosing whether the disease is included in the Covid-19 category or not, so that in the future this method can be used sustainably. Praya Health Center is one

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of the health centers that has received several cases related to Covid-19, where there are local residents who have tested positive for Covid-19. To get real data on handling this case, the author conducted research at the Praya health center, as well as experts who had handled Covid-19 cases before.

II. RESEARCH METHODOLOGY

2.1 Research Stages

This data was obtained from literature studies, medical databases, and collaboration with health institutions, namely the Praya Health Centre and experts who have handled COVID-19 cases before. Researchers then integrated the data into the system to model the reasoning process with the forward chaining method. The stages of this expert system research are made in a flow chart which is arranged clearly and in stages so that it can be used as a reference in conducting research so that it can be made according to previously planned research objectives. The stages of the research flow are as follows:

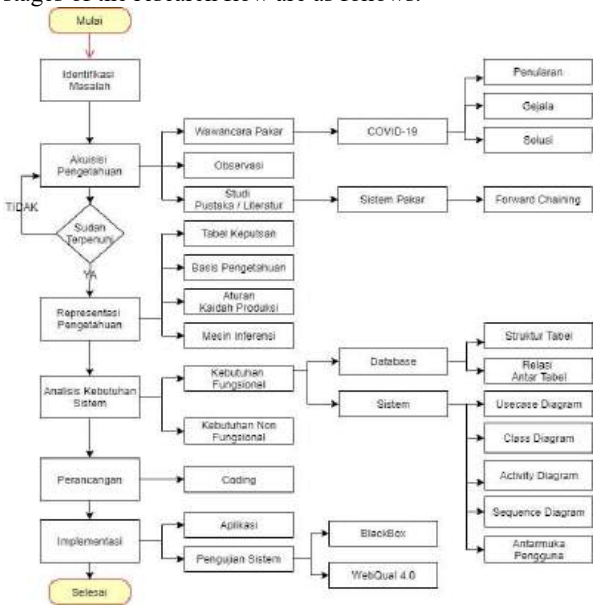

Fig 1. Research Flow Stages

The following is an explanation of the research flow stages that have been designed by the author:

a. The author identifies the problem of the Covid-19 disease which was the reason for the pandemic even though it has recently been declared endemic. It is hoped that in the future this method can be used sustainably.
b. At the knowledge representation stages the author carries out the process of modeling the data that has been collected at the problem identification stage so that it is easy to understand.
c. System Requirements Analysis is a stage where the author analyzes what the system needs, such as functional requirements and non-functional requirements.
d. Design is the stage where the writer carries out coding to build the system.
e. Implementation is the stage where the application system is tested.

2.2 Method Forward Chaining

Forward Chaining is a method used to find conclusions, starting from previously existing facts, then comparing all the facts using sections IF from rules or rules IF-THEN. If in partIF If there are appropriate facts, then the rule will be executed. And if a rule is executed, then the facts in the section THEN will be added in database. Each comparison will begin with a rule. Each Rule can only be executed once. The comparison process will stop if it is no longer thererule which can be compared [8]. While MethodBackward Chaining is a control of a thought to achieve a goal or goal [13]. Hence the method Forward Chaining applied to this expert system [14].

2.3 Method Certainty Factor

Shortliffe Buchanan introduced the method certainty factor (CF) which can be used to calculate the level of confidence for a decision maker. An expert often explains information with assumptions such as the words “possible”, “most likely” and “almost certain”. There are two factors that cause uncertainty in a question presented by the system to experts, namely something that is not certain rule/rules from experts and something that is not certain, namely the answer given user [15].

2.4 Test Method Black-Box

The method commonly used in testing a software without observing the details of software This is a testing method Black-Box. Method Black-Box just analyzes the value output based on the value input of each function available on software which will be tested. The program code used does not need to be analyzed. Testing process Black-Box is the process of program analysis by input data on each form-to find out how far along the program software can run according to needs [16].

III. RESULTS AND DISCUSSION

3.1 Knowledge Representation

The knowledge representation model in this expert system uses production rules where the writing form is if-then. There are 3 diagnostic results, namely Negative, Reactive, Positive for Covid-19, each diagnosis will be accompanied by a solution. Each of these solutions ensures that expert system users get the right direction to respond to their diagnosis results, supporting more effective management of individual and community health. The diagnostic table will explain the diagnostic results in this system:

Table 1. Diagnosis

No.	Diagnostic Code	Diagnosis Name
1.	D001	Negative
2.	D002	Reactive
3.	D003	Positive

a. Decision Table

Decision tables are a way to document knowledge gained from experts. The following is the decision table for this research [3]:

Table 2. Decision Table

Code	Symptom Name	Diagnosis		
		D001	D002	D003

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G001	Cough	✓		
G002	Have a cold	✓		
G003	Fever	✓		
G004	Fatigue	✓		
G005	Headache	✓		
G006	Loss of Appetite	✓		
G007	Loss of Sense of Smell (Anosmia)		✓	
G008	Loss of Sense of Taste (Ageusia)		✓	
G009	Sore throat		✓	
G010	Coughs and colds accompanied by shortness of breath		✓	
G011	Asthma		✓	
G012	Red Eyes/Irritation		✓	
G013	Diarrhea		✓	
G014	Muscle ache		✓	
G015	Pulmonary Hypertension			✓
G016	Diabetes Mellitus			✓
G017	Heart failure (Decompression of the Heart)			✓
G018	Pneumonia (Pneumonia)			✓
G019	Pain in the Chest			✓
G020	Hard to breath			✓

b. Knowledge Base

Knowledge base is a particular form of information or knowledge that is used for knowledge management. Knowledge base functions in several processes, namely collecting, organizing and rediscovering knowledge. The method used for calculation operations in this system is method Certainly Factor where the knowledge base used therein is Diagnosis, Symptoms, MB (Measure of increased belief) and MD (Measure of increased disbelief), based on the Term Interpretation value in the method Certainty Factor [17]:

Table 3. Mark Interpretation of terms

No	Information	Mark
1	Very confident	1
2	Confident	0.8
3	Sure enough	0.6
4	A little sure	0.4
5	Not sure	0.2
6	Very Unsure	0

The following table shows the knowledge base obtained by the author after carrying out the expert interview process:

Table 4. System Knowledge Base

Code	Symptom Name	MB	MD
G001	Cough	0.6	0.2
G002	Have a cold	0.6	0.2
G003	Fever	0.6	0.4
G004	Fatigue (Fatigue)	0.6	0.4
G005	Headache	0.6	0.4
G006	Loss of Appetite (Anorexia)	0.6	0.2
G007	Loss of Smell (Anosmia)	0.8	0.2
G008	Loss of Taste (Ageusia)	0.8	0.2
G009	Sore throat	0.6	0.4
G010	Coughs and colds accompanied by shortness of breath	0.8	0.2
G011	Asthma	0.8	0.2
G012	Red Eyes/Irritation	0.4	0.2
G013	Diarrhea	0.4	0.2
G014	Muscle ache	0.4	0.2
G015	Pulmonary Hypertension	1	0.2
G016	Diabetes Mellitus	0.6	0.2
G017	Heart Failure (Decompression Cordis)	1	0.2
G018	Lung Inflammation (Pneumonia)	1	0.2
G019	Pain in the Chest	0.8	0.2
G020	Hard to breath	0.8	0.2

The next stage after the MB and MD weight values are obtained is to accumulate the CF values for each symptom using calculation formula (1), the results of calculation (1) can be seen in table 5 [18]:

$$CF[H,E] = MB[H,E] - MD[H,E] \text{ (Basic)}. \quad (1)$$

Table 5. The value given by the expert is according to the diagnosis

Code	Symptom Name	Diagnosis		
		D001	D002	D003
G001	Cough	0.4		
G002	Have a cold	0.4		
G003	Fever	0.2		
G004	Fatigue	0.2		
G005	Headache	0.2		
G006	Loss of Appetite (Anorexia)	0.4		
G007	Loss of Sense of Smell (Anosmia)		0.6	
G008	Loss of Sense of Taste (Ageusia)		0.6	
G009	Sore throat		0.2	
G010	Coughs and colds accompanied by shortness of breath		0.6	
G011	Asthma		0.6	
G012	Red Eyes/Irritation		0.2	
G013	Diarrhea		0.2	
G014	Muscle ache		0.2	
G015	Pulmonary Hypertension			0.8
G016	Diabetes Mellitus			0.4
G017	Heart failure (Decompression of the Heart)			0.8
G018	Pneumonia (Pneumonia)			0.8
G019	Pain in the Chest			0.6
G020	Hard to breath			0.6

3.2 Process Method Forward Chaining

Method Forward Chaining applied as a rule or inference engine to the system from a decision table that has been made in ordering the symptoms experienced by the user and providing the right solution according to the results provided by the user. Then the author makes production rules in preparing symptoms according to table 5 as follows:

Table 6. Production Rules

Code	Rules
R001	**If** Cough **And** Have a cold **And** Fever**And** Fatigue **And** Headache **And** Loss of Appetite **For** Negative
R002	**If** Loss of Sense of Smell (Anosmia) **And** Loss of Sense of Taste (Ageusia) **And** Sore throat **And** Cough **And** Colds accompanied by shortness of breath **And** Asthma **And** Red Eyes/Irritation **And** Diarrhea **And** Muscle ache**For** Reactive
R003	**If** Pulmonary Hypertension**And** Diabetes Mellitus **And** Heart Failure (Decompression Cordis) **And** Lung Inflammation (Pneumonia) **And** Pain in the Chest **And** Hard to breath **For** Positive

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Next it will be simplified in a chart arranged according to table 6 To make it easier for the author to understand in creating the system, the following is a flowchart for implementing the method Forward Chaining:

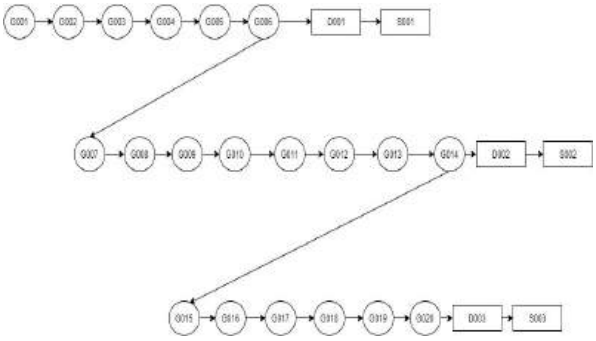

Fig 2. Application of the Forward Chaining Method

The symptoms that will be displayed to the user will be displayed in the form of questions that will be answered according to the symptoms experienced by the user themselves, as follows:

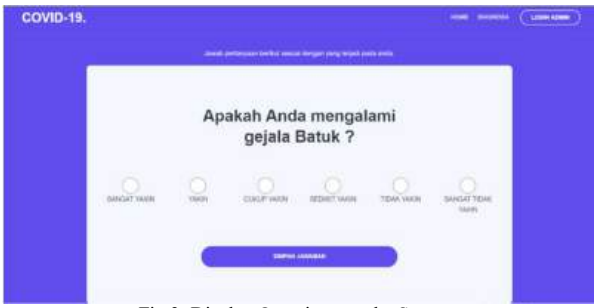

Fig 3. Display Questions on the System

3.3 Calculation Process

The accumulation process used in the system is a calculation method Certainty Factor, where in this case answers are needed from users regarding the symptoms they are experiencing as well as expert knowledge who have dealt with Covid-19. Users will answer according to the values interpretation of terms (can be seen at table 3) found in the Method Certainty Factor which is the decision determining value of the method [15]. The following is an example of a user answer with values interpretation of terms in Methods Certainty Factor regarding the symptoms experienced:

Table 7. Example User Answers

Code	Symptom Name	User Answers
G001	Cough	0.8
G002	Have a cold	0.8
G003	Fever	1
G004	Fatigue	1
G005	Headache	1
G006	Loss of Appetite	0.6
G007	Loss of Sense of Smell (Anosmia)	0
G008	Loss of Sense of Taste (Ageusia)	0
G009	Sore throat	0.2
G010	Coughs and colds accompanied by shortness of breath	0
G011	Asthma	0
G012	Red Eyes/Irritation	0.2
G013	Diarrhea	0
G014	Muscle ache	0
G015	Pulmonary Hypertension	0
G016	Diabetes Mellitus	0
G017	Heart failure (Decompression of the heart)	0
G018	Pneumonia (Pneumonia)	0
G019	Pain in the Chest	0.2
G020	Hard to breath	0

The user's answers will then be accumulated with a value determined by the expert as described in table 5. The formula used to accumulate expert data values with user answers [17]:

$$CF[H,E] = CF[H] * CF[E] \text{ (Single)} \quad (2)$$

Information:

CF[E] / E = Evidence is a fact supporting the patient's hypothesis.
CF[H] / H = Hypothesis results sought/obtained from facts obtained through experts.
CF[H,E] = The results of the Certainty Factor are obtained from the expert hypothesis (H) and the patient hypothesis (E).

The following table shows the calculation process based on each alternative diagnosis result according to the answers given by the user and expert knowledge.

Table 8. Negative Diagnosis Single CF Calculation

Code	Symptom Name	Calculation CF[H] * CF[E]	Result (H)= CF[H,E]
G001	Cough	0.4 * 0.8	H1= 0.32
G002	Have a cold	0.4 * 0.8	H2= 0.32
G003	Fever	0.2 * 1	H3=0.2
G004	Fatigue	0.2 * 1	H4 = 0.2
G005	Headache	0.2 * 1	H5= 0.2
G006	Loss of Appetite	0.4 * 0.6	H6= 0.24

Table 9. Reactive Diagnostic Single CF Calculation

Code	Symptom Name	Calculation CF[H] * CF[E]	Result (H)= CF[H,E]
G007	Loss of Sense of Smell (Anosmia)	0.6 * 0	H1= 0
G008	Loss of Sense of Taste (Ageusia)	0.6 * 0	H2=0
G009	Sore throat	0.2 * 0.2	H3 = 0.04
G010	Coughs and colds accompanied by shortness of breath	0.6 * 0	H4 = 0
G011	Asthma	0.6 * 0	H5=0
G012	Red Eyes/Irritation	0.2 * 0.2	H6= 0.04
G013	Diarrhea	0.2 * 0	H7= 0
G014	Muscle ache	0.2 * 0	H8=0

Table 10. Calculation of CF Single Positive Diagnosis

Code	Symptom Name	Calculation CF[H] * CF[E]	Result (H)= CF[H,E]
G015	Pulmonary Hypertension	0.8 * 0	H1= 0
G016	Diabetes Mellitus	0.4 * 0	H2=0
G017	Heart failure	0.8 * 0	H3=0
G018	Pneumonia (Pneumonia)	0.8 * 0	H4 = 0
G019	Pain in the Chest	0.6 * 0.2	H5= 0.12
G020	Hard to breath	0.6 * 0	H6= 0

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After getting the accumulated results from user answers with expert values, the accumulated results will be combined with the formula [17]:

CF[H,E] = CF[x] + CF[y] (1 - CF[x]) (Combination) (3)

Information:

CF[H,E]	=	The results of the certainty factor obtained from experts (H) and patients (E).
CF[x]	=	Initial CF or CF from previous calculations
CF[y]	=	Second CF or next CF

The following is the calculation process based on each alternative diagnosis:

Table 11. Negative Diagnosis Combination CF Calculation

Combination CF	Calculation CF[x] + CF[y] (1 - CF[x])	Results Combination
H1 and H2	0.32 + 0.32 (1 – 0.32)	CFc1 = 0.537
CFc1 and H3	0.537 + 0.2 (1 – 0.537)	CFc2 = 0.629
CFc2 and H4	0.629 + 0.2 (1 – 0.629)	CFc3 = 0.703
CFc3 and H5	0.703 + 0.2 (1 – 0.703)	CFc4 = 0.762
CFc4 and H6	0.762 + 0.24 (1 – 0.762)	CFc5 = 0. 819
RESULTS		**0.82 (82%)**

Table 12. Reactive Diagnostic Combination CF Calculation

Combination CF	Calculation CF[x] + CF[y] (1 - CF[x])	Results Combination
H1 and H2	0 + 0 (1 – 0)	CFc1 = 0
CFc1 and H3	0 + 0.04 (1 – 0)	CFc2 = 0.04
CFc2 and H4	0.04 + 0 (1 – 0.04)	CFc3 = 0.04
CFc3 and H5	0.04 + 0 (1 – 0.04)	CFc4 = 0.04
CFc4 and H6	0.04 + 0.04 (1 – 0.04)	CFc5 = 0.07
CFc5 and H7	0.07 + 0 (1 – 0.07)	CFc6 = 0.07
CFc6 and H8	0.07 + 0 (1 – 0.07)	CFc7 = 0.07
RESULTS		**0.07 (7%)**

Table 13. CF Calculation of Positive Diagnostic Combinations

Combination CF	Calculation CF[x] + CF[y] (1 - CF[x])	Results Combination
H1 and H2	0 + 0 (1 – 0)	CFc1 = 0
CFc1 and H3	0 + 0 (1 – 0)	CFc2 = 0
CFc2 and H4	0 + 0 (1 – 0)	CFc3 = 0
CFc3 and H5	0 + 0.12 (1 – 0)	CFc4 = 0.12
CFc4 and H6	0.12 + 0 (1 – 0.12)	CFc4 = 0.12
RESULTS		**0.12 (12%)**

So, based on the answers from users the resulting diagnosis results are:

1. Negative diagnosis result = 82%
2. Reactive diagnosis results = 7%
3. Positive diagnosis result = 12%

Then the user's diagnosis results are Negative.

3.4 System Calculation Results

Fig 4. System Calculation Results

Figure 4 is the diagnosis result of the user's answer which has been adapted to the user case example in table 7. Comparison of manual diagnostic calculation results with system diagnostic results is as follows:

Table 14. Comparison of Manual Calculation Results with the System

Diagnosis	The calculation results	
	Manual Calculation	System Calculation
Negative	82%	82%
Reactive	7%	8%
Positive	12%	12%
Diagnostic Results	**Negative**	**Negative**

IV. CONCLUSION

This expert system is a system that can channel expertise in early diagnosis of COVID-19. Flow methodForward Chaining which is implemented can run well on the system, and provide correct results according to the calculation methodCertainty Factor as a reference for certainty. Comparison of manual calculation results with system results has the same direction. Based on the results of comparing laboratory tests with the results of comparison point-2, it shows the same decision direction, with a percentage accuracy of 70%. Based on test results on users, user satisfaction is at a percentage of 60-84%, indicating that users are satisfied with using the system. There are also several suggestions that can be used as a reference for the next steps in developing this expert system, namely being able to create an Android-based system so that it can be used on any device, being able to add a feature for downloading diagnostic results, and being able to implement the method used by the author with different cases.

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Battery Performance Evaluation through Decision Tree

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Abstract – This study addresses the pervasive concern surrounding battery performance degradation in electronic devices. While some attribute this decline to device aging, a significant portion of the population lacks awareness of the precise factors contributing to diminished battery efficiency. Consequently, the research investigates the factors related to battery performance, aiming to identify the determinants of reduced efficiency. Decision trees are used to meticulously analyze the intricate relationships between variables and discern the factors that respondents perceive as causative of diminished battery performance. This algorithm is chosen since, in predicting high-capacity lithium-ion battery performance, the decision tree outperforms other algorithms in machine learning in accuracy. The study elucidates diverse user preferences, with 55.38% favoring Android and 44.62% expressing a preference for iOS, indicating disparate perceptions of battery health: 61.54% consider their batteries as "Good," while 38.46% acknowledge a decline. The decision tree analysis of 195 participants underscores the pronounced impact of prolonged usage on battery health, revealing that 95% maintain good battery performance. In contrast, 27.69% of Android users face reduced battery performance, emphasizing the need for targeted user education and Android manufacturers to prioritize device longevity. The ultimate objective is to give readers a comprehensive understanding of the dynamics of battery performance in the context of device aging and its contributing factors and give some input to manufacturers and service providers.

Keywords – Android, Battery Performance Evaluation, Decision Tree, iOS.

I. INTRODUCTION

The rapid advancement of information and communication technology has significantly influenced human activities in daily life, often without being consciously recognized [1]. With the continuous evolution of information technology, accessing the necessary information has become increasingly effortless. Technology is crucial for individuals engaged in professional work by facilitating data exchange and communication tasks. Similarly, technology is integral for students as it aids in completing school assignments and tasks. Data exchange, communication, and task execution typically require electronic devices.

Electronic devices serve specific purposes or functions. In the present era, many people own electronic devices [2], with even young children having their own. This prevalence is driven by the inherent enjoyment derived from using such devices. Individuals of all ages can find various forms of entertainment through these electronic devices. Electronic devices prove particularly helpful where remote work and learning have become prevalent [3]. Virtual meetings are still a common practice, highlighting the crucial role of electronic devices in daily life. The importance of electronic devices becomes even more evident when considering the declining battery performance. Many individuals seek new devices due to the decreasing battery performance, especially during the pandemic, where reliance on electronic devices for work and study has increased. While there is speculation that the age of device usage influences the decline in battery performance, some people still do not adequately maintain their devices.

Additionally, some are unaware of the various factors affecting battery performance, including the age of device usage [4]. The decision tree algorithm has been applied for public awareness. In this context, the decision tree likely contributes by providing a structured analysis of the factors influencing the decrease in public awareness regarding the application of health protocols [5]. In the context of a decision tree-based user-centric security solution for critical IoT infrastructure, the decision tree contributes by offering a systematic framework to analyze and respond to security-related events or conditions [6]. The decision tree contributes to analyzing impact factors for smartphone-sharing decisions by providing a structured and interpretable model that helps identify critical variables influencing the decision-making process [7]. In addition, among machine learning algorithms, a decision tree is particularly notable for its interpretability [8]. When it comes to predicting the electrical performance of high-capacity lithium-ion batteries, decision tree regression often outperforms other commonly used algorithms such as Linear Regression, k-nearest Neighbors Regressor, and Random Forest Regressor in terms of R-squared (R2) accuracy metric [9].

Hence, we are intrigued to conduct a study on the relationship between the age of device usage and battery performance. The research aims to determine the strength of the correlation between the age of device usage and battery performance. Furthermore, the factors contributing most significantly to the decline in battery performance are identified as perceived by the general populace.

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II. METHODS

In this particular research endeavor, the focus is directed toward three key elements: the age of electronic devices, the performance of their batteries, and the myriad factors that contribute to the diminishing efficiency of these batteries. The age of electronic devices serves as a fundamental aspect of investigation. Understanding how the longevity of these devices may impact their overall functionality, particularly in terms of battery performance, is crucial. Factors influencing battery performance may come from operating system software [10] and device age [11].

The division of Battery performance into "Good" and "Decline" categories reflects the dual states of satisfactory and diminishing battery health, offering insights into the overall condition of device batteries. Simultaneously, the segmentation of Battery Health Percentage into 65%, 75%, 85%, and 95% provides a nuanced classification of battery health, ranging from significant decline to optimal performance. These categorizations serve as crucial indicators for users, manufacturers, and service providers, guiding decisions on troubleshooting, user education, and future device improvements. The precise delineation allows for targeted interventions based on individual batteries' specific health and performance needs, promoting informed decision-making and proactive measures to enhance overall device satisfaction and longevity. In comparison, factors affecting the decline in battery performance include Charging while playing [12], overcharging [13], and frequent use of power banks [14].

Data collection in research aims to obtain valid and accurate information that can be responsibly used as a basis for seeking solutions and addressing existing issues. This process represents the initial stage in conducting research before delving into the analysis of the acquired data. In this study, the researcher employs a quantitative data collection method by distributing structured questionnaires to respondents who meet specific criteria. The questionnaires are designed with closed-ended questions, signifying that the researcher has provided predefined response options. Consequently, respondents are required to select one of the provided answers.

The researcher employs two research methods in this study. First, the correlational research method enables the researcher to identify or uncover relationships between variables or multiple variables with other variables. This method is chosen because the researcher aims to explore the relationship between the age of device usage and battery performance variables. Additionally, the researcher seeks to determine the factors influencing the decline in battery performance. Afterward, the quantitative research method involves numerical data, which is processed and analyzed using specific statistical criteria and presented as mathematical calculations [15]. The researcher utilizes the quantitative research method through a survey, distributing questionnaires to respondents who meet the specified criteria.

Based on the problem above, the researcher utilized the Decision Tree. The Decision Tree constitutes a hierarchical framework where localized regions are recognized through a sequence of iterative divisions facilitated by decision nodes within the testing function [16]. The decision tree is a popular method for prediction or classification due to its ease of interpreting results and human-friendly nature [17]. Additionally, this algorithm is effective in discovering relationships between variables. The Decision Tree structure is easy to remember as it resembles a tree consisting of root, internal, and leaf nodes [18]. The root node is the topmost node with one or more outgoing edges but no incoming edges. Internal nodes have one incoming edge and one or more outgoing edges. Leaf nodes are the bottommost nodes with only one incoming edge and no outgoing edges, representing the outcomes of the process [19]. Advantages of the Decision Tree algorithm include its simplicity, specificity, results easily understandable by humans, accurate calculations, and the ability to process numeric and categorical data [20]. However, it has disadvantages such as overlap, lack of tree growth, and increased decision-making time and memory usage in the presence of extensive classes and criteria [21].

A decision tree model is shown in Figure 1. A decision tree algorithm starts with the whole dataset at the central part of the tree, called the root node. It then repeatedly picks the best feature to group the data based on factors like how well it is separated or how much information it can give. At each step, it splits the data into smaller parts called decision nodes and keeps splitting until it reaches "leaf nodes." These leaf nodes have a predicted value or a label based on the most common value or average value of the data in the node.

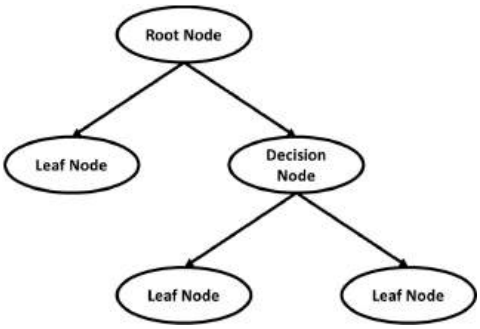

Fig 1 Decision Tree Model

III. RESULTS AND DISCUSSION

This study gathered responses from 195 participants, as shown in Table 1. Firstly, the analysis of OS Software preferences revealed that among the surveyed respondents, 55.38% preferred Android, while 44.62% preferred iOS. Specifically, 108 respondents opted for Android, constituting the majority, while 87 chose iOS. This breakdown provides insights into the distribution of operating system choices among the surveyed individuals. This distribution suggests that the studied population is diverse regarding the age of their devices, providing a

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comprehensive snapshot of the different stages of battery aging. Understanding this diversity is crucial for device manufacturers, service providers, and researchers in tailoring solutions, support, and innovations that cater to the varying needs and challenges associated with distinct phases of battery life. It also emphasizes the importance of considering a wide range of user experiences and expectations related to battery performance in developing technology and services.

Secondly, the distribution of battery age among surveyed respondents reveals a balanced representation. Approximately 50.77% of participants reported using devices with batteries aged two years or more, while the remaining 49.23% indicated devices with batteries less than two years old. This even distribution offers insights into the varied timelines of battery aging within the surveyed population. This even distribution signifies a diverse representation of devices at different stages of battery aging within the surveyed population. The implication is that the study captures a comprehensive view of various timelines in the life cycle of batteries. This diversity is crucial for drawing robust conclusions about the factors influencing battery performance and devising targeted strategies for maintaining or enhancing battery efficiency. Additionally, it underscores the need for tailored solutions and support that consider the unique challenges associated with distinct phases of battery life experienced by users.
Furthermore, the survey results reveal notable factors influencing the decline in battery performance among respondents. The majority, accounting for 55.38%, identified "Charging while playing" as a significant contributor to reduced battery efficiency. Additionally, 27.69% highlighted "Overcharging," and 16.92% pointed to the "Frequent use of power banks" as a factor impacting battery performance. These insights comprehensively understand prevalent user practices contributing to decreased device battery efficiency. These findings hold important implications for user behavior and device usage patterns. Understanding these general practices allows device manufacturers, service providers, and users to address these factors proactively. It emphasizes the importance of designing devices resilient to these common practices for manufacturers. Service providers can offer guidance on optimal charging habits, and users can adopt practices contributing to prolonged battery health. Overall, this comprehensive understanding aids in formulating strategies to mitigate battery performance decline, enhancing user experience and device longevity.

The analysis of battery performance perceptions among respondents reveals that 61.54% of participants reported their devices' batteries as "Good," indicating satisfactory health. In contrast, 38.46% acknowledged a decline in battery performance. These insights provide a comprehensive overview of user perspectives on the condition of their device batteries, shedding light on the prevalence of both satisfactory and deteriorating battery health among the surveyed population. The implication lies in the need for targeted interventions and support mechanisms tailored to both groups. For users with satisfactory battery health, highlighting positive experiences can contribute to brand loyalty and user satisfaction. Meanwhile, addressing the concerns of those experiencing declining battery performance becomes imperative for device manufacturers and service providers. Strategies could include offering troubleshooting assistance, optimizing software updates, or providing information on battery maintenance practices.

Table 1. Questionnaire Results

Factors	Answers	Total	Percentage
OS Software	Android	108	55.38%
	IOS	87	44.62%
Device Age	Two years or more	99	50.77%
	Less than two years	96	49.23%
Factors affecting the decline in battery performance	Charging while playing	108	55.38%
	overcharging	54	27.69%
	frequent use of power banks	33	16.92%
Battery Performa	Good	120	61.54%
	Decline	75	38.46%
Battery Health Percentage	95%	120	61.54%
	85%	27	13.85%
	75%	42	21.54%
	65%	6	3.08%

Finally, a high % Battery Health Percentage of 95% indicates optimal battery conditions. However, a noteworthy proportion of respondents (21.54%) have a Battery Health Percentage of 75%, suggesting a decline in battery health. Additionally, 13.85% report a Battery Health Percentage of 85%. The presence of varied Battery Health Percentages emphasizes the diverse experiences of users, highlighting the need for targeted interventions. Manufacturers and service providers can address the specific concerns of users with lower Battery Health Percentages, offering support, guidance, or potential solutions to enhance overall battery performance. This breakdown aids in tailoring strategies for maintaining and optimizing battery health, contributing to improved user satisfaction and prolonged device lifespan.

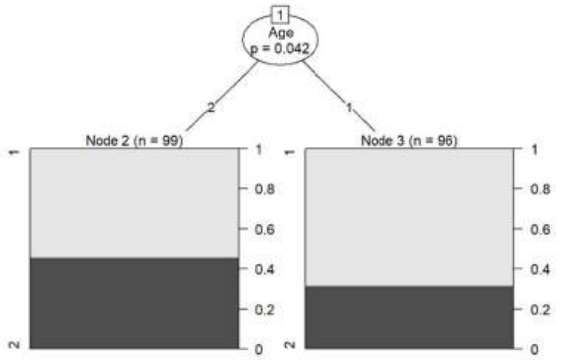

Fig. 2 Decision Tree of Device Age

The utilization of the decision tree, as depicted in Figure 2, meticulously examines the correlation between the duration of device usage (less than two years or at least two years) and the consequent battery performance. The Figure reveals that 99 individuals have been utilizing their devices for at least two years, while 96 have used them for less than

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two years. Notably, users who have been using their devices for at least two years experience a more pronounced decline in battery performance than those who have used them for less than two years. This observation underscores the potential impact of prolonged device usage on battery health, signaling a critical consideration for manufacturers regarding product durability and user satisfaction. Addressing this trend may involve developing technologies that better withstand extended usage periods or implementing strategies to optimize battery performance over an extended device lifespan.

Figure 3 shows the decision tree used to observe users' devices' battery performance and battery health. According to the decision tree analysis, it can be observed that the majority of individuals still maintain good battery performance. Based on the decision tree analysis presented above, it is evident that 95% of the sample exhibits good battery performance. Conversely, 75 individuals have experienced a decline in their device's battery performance, with battery health percentages ranging from 75% followed by 85% and 65%. This breakdown provides a nuanced understanding of the distribution of battery performance within the sampled population. The implication here is twofold. Firstly, it highlights the need for targeted interventions or support mechanisms for users experiencing declining battery performance. Understanding the factors influencing this decline, as identified in the decision tree, can guide manufacturers and service providers in tailoring solutions to address specific issues such as overcharging, usage patterns, or other contributing factors. Secondly, identifying this subgroup underscores the importance of user education and awareness programs. Users may benefit from guidance on best practices for maintaining battery

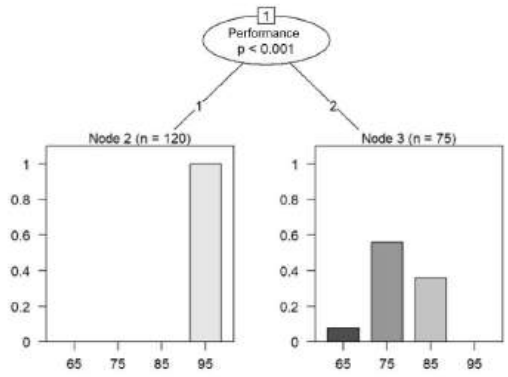

Fig. 3 Decision Tree of Battery Performance

health, thus potentially mitigating issues related to performance decline.

The decision tree analysis in Figure 4, illustrating factors contributing to the decline in battery performance according to respondents' understanding, indicates that the operating system type divided between iOS and Android is the most crucial variable in category separation. The implication is a significant difference in the understanding and habits of iOS and Android users in battery management.

For iOS device users, a specific observation was made regarding battery health at 85%. The battery performance on these devices is primarily influenced by overcharging, followed by device usage while charging. The implication is that managing overcharging practices and discouraging device usage during charging is critical for iOS users in

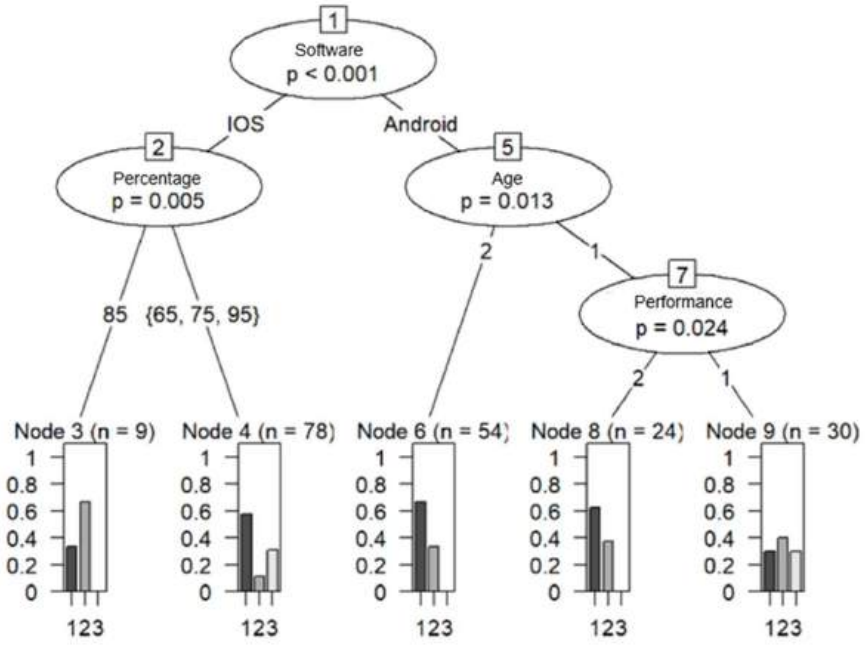

Fig. 4 Decision Tree to show Factors contributing to the decline in battery performance according to respondents' understanding.

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optimizing battery health and performance. Meanwhile, the revelation that up to 40% of respondents attribute diminished battery performance to usage during charging and reliance on power banks underscores the importance of addressing user behavior and technological limitations. In the context of iOS users, these implications gain specific relevance for Apple and its consumer base. Many respondents, including iOS users, attribute reduced battery performance to charging practices and power bank usage. In that case, Apple may need to tailor its user education efforts, potentially integrating features or notifications that guide users toward optimal charging habits. The findings may also signal a need for continuous innovation in battery technology within Apple devices to ensure resilience against common user behaviors.

The revelation that 27.69% of Android users experience reduced battery performance, primarily linked to devices in use for at least two years and exacerbated by usage during charging and overcharging, underscores the need for Android manufacturers to focus on device longevity. It entails investing in user education on optimal charging practices, refining product lifecycle management strategies to create more durable devices, and exploring ongoing innovation in battery technology. Furthermore, for users whose devices are less than two years old, a significant majority still experience diminished battery performance, primarily attributed to the common usage factors during charging and overcharging. Interestingly, among users who perceive their batteries to be in good condition, the reasons for potential performance decline are evenly distributed across the three factors above. The implications for Android manufacturers are notable, given that most users with devices under two years old report diminished battery performance, mainly due to usage during charging and overcharging. It suggests a need for targeted efforts in user education regarding optimal charging practices, emphasizing the impact of these common behaviors on battery health. Android manufacturers could consider implementing more robust battery management systems and giving users more precise guidelines on charging habits to mitigate premature performance decline. It underscores the importance of integrating innovative technologies into newer Android devices that can withstand and adapt to user behaviors, enhancing overall battery longevity. Addressing these implications is critical for maintaining user satisfaction, improving product longevity, and remaining competitive in the Android market.

IV. CONCLUSION

This study reveals that 55.38% preferred Android, while 44.62% favored iOS. Notably, 50.77% reported devices with batteries aged two years or more, and 49.23% had batteries less than two years old. Factors influencing battery decline included "Charging while playing" (55.38%), "Overcharging" (27.69%), and "Frequent use of power banks" (16.92%). 61.54% perceived their batteries as "Good," while 38.46% acknowledged a decline. Battery Health Percentages varied, with 95% optimal conditions, 21.54% at 75%, and 13.85% at 85%. This diverse data emphasizes the importance of tailored interventions for different user groups, guiding strategies for enhanced battery performance, user satisfaction, and prolonged device lifespan.

The decision tree analysis indicates that out of 195 participants, 99 used their devices for at least two years and 96 for less than two years. Users with over two years of usage experienced a more pronounced decline in battery performance, underscoring the impact of prolonged use on battery health. The decision tree also shows users' device battery performance and health. According to the analysis, 95% of the sample maintains good battery performance, while 75 individuals have experienced a decline, with health percentages at 75%, 85%, and 65%. Furthermore, the decision tree highlights the operating system's crucial role in understanding battery performance, primarily dividing iOS and Android users. For iOS users, managing overcharging and discouraging device usage during charging are pivotal for optimizing battery health, especially at 85%. The revelation that 27.69% of Android users face reduced battery performance emphasizes the need for Android manufacturers to focus on device longevity. Users with devices under two years old still experience diminished performance, highlighting the importance of targeted user education.

Device users are advised to optimize battery performance by monitoring charging habits and avoiding overcharging and excessive use while charging. Limiting the frequent use of power banks, periodically checking battery health, and adhering to manufacturer guidelines for setting practices are crucial. Considering the impact of the operating system on battery performance, understanding the influence of device age and being cautious with devices aged two years or more are also recommended. Education programs by manufacturers and service providers can inform users about best practices while seeking support for declining battery performance is encouraged. These measures aim to enhance user experiences and contribute to prolonged battery life.

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Design of Warehouse Information System for KCM Division Using Javascript

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Abstract - *Increasingly advanced technological developments force business people to be adaptive, especially when there is an increase in production. The KCM division, one of the PT XYZ business units operating in the media sector, experienced increased production. This causes the production equipment to be borrowed irregularly, and information on the warehouse of production equipment is also difficult to find. The Warehouse Information System is the solution to this problem. This research aims to create a warehousing information system that records all information on borrowing production equipment, fulfills warehousing information needs, and solves several existing warehousing problems. This research method is an experimental one-shot case study designed with the Framework for the Applications of System Thinking (FAST) and using simple, easily accessible, and free tools, namely Google Spreadsheet and Javascript coding. The results of this research are that the KCM division's warehousing information system that has been created has been tested to be 100% capable of meeting information needs for borrowing production equipment and resolving existing warehousing problems based on system tests that have been carried out. It is recommended that this system be further developed in future research to overcome minor errors in coding.*

Keywords *: Warehouse Information System; Google Spreadsheet; JavaScript.*

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I. INTRODUCTION

Current technological advances make the need for information important for everyone. This is no exception for business people in various industries. Company or organization leaders must be adaptive to circumstances if they want their business to survive. More than 85% of results from a survey of organizations have adopted technology and used digitalization to adapt in their country [1]. This means they also use technology in various company activities, from operations to production processes, including a warehouse area for storing various production equipment.

Company warehouses with large amounts of data and information must be managed with a well-structured management system. This becomes a new challenge for companies regarding the need for information on production equipment, which is not linear with increasing production.

KCM is a division under the business unit of the parent company, PT. XYZ, which operates in the media sector. The increasing production of programs makes the flow of information, especially warehousing information, overloaded. There are two types of information overload. First, people get too much information to handle at work, beyond their capabilities. The amount of information organizations produce is greater than what society can manage. Second, the time required to process information for a task is more than the time available.[2]

The problem of excess information can be simplified to the need for information on production equipment stored in warehouses. Therefore, in this research, warehousing information needs will be used as the basis for designing an information system that can solve several warehousing problems that arise in the KCM division.

Information systems include two things, namely physical and functional. From a physical perspective, an information system means an arrangement of hardware, software, or both that collaborate to support a job. In terms of function, an information system is a sequential process starting from data collection to its distribution and communication. An information system is said to be effective if it can produce good information and content that is clear, accurate, complete, concise, and timely [3]. So, to measure the functioning of the designed information system, the Framework for Applications of System Thinking (FAST) method will be used in this research [4]. And use Google Spreadsheets with the JavaScript coding language as the software.

Google Spreadsheet is Google's default application, which functions similarly to Excel. It has the advantage of storing, summarizing, analyzing, and sharing data in real-time, and it is free for its users [5]. Even though the functions and settings in the spreadsheet are almost the same as in Excel, they could be lacking. Google still allows users to make their own settings for data processing with the App-Script feature in the Extensions menu.

Google Apps Script is a fast way to create custom business tools that work with Google Workspace. It uses Javascript as its programming language to write code that is immediately ready for use in various Google products, such as Gmail, Google Calendar, Sheets, and others. Another advantage is that there is no need to install anything else; coding can be created directly in a web browser and can run now on Google servers. [6]

Meanwhile, FAST is a framework or agile model for creating and testing systems that suit learning needs and connect them to existing systems [7]. This method is used not only for system design and application creation but also often in information engineering, structured system analysis, and object-oriented design projects [8]. This method was chosen because of its flexible characteristic, which can be used in sharing projects and strategies and can also be combined with system development with commercial and reference methods [9].

Research related to the design of a warehouse information system was previously carried out by Yasin and Sari (2020) with the results of the GA Storage information system, which uses the FAST method based on VBA macro Excel to make it easier for employees to pick up work equipment because it can reduce the time for picking up goods [10]. Subsequent research by Bagir and Putro (2018) resulted in a warehousing information system connected to every part of the warehouse, thereby speeding up the time for inputting raw material data [11]. Then, research by Islakhuddin et al. (2021) produced an information system that makes it easier to collect data on incoming and outgoing goods and provide inventory information quickly and accurately [12]. Lastly, research was carried out by Fauzan et al. (2022) with the results of designing a warehouse information system to be a solution to four warehouse problems, namely ordering, purchasing, production, and goods management [13].

The four studies above describe a system design process using too complex tools. Thus, to overcome these shortcomings, this research uses readily available and easy-to-use tools, such as Google Spreadsheets. This research aims to design a system that can record all information on borrowing production equipment, meet warehousing information needs, and solve several existing warehousing problems.

II. RESEARCH METHODOLOGY

This study's research method is an experiment using a one-shot case study approach to test the impact of new tools on productivity. This model compares productivity levels before and after implementing the tool. [14]

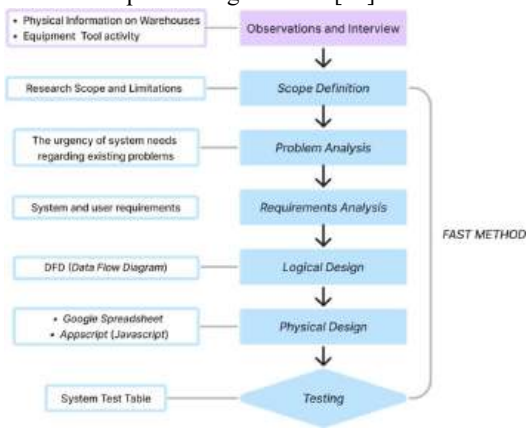

Fig.1 FAST Method

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The first step taken was data collection through observation and interviews. Observations are carried out by looking directly at the physical condition of the warehouse and the production equipment stored there. The interview was conducted with the warehouse manager of the KCM division, the person in charge of the warehouse. Then, the data will be processed using the Framework for Applications of System Thinking (FAST) method.

This method has several stages [15]:

1. Scope Definition
   The initial phase defines the scope, the parameters of the warehouse information system are clearly outlined, and the limitations of the desired information are clearly outlined.
2. Problem Analysis
   Problem analysis is carried out to accurately describe the scope, problems, and cases that occurred before, after, and during the development of the information system.
3. Requirements Analysis
   This stage involves identifying system requirements that are important in designing information systems. This stage includes determining user needs and system requirements.
4. Logical Design
   Using an object-oriented design method, this design phase uses DFD (Data Flow Diagram) as the primary tool.
5. Physical Design
   At this stage, the logical design will be translated into physical form in terms of a digital system, which includes designing database tables using Google Spreadsheets and Javascript coding.
6. Testing
   Finally, there is a trial of a system that has been designed with the desired information needed for a certain period..

III. Results And Discussion

3.1 System Description

The KCM Division's warehouse information system is a system that only provides information related to borrowing production equipment, distribution, and tracking of equipment, as well as equipment inventory information stored in the warehouse. It is a simple system whose output is not a website or application but only a simple loan recording system using Google's default application, Spreadsheet. The warehouse manager will later use the data stored in the Spreadsheet to monitor the use of valuable tools for making decisions on production arrangements..

3.2 System Development

1. Scope Definition

This research has the scope of designing a warehouse information system for the KCM PT division, XYZ, with the problem of needing information on borrowing production equipment from the warehouse.

2. Problem Analysis

The problem will be analyzed using cause-and-effect analysis.

Table 1. *Cause and Effect Analyze*

Cause and Effect Analyze	
Problem or Opportunities	***Cause and Effect***
Production equipment is sometimes located in other places or divisions when needed	There is no neat recording, so information about the whereabouts of the equipment is unknown
There is no information on the time for borrowing or using production equipment	Equipment returned late
Equipment was not returned on time.	Difficulty setting program production schedules
The condition of production equipment is different between those entering and leaving the warehouse.	Decreased tool performance.
Storage of production equipment mixed with other items	unable to create a production tool database.
The need for equipment does not meet the number of employees who need itn	Delays in the production process
There is no neat tool database yet	The tool information stored is not known to certain
Recording of equipment loans is still manual	Reduction production process time

Several problems and weaknesses related to the KCM division's warehousing are shown in Table 1, which will affect the production process. Thus, it is necessary to design a warehouse information system to handle these problems and information needs.

3. Requirements Analysis

Entity/Actor

The following are entities/actors that are directly related to the KCM warehouse division

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Table 2. Entity/Actor

Entity	Description
Warehouse Manager	The second user can access, edit, and find out all the information in the system
Warehouse Officer	The first user can access and input data and information but cannot edit the system
Videographer	Users can only access, view, and find out information in the system
Produser	Users can verify the tool list data provided by the videographer in the system

User Requirements

Table 3. User Requirements

User	Requirements
Warehouse Manager	Could change data in the system Has full system access rights Could update the inventory of goods in the system Could edit other users' access rights
Warehouse Officer	Could edit other users' access rights Could input data on borrowing production equipment into the system Could see the stock of tools
Videographer	Could see information on the tool being borrowed
Produser	Could check information on the availability of equipment and tools that are being borrowed

Hardware and Software Requirements

Table 4. Hardware and Software Requirements

Jenis Perangkat	Kebutuhan
PC	Laptop or ordinary computer
Browser App	Google updated (*Chrome* 109)
Internet	Minimum connection speed is 500 Kbps
Windows System	Minimum Windows 7
Keyboard	*All device*
Mouse	*All device*

4. Logical Design

The data flow design will use a data flow diagram (DFD). The initial stage in building a DFD involves developing a level-0 diagram, called a context diagram. This diagram serves as a broad representation of the entire system and its feedback [16]. Next, DFD levels 1 and 2 are formed. Figure 1 illustrates the context diagram for the KCM division's warehousing information system.

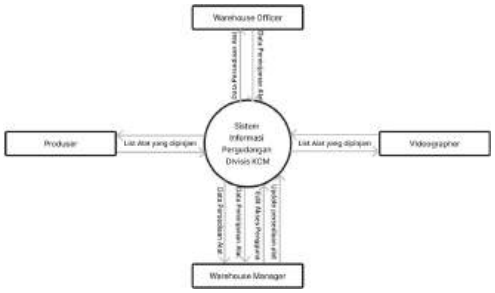

Figure.2 Context Diagram

The context diagram above explains several entities interests in the KCM division's warehouse information system. This is designed in general form before going into the more detailed in DFD level 1 in Figure 2.

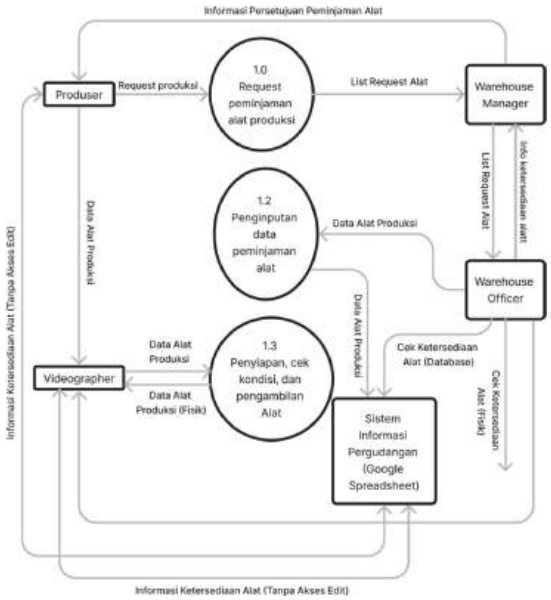

Fig.3 DFD level 1

DFD Level 1 shows the data flow, starting from information on requests for production equipment from the producer, then approved by the warehouse manager, and then the data is input by the WO into the warehouse information system, namely Google Spreadsheet. Finally, the equipment list information is received by the videographer and then taken together with the WO in the warehouse.

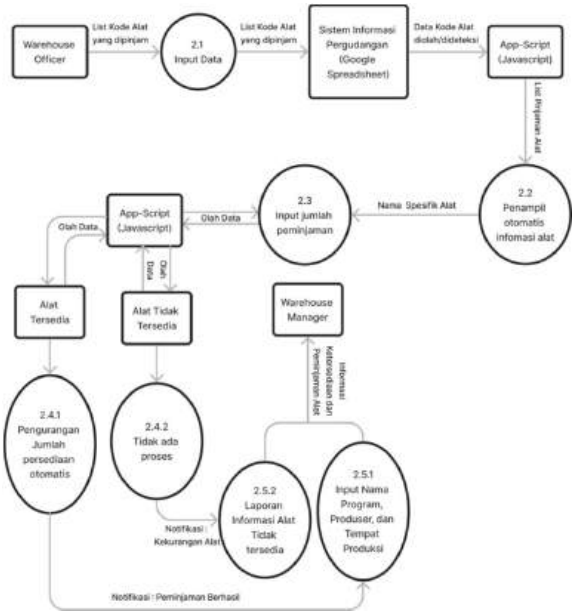

Figure.4 DFD level 2

DFD Level 2 is the data flow received by the WO and will be input into the system. It begins with equipment information received by the WO and then entered into a spreadsheet that records equipment borrowing. At this

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stage, JavaScript coding is used to make it easier to input data and reduce the amount of inventory data in the warehouse automatically, thereby speeding up recording time..

5. Physical Desgin

The next step is to directly interpret the logical design that has been created into the physical design, namely the information system. This uses the help of a tool that is already available and can be easily accessed using the internet, namely Google Spreadsheet..

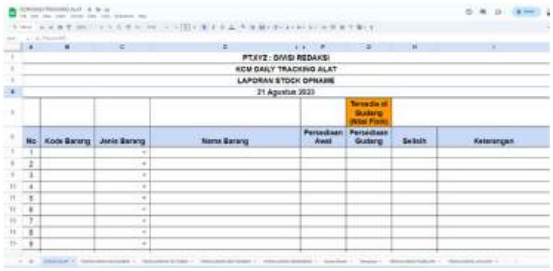

Fig.5 Tool Stock Database Sheet

The Tool Stock Database Sheet was created as a database of information on what tools are owned and stored by the KCM division, both physically and in digital records. Previously, stock-taking had been carried out first.

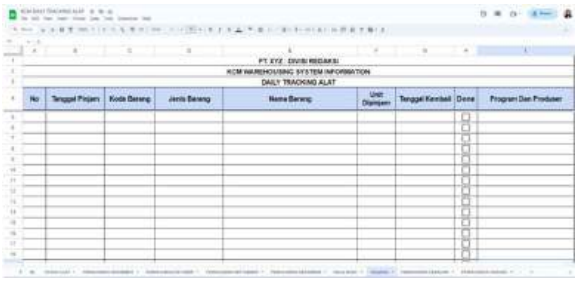

Fig. 6 Tool Tracking Sheet

The Tool Borrowing Tracking Sheet was created to record the borrowing of production equipment used every day. From here, you will find out all the information relating to the equipment borrowed, the program produced, the production location, and the videographer and producer who are responsible for the equipment..

Fig. 6 Coding *Javascript*

Due to the limitations of some of the built-in spreadsheet functions, JavaScript coding is used in Google Extensions, namely Apps Script. It will bring up a new function in the form of automatic reading and detection. When the item or tool code appears, the specific name of the tool will also appear in a matter of seconds. It will also automatically reduce and add equipment inventory to the stock-taking sheet to provide information on successful borrowing, shortages of goods, and successful returns on the equipment loan tracking sheet...

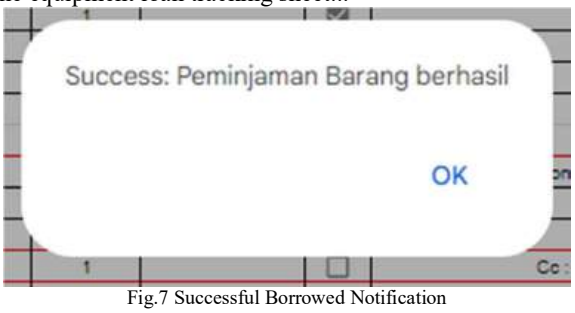

Fig.7 Successful Borrowed Notification

This notification is for sign that automatic deduction for successful item borrowing.

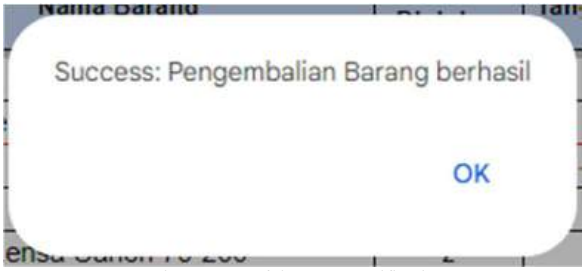

Fig.8 Successful Return Notification

This notification is for sign that automatic addition of returned goods is successful.

Fig.9 Less Stock Notification

This notification is for sign that there is no process for shortages of goods.

The notification above will only appear when data on the number of tools borrowed is entered in the Borrowed Unit column. All of these notifications are a sign that the Javascript coding has been successfully executed, and changes to the inventory data in the Equipment Stock sheet, specifically in the Warehouse Inventory column, have also changed

6. Testing

The final step is testing the system that has been created. This was done to measure the achievement of existing problem solving by the KCM division's warehousing information system. The following is the system test table:

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Table 5. System Test Results

Indicator	How To Test	Achievement	Test Result
Equipments Inventory Information	WM inputs tool data and information in the form of item code, name, and quantity available.	√	The Stock Name Sheet was formed as a database tool that can be used flexibly by simply adding data to the next empty column without disturbing Javascript coding
Equipments Borrowed Information	WO inputs data and information on borrowing equipment.	√	The notification "Succes : Peminjaman Barang Berhasil" appears
Equipments Retunr Information	Check the box in the Done column	√	The notification "Succes : Pengembalian Barang Berhasil" appears
Equipments Availaibility Information	Input a number that exceeds the tool inventory amount	√	The notification "Terjadi Eror : Barang Kekurangan" appears
Equipments Existense Information	-	√	It's in the Program and Producer column
Neatness of Equipment Storage	-	√	A stock tool sheet is available digitally, and a physical stock take has been carried out.
Equipment Condition Information	-	√	There is no solution yet due to the fast and flexible distribution of production equipment

IV. CONCLUSION

This study designs a simple KCM editorial division warehousing information system. By focusing on recording production equipment loans, this system was built using free and easy-access tools, namely Google Spreadsheet and Javascript coding. This system is suitable for application in the KCM division because it has resolved various problems and fulfilled warehouse information needs based on evidence of system test results 100%. Hopefully, This system can be further developed for complex uses with simple tools. Creating solutions to Javascript coding errors and bug problems in further research is also recommended..

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Implementation of the Bethany Tower of Christ Congregation Management Information System Design

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Abstract – Along with the development of the digital era and pandemic conditions have increased the need for systems capable of working remotely. This motivated the researchers to conduct observations at the Bethany Tower of Christ Church. Based on observations and interviews that have been conducted with church pastors and deacons, it is found that the system already owned by the church has a lack of features, one of which is the feature of submitting requests to the church. In addition, there is also a need to update features related to adding devotionals, news, and posts to make it more practical and efficient. The development of this system uses the Waterfall method in which in the process the researcher first conducts direct observation and research at the Bethany Tower of Christ Church followed by analyzing the needs of the church and congregation which results in the design of a congregation management system. As for after the design is done, the system implementation is carried out. After that, researchers conducted testing of system maintenance. Based on the overall results obtained from the survey of respondents' assessment of the website, an average assessment of 87.3% was obtained, indicating that the website is feasible and has impressive respondent satisfaction. Researchers still find shortcomings in the system created, namely the lack of some features and the presence of bugs that need to be fixed. However, researchers still hope that the designed system can be useful for congregations and churches and can continue to be developed and maintained so that the system can be better.

Keywords – Congregation Management, Information System, Church, Website, Digital

I. INTRODUCTION

Church services involve a variety of needs, including the needs of the congregation and the church ministry, so a church must adapt to the times and technology. Especially, in this digital era, digitalization can be a powerful tool to improve the quality of church services and meet the needs of the congregation [1]. The COVID-19 pandemic, which limits mobility and social interaction, has provided additional impetus to look for digital solutions that can help churches function optimally.

Based on the results of the surveys we conducted by interviewing pastors and deacons and observations that we conducted at the Bethany Tower of Christ Church with church pastors and church administrators. Researchers found a lack of an adequate congregational management system in meeting the congregation's increasing needs for information and services.

Fig 1. Documentation of Researcher's Interview with Church Administrator at Bethany Tower of Christ Church on September 25, 2023

Therefore, we want to make an update to the church management system by designing a church management system that is expected to provide solutions for this church in managing data, information, communication, and services more effectively and efficiently.

In this research, researchers used the waterfall method as an approach to developing the system to be designed. The waterfall method itself is a method that provides a structured description of system development with each phase by phase that must be completed, thus the researcher's planning will be more organized.

This management system is needed to be a useful tool for the church and congregation, and can increase the productivity of the church and congregation. In other words, this project aims to help the church transform into a church that is more connected, efficient, and responsive to the needs of the congregation in this ever-changing world. In other words, the project aims to help the church transform into a church that is more connected, efficient, and responsive to the needs of the congregation in this ever-changing world.

1.1 LITERATURE REVIEW

1. Church

A church is a place of worship for Christians to pray, praise, worship, and fellowship with God. In the church, Christians can also participate in various other religious activities, such as studying the Bible, singing hymns, and Sunday school or youth worship [2].

2. Management Information System

Management information system is the provision of information in various forms of output on computers or other system equipment that can be used by a person or

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group of managers or non-managers in solving a problem or fulfilling the needs of an agency/company [3].

3. Website

Website is a collection of pages that display various types of text, image, audio, and video information linked together via hyperlinks on a web server. Websites allow people to communicate with others, transact, entertain, and search for information in cyberspace [4].

4. HTML

Hypertext Markup Language is a standard language that serves to organize the display while displaying various kinds of information and content such as images, text, animation to video on a web page and can be published online. HTML has a code writing structure called tags [5]. HTML documents consist of two elements or tags called head and body, where the head as the head of the document is used to place the identity of the file, while the body is used to organize content and other elements that will be displayed on the website [6].

5. CSS

CSS is (Cascading Style Sheets) used to organize the layout of components and the visual appearance of web pages. By using CSS, developers can control formatting [7].

6. JavaScript

JavaScript is a programming language that can enhance the running of the system and the appearance of the web-based application page being developed. This language consists of a collection of scripts that can run on HTML documents [6].

7. PHP

PHP is a script programming language that is processed on a computer server and is designed for web development. PHP has a syntax that is easy to learn and has many strong features that can support dynamic and interactive web development [8].

8. Bootstrap

Bootstrap is a CSS (Cascading Style Sheet) framework that is useful for designing website displays. Bootstrap provides convenience and benefits for web developers in creating websites. For example, Bootstrap provides a wide variety of CSS elements such as fonts, buttons, menus, and others that can be combined with JavaScript to create a more attractive and consistent interface. Bootstrap also has many ready-to-use CSS classes and plugins to help developers customize website design and style. Thus, Bootstrap has become one of the most popular front-end frameworks among web developers [9].

9. XAMPP

Xampp is a complete web server package that can be easily installed on various operating systems. This package includes Apache (webserver), MySql (database), PHP (server-side scripting), and various other supporting libraries. Xampp can be used on Linux, Windows, MacOS, and Solaris, making it possible to create a multiplatform web server [10].

10. MySQL

MySQL is a SQL database management system software that is capable of handling multiple threads and users simultaneously. MySQL can be used to manage database and also can be used to connect server database with software .MySQL is designed to manage databases with high speed and easy to use [11].

11. Unified Modeling Language

Unified Modeling Language (UML) is a way to visually display the analysis of a system. UML is also a model used to describe systems and objects [12].

12. Class Diagram

Class Diagram is a structured picture of a system by defining the classes created in designing a system consisting of attributes and operations. Class Diagram aims to adjust the relationship between software and design documentation [13].

13. Use Case Diagram

Use Case Diagram is a design of interactions that occur in the system. Use Case Diagrams can be used to understand the processes that are happening in the system [14].

14. Waterfall Method

The Waterfall method is a method with a framework that presents a flow of system and software design in sequence [15].

II. RESEARCH METHODOLOGY

In this study, researchers first analyzed the needs of the church in terms of church pages, devotionals/sermons, church news, requests, and event posts. From the results of this analysis, researchers made a system design in the class diagram model to provide a detailed description of the church management system structurally and use case diagrams to explain the role of actors contained in the church management system. For system implementation, researchers developed a system based on the system design design. The system that has been implemented, testing the system is carried out to ensure that the system is running well and smoothly. After that, researchers carry out regular system maintenance to ensure that the system can continue to run smoothly in the future and correct existing errors.

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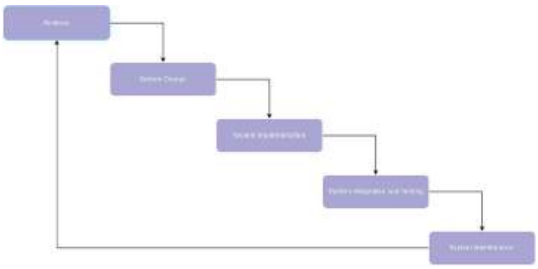

Fig 2. Waterfall Method

1. Analysis

Researchers conducted a survey by interviewing the pastor and the Bethany Tower of Christ church management.

2. System Design

Researchers drafted a system design along with its features and then consulted with the church to ensure that the information system created could suit the needs of the church.

3. Implementation System

Researchers implement the system design that has been designed into a complete system with its functions.

4. System Integration and Testing

The system that has been implemented is integrated into a unified system as a whole to be tested through hosting to ensure the system is functioning properly or needs improvement. The system testing process is carried out by both researchers and congregations through surveys given. So that the results obtained can help the maintenance process carried out after that.

5. System Maintenance

After testing the website along with conducting surveys and interviews at Bethany Tower of Christ church, repairs are made to existing bugs and improvements to existing features. So that the system runs well

III. RESULTS AND DISCUSSION

3.1. Analysis and Identification

3.1.1 Analysis Method

1. Interview Method

Data collection related to church needs / problems is carried out directly in the field by interviewing researchers with the pastor as well as the Bethany Tower of Christ church management.

2. Observation Method

Researchers observed the website that the Bethany Tower of Christ church had previously owned to observe the shortcomings / problems that the website had.

3. Literature Study

Researchers conducted a literature review in order to ensure that the system created can run well and can find out what features are needed.

3.1.2 Problem Identification

Based on the analysis conducted by researchers, several core problems were found as follows:

1. The current website has shortcomings in providing features for requesting congregational assistance to the church.
2. The current website lacks detailed information related to an event including notifications for upcoming events.
3. Lack of integration between information systems with church service features.
4. The importance of integration and development of church information systems to support digitalization.

3.2. System Architecture Diagram

1. Class Diagram Relation

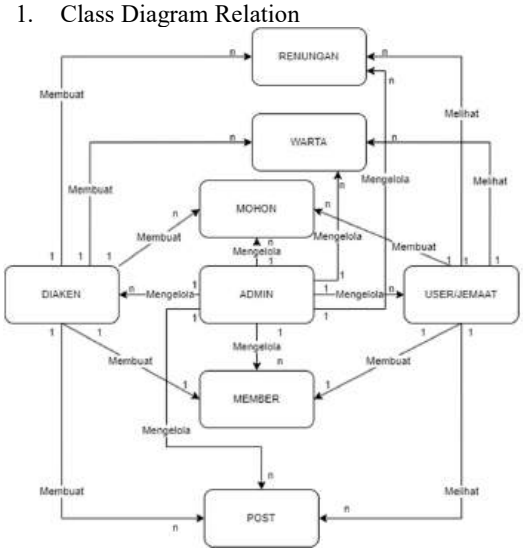

Fig 3. Class Diagram Relation

In this class diagram, we can see the relationships that occur in the flow of the system, where 8 classes consist of users/congregations, deacons, and admins as actors who have their respective roles for each system menu, namely members, posts, news, requests, and devotionals.

The administrator role encompasses the capacity to oversee all facets of the system, including user and member management, as well as the addition and deletion of devotionals, newsletters, and posts. Administrators can also review requests submitted by congregants. Similarly, the Deacon role shares these responsibilities but lacks the authority to control other users and members. In contrast, regular users are limited to viewing devotionals, newsletters, and posts, with the added capability to submit requests for assistance from the church regarding matters such as marriage, baptism, etc. Furthermore, users have the option to register for upcoming events and can also sign up as members via the website.

2. Class Diagram Properties

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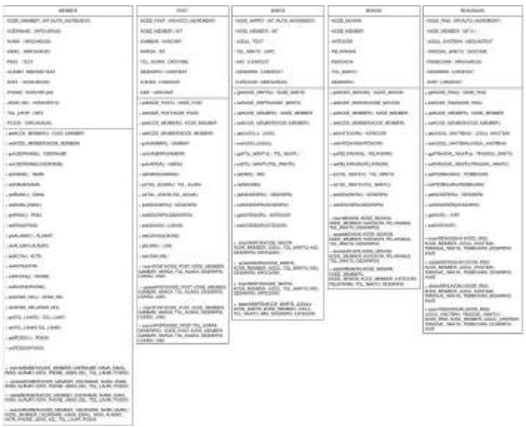

Fig 4. Properties of Class Diagram as System Menu

Based on the class diagram relationship, there are member, post, news, request, and devotional classes that describe the system menu with various attributes and methods owned by each class.

Fig 5. Properties of the Class Diagram as a System Actor

In addition, in the class diagram relationship there are 3 classes as actors of the system consisting of users / congregations, admins, deacons with each attribute and method owned by each class.

3. Use Case

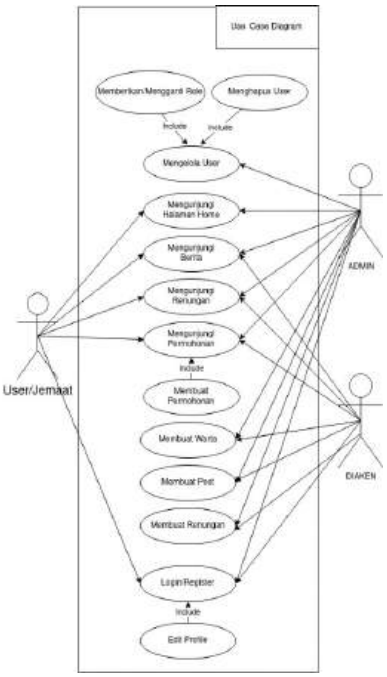

Fig 6. Use Case Diagram

As can be seen in the use case diagram design above, in this system design there are 3 actors, namely Admin, Deacon / Church Servant, User / Congregation with their respective roles and flows. Starting from the admin who can manage user accounts and requests made by users as well as the creation of various kinds of services and information, such as adding news, devotionals, events, and other information related to the church cannot be separated from access to visit these pages. Then deacons have almost the same access as admins in adding church information, newsletters, devotionals, events, and managing user requests. However, deacons cannot manage user accounts. In contrast, users can only visit the home page, news, devotionals, and posts, to see various information that has been published by the admin and deacons and visit the application page including submitting a request to the church for something.

3.3. Implementation

1. Homepage

Fig 7. Top View of the Home Page

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Fig 8. Bottom View of the Home Page

On the main page there is a church homepage feature which can be seen in Figure 3 and there is a feature to contact the church which can be seen in Figure 4.

2. Church News Page

Fig 9. Church News List Page

Fig 10. Church News Page

On this page, the system displays various kinds of church-related information presented in the form of news.

Fig 11. Display of the Form for Adding Newsletters

On this page the deacon/admin can add church news so that church news can be seen as can be seen in Figures 8 and 9.

3. Dawn Prayer & Sermon Summary Page

Fig 12. Dawn Prayer & Sermon Summary Page

On the sermon summary and dawn prayer page there is a feature that can be used to view the summary of sermons and dawn prayers that are already available.

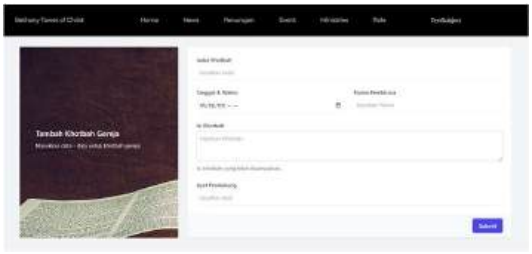

Fig 13. Form for Adding Dawn Prayer & Sermons

This page contains a form for adding church sermons & dawn prayer that will later be displayed on the dawn prayer & sermon summary page, as can be seen in Figure 12.

4. Application Form Page

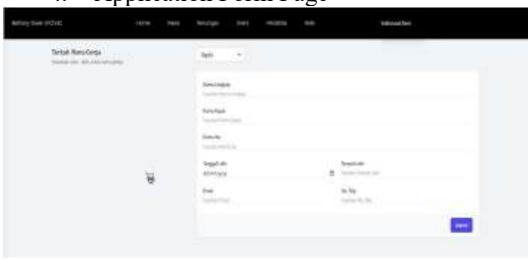

Fig 14. Application Form Page

On this page, the system displays a request form that can be filled in and submitted by the user to the church service.

5. User Role Setup Page

Fig 15. User Role Setup Page

This page is used by Admin to view user data and change or set the role types of all users.

6. Event Page

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Fig 16. Event Page (With Admin/Deacon Role)

The picture above is the admin or deacon page for uploading events in the Church that will run or have already run

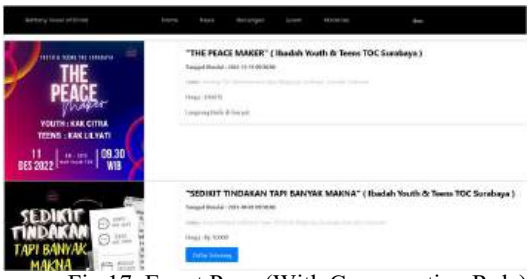

Fig 17. Event Page (With Congregation Role)

This page is intended for users/congregations to be able to view and register for events that will run.

3.4 Survey Results

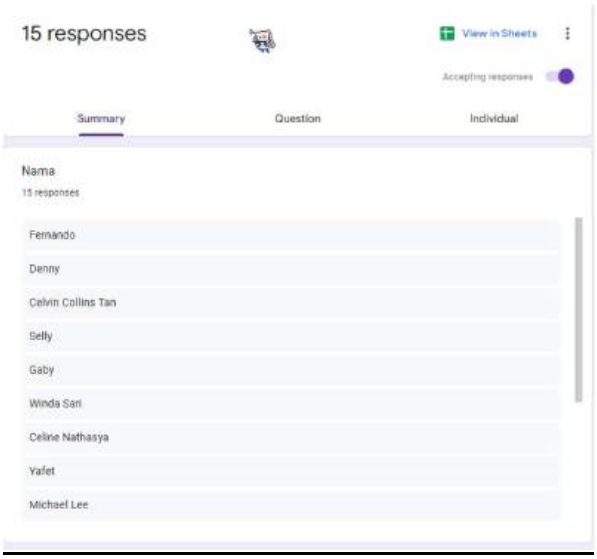

Figure 18. Survey Respondent Name List 1

Fig 19. Survey Respondent Name List 2

As can be seen in the Figure 18-19, there are 15 respondents who give responses to the church website assessment survey, ranging from congregations to church administrators.

Fig 20. Results of the First Question of the Website Satisfaction Survey

The first question of the survey showed an average score of 91.2%, with 60% of respondents giving a perfect score of 10. This reflects the respondents' satisfaction as church members with their experience using the website.

Fig 21. Results of the Second Question of the Website Satisfaction Survey

The second question of the survey showed an average score of 86.8%, with 33.3% of respondents giving a perfect score of 10. This proves that the website can help facilitate what respondents' needed.

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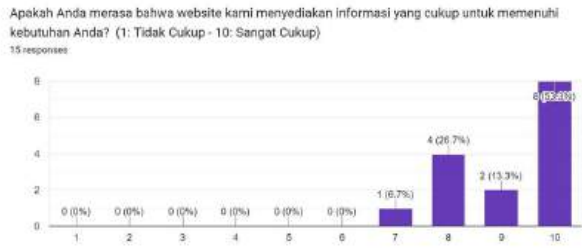

Fig 22. Results of the Third Question of the Website Satisfaction Survey

The third question of the survey showed an average score of 91.8%, with 53.3% of respondents giving a perfect score of 10. This shows that respondents feel fulfilled with the information and information features provided on the website.

Fig 23. Results of the Fourth Question of the Website Satisfaction Survey

The fourth question of the survey showed an average score of 92.5%, with 53.3% of respondents giving a perfect score of 10. This proves respondents' ease of use of the website

Fig 24. Results of the Fifth Question of the Website Satisfaction Survey

The fifth question of the survey showed an average score of 91.2%, with 53.3% of respondents giving a perfect score of 10. This proves that respondents agree to use the website in the future.

Fig 25. Results of the Sixth Question of the Website Satisfaction Survey

The sixth question of the survey showed an average score of 86.8%, with 40% of respondents giving a perfect score of 10. This shows that respondents feel the appearance and design on the website has satisfied church members.

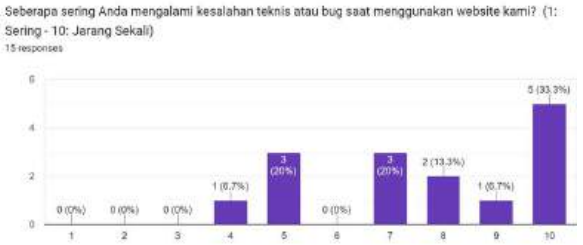

Fig 26. Results of the Seventh Question of the Website Satisfaction Survey

The seventh question of the survey showed an average score of 76.2%, with 33% of respondents giving a perfect score of 10 followed by 20% scoring 5 and 7 as well as 6.7% scoring 4. This shows that although some respondents rarely encounter technical errors/bugs, there are also some respondents who feel there are problems with technical errors/bugs when running the website.

Fig 27. Results of the Eighth Question of the Website Satisfaction Survey

The eighth question of the survey showed an average score of 81.8%, with 40% of respondents giving a perfect score of 10. This shows that it is very likely for some respondents to recommend our website to others.

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Fig 28. Results of the Ninth Question of the Website Satisfaction Survey

The ninth question of the survey showed an average score of 86.8%, with 46.7% of respondents giving a perfect score of 10. This shows that respondents are satisfied with the overall quality of the website.

Fig 29. Collection of Website Satisfaction Survey Respondent Suggestions 1

Fig 30. Collection of Website Satisfaction Survey Respondent Suggestions 2

The last question of this survey is a suggestion for the development of the website designed by the researcher. Some respondents suggested adding chat features, design or appearance can be arranged better, adding content to some features, and so on.

IV. CONCLUSION

Based on the results obtained from the survey of respondents' assessment of the website designed by the researcher, overall, an average assessment of 87.3% was obtained, indicating that the website is feasible and has impressive respondent satisfaction.

So it can be concluded that the system can help the needs of its congregation, both for the fulfillment of church information and the fulfillment of church services. Even so, researchers still find weaknesses in this system, one of which is the lack of features such as direct chat to the church, the display design needs to be better organized and other features added. Researchers also realize the need to improve the website to avoid bugs. All of these weaknesses motivate researchers to work on further system maintenance and development of the website to improve the user experience.

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Analyzing User Experience in KAI Access Application using the UEQ Method

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Abstract – This research aims to provide a comprehensive analysis of the User Experience (UX) components within the KAI Access platform framework, with a particular focus on the need to evaluate the platform's UX. This evaluation is very important because of the emergence of user complaints and usability problems in the KAI Access application rating on the Appstore and Playstore which can affect user satisfaction and overall user engagement. This study leverages insights from previous research in UX analysis, particularly in transportation applications, it identifies key areas for improvement. It implements best practices to ensure a smooth and intuitive user experience. Leveraging frameworks and theories from the field of UX design, the methodological approach revolves around conducting UEQ surveys to comprehensively understand user behavior and interactions. Through systematic evaluation, this research assesses the UX dynamics of the KAI Access system, by carefully examining the strengths, weaknesses, and areas that require improvement to increase user satisfaction and system usability. This research succeeded in showing that the KAI Access platform has good performance in terms of efficiency and reliability. However, from the evaluation there are deficiencies in various areas such as user interface design and interactive responsiveness which are shown in the discussion results indicating the potential for increasing user satisfaction and system usability through pragmatic improvements. Additionally, this paves the way for future research to explore the impact of these improvements on user satisfaction and consider the integration of new technologies for a richer user experience.

Keywords – KAI Access, User Experience, User Experience Questionnaire.

I. INTRODUCTION

KAI Access is the official PT Kereta Api Indonesia (Persero) application, which provides online train ticket booking services. This application was first released on September 4, 2014. With features such as ticket reservations, online payments, travel information, seat selection, digital e-tickets, travel notifications, and route search, this application aims to make it easier for users to plan and track their train journey. Apart from that, KAI Access also provides the latest information regarding schedules, stations, and facilities so that it becomes a comprehensive tool for handling aspects of train travel in Indonesia. To achieve these goals and maximize its use, a positive user experience is crucial for the KAI Access application.

The User Experience (UX) component is very important in shaping user engagement and satisfaction on digital platforms. We carry out assessment evaluations not only on several features but on all features in the KAI Access application because this is related to the application's rating on Google Playstore and Appstore. Thus, this article provides an in-depth examination of the UX elements within the KAI Access platform framework that aimed to improve user-centered interactions and optimize overall satisfaction.

Improving UX aspects in an information platform is crucial as it has a direct impact on user engagement, task efficiency, and adoption rates, thereby influencing user retention. Suboptimal UX can lead to user frustration and reduced efficiency, highlighting the importance of addressing these components (Kushendriawan et al., 2021). This statement emphasizes the importance of User Experience (UX), which reflects user sentiment when interacting directly with applications and will be a crucial factor in developing and improving applications in the future.

This research will evaluate various aspects of user experience, using methods such as the User Experience Questionnaire (UEQ) and assessing usability aspects. This approach allows us to measure the effectiveness of these features and set benchmarks for continuous improvement. By doing this, we can meet users' needs and guarantee their satisfaction with the system (Pahlevi et al., 2019). Through this research methodology, we seek to gain insight into user behaviour and their engagement with the system, ultimately allowing us to recommend impactful improvements.

In this research, the User Experience Questionnaire (UEQ) method is used as a testing method using six assessment scales, namely attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty, which have hedonic and pragmatic quality assessment aspects. Another method used in this research is Usability Testing, which tests applications objectively by seeing how users use the application directly. Usability Testing involves assessing three main aspects: effectiveness, efficiency, and satisfaction, which can support the elements in the User Experience Questionnaire (UEQ) in this research.

By finding out what works well, what needs to be improved, and what areas could be better, our goal is to make users happier and the system easier to use, especially in mobile applications. Additionally, it is relevant to regular

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evaluation of applications, and user experience is essential based on user feedback obtained from platforms such as Google Play Store and Apple Store (Sabukanze & Arakaza, 2021). This ensures user retention and supports KAI Access in its mission to provide seamless access to transportation services for the people of Indonesia, especially focusing on users who utilize the ticket purchasing feature. Continuous improvement efforts are essential to maintain a high level of user satisfaction and loyalty, specifically focusing on the UX dynamics in the KAI Access system, we aim to provide a seamless and intuitive user experience. Leveraging insights from previous research in UX analysis, particularly in transportation applications, we sought to identify areas for improvement and implement best practices.

II. RESEARCH METHODOLOGY

Evaluation of the user experience of the KAI Access application information system was carried out using the User Experience Questionnaire (UEQ) method. Factors measured using the UEQ include attractiveness, efficiency, clarity, reliability, and stimulation. The methodology used in this research is explained as follows:

A. Population and Sample

In the context of this research, respondents are people aged 19-30 years who have downloaded the KAI Access application and have user experience with the application. This survey was distributed through various online channels that are popular among the target age group, such as social media platforms and email newsletters, to ensure wide reach especially among users on the island of Java. We were able to collect responses from fifty-five participants over about three weeks. This sample size reflects focused exploratory analysis to identify initial trends and user feedback on the UX of the KAI Access platform. The data collection period was strategically limited to two weeks to maintain speed in gathering timely feedback and simplify the analysis phase of the study.

B. Data Collection uses UEQ

Fig. 1 UEQ in Bahasa

Table 1. User Experience Questionnaire

On a scale of 1-5, how do you rate the visual appearance of the KAI Access application? (Colors, icons, typography)
On a scale of 1-5, how easy was it for you to find the information you were looking for in the KAI Access application?
On a scale of 1-5, how intuitive do you find the navigation in the KAI Access app?
On a scale of 1-5, what do you think about the responsiveness and speed of the KAI Access application?
On a scale of 1-5, how often do you experience problems or bugs when using the KAI Access application?
On a scale of 1-5, how satisfying was your experience when ordering tickets via the KAI Access application?
On a scale of 1-5, how easy is it for you to use the search feature in the KAI Access app?
On a scale of 1-5, how effective do you think the notification feature in the KAI Access application is?
On a scale of 1-5, how satisfied are you with the payment options available in the app?
On a scale of 1-5, how easy is it for you to access key features (such as train schedules, bookings and payments) on the KAI Access app?
On a scale of 1-5, how fast do KAI Access application pages load?
On a scale of 1-5, how well does the KAI Access app work on your mobile device in terms of app stability?
On a scale of 1-5, how consistent is the user experience of the KAI Access app when used on different devices (for example, phone vs tablet)?
On a scale of 1-5, how easy is it to navigate the menus and sub-menus in the KAI Access application?
On a scale of 1-5, how satisfied are you overall when using the KAI Access application?

User Experience Questionnaire (UEQ) is a quantitative measure of a product's user experience (UX) and can be used in the quality assurance process for concrete projects. In this study, user experience was measured using the UEQ questionnaire, which consists of 14 statements, as in Figure 1 and Table 1. There are six user experience (UX) factors that were measured using UEQ, namely attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty.

Figure 1 displays a rating scale that is usually used in surveys or questionnaires to assess various aspects of a subject or object. On the left and right are a series of rated attributes, such as "Interesting," "Difficult," "Intuitive," "Responsive and Slow," "Ever," "Satisfactory," "Effective," "Satisfying," "Slow," “Poor,” and “Consistent.” For each of these attributes, there is a scale with options that range from negative to positive, for example, from “Very Unattractive” to “Very Attractive”. Respondents are expected to provide their assessments by marking one of the circles on the scale that corresponds to their perception or experience. Such a scale allows raters to measure responses in gradations, providing a nuanced picture of how strongly respondents feel about each aspect being assessed. This approach is aligned with the testing scale for meth supporters, incorporating the six factors of attractiveness, perspicuity, efficiency, dependability, stimulation, and novelty.

C. Data Processing and Analyst

At this stage, descriptive analysis is carried out to provide a comprehensive picture of how KAI Access application users experience their experience. The collected data will be analyzed using statistical software relevant to aspects of the user experience. Descriptive statistical analysis will be used to summarize the findings from the questionnaire,

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including the calculation of the mean, median, and standard deviation for each aspect of the user experience.

III. RESULTS AND DISCUSSION

The questionnaire was distributed online through various media platforms on the internet and involved 55 respondents from various regions in Indonesia. Researchers compiled a questionnaire and distributed it to respondents based on the frequency of use of the KAI Access application. The frequency diagram for using the KAI Access application is shown in Figure 2.

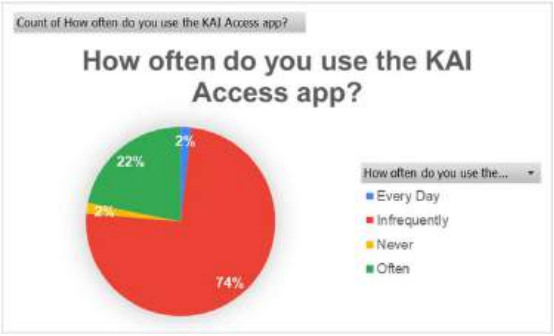

Fig. 2 Frequency Diagram

This research was carried out first by converting the data into the UEQ data analysis tool. Next, the average value is calculated using the mean UEQ grading scale rules.

Table 2. Result from UEQ Scale

No	Mean	Variance	Std. dev	Scale	Benchmark Comparison
1	3.09	1.96	1.40	Attractiveness	Below
2	2.86	1.82	1.35	Perspicuity	Below
3	3.13	1.87	1.37	Efficiency	Above
4	2.96	2.08	1.44	Dependability	Below
5	2.99	2.07	1.44	Novelty	Above
6	2.86	1.78	1.33	Efficiency	Below
7	3.26	2.01	1.42	Perspicuity	Above
8	2.63	1.67	1.29	Efficiency	Below
9	2.98	2.55	1.60	Stimulation	Above
10	3.08	1.89	1.38	Perspicuity	Above
11	2.90	1.77	1.33	Efficiency	Below
12	2.78	1.89	1.37	Novelty	Below
13	3.11	2.02	1.42	Attractiveness	Above
14	3.15	2.19	1.48	Stimulation	Above

Table 2 shows that Stimulation has the widest variation in opinion among respondents, which is indicated by the highest variance and standard deviation, namely 2.55 and 1.60 for item 9. and getting an 'Above' value in the benchmark comparison. This shows that some respondents may feel very stimulated by this product or service.

The ease of understanding (Perspicuity) in item 7 received the highest average score of 3.26, which shows that this is one of the strongest attributes of the product or service. This is supported by the comparison benchmark, which shows the 'Above' value. This value is obtained based on a table of average values for each aspect of the UEQ scale, which can be seen in Table 2.

Table 2. UEQ Scales Mean

UEQ Scales (Mean)			
Attractiveness	3.10	Attractiveness	3.10
Pragmatic Quality	2.97	Perspicuity	3.07
		Efficiency	2.88
		Dependability	2.96
Hedonic Quality	2.98	Stimulation	3.07
		Novelty	2.89

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From the results of this research, the user experience of the KAI Access application has several prominent aspects. The aspects most strongly assessed by respondents were attractiveness and novelty, which shows that users feel stimulated and interested in the features or services offered by this application.

However, several pragmatic aspects are rated below user expectations, such as efficiency and reliability. This shows that although the features offered are attractive, users want improvements in terms of application performance and reliability.

The ratings on Playstore or AppStore show how many users have complained about the KAI Access application service. Some of the complaints are related to application bugs, application responses that are not fast enough, and even ticket orders that have been paid for disappear. This needs special attention from the development team so that KAI's ratings and services improve on the mobile platform.

In the analysis of the UEQ evaluation results for the KAI Access application between Table 1 and Table 2, prominent findings include high scores on the Stimulation and Perspicuity aspects, indicating the app succeeded in attracting user interest and facilitating understanding. The large variation in user opinions about Stimulation signifies appealing app features, although there is a need to improve the consistency of experience. On the other hand, aspects such as efficiency and dependability were rated below expectations, indicating that despite having attractive features, performance and reliability issues need to be addressed.

This aligns with user feedback from the Play Store and App Store, revealing complaints related to app bugs, insufficient response speed, and issues with paid ticket orders disappearing. These complaints show that while the KAI Access app has a high Attractiveness score and succeeded in attracting user interest, there is a need to focus on improving pragmatic aspects such as performance and stability. The success in stimulating interest must be

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balanced with effective handling of technical issues to improve ratings and increase user satisfaction with this app. This becomes an important task for the development team to ensure that the app is not only visually and functionally appealing but also reliable and efficient in its operations. Thus, improvements in these pragmatic aspects will strengthen the app's value, increase user satisfaction, and boost long-term retention.

The results of this research imply that KAI App developers need to focus on improving pragmatic aspects such as efficiency and reliability while still maintaining hedonic aspects that make users interested and feel stimulated. They can do this by updating the user interface, improving application stability, and speeding up response times, thereby increasing overall user satisfaction.

IV. CONCLUSION

The research findings regarding the use of the KAI Access application have successfully demonstrated the alignment between the expectations outlined in the Introduction and the findings in the Results and Discussion sections. This research shows that the KAI Access application has strong hedonic potential, but improvements are needed in the pragmatic aspects to meet user expectations more comprehensively. In the context of development, this research opens up prospects for further studies that can explore the impact of enhancing pragmatic aspects on user satisfaction, as well as the potential integration of new technologies to improve the overall user experience. This marks an important step in understanding the dynamics of information systems in the context of user experience and offers guidance for strategic implementation in application development.

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Implementation of the K-Means Clustering Algorithm in Determining Productive Oil Palm Blocks at Pt Arta Prigel

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Abstract – The purpose of this study is to implement the K-Means Clustering method to determine the patterns of productive oil palm production based on their blocks at Pt Arta Prigel. The research is motivated by issues within the oil palm blocks, such as the absence of productive block summaries, insufficient plantation land analysis, and erroneous decision-making. The development method utilizes CRISP-DM, with data spanning 2 years from October 2021 to October 2023. From the 1275 production records, after cleaning, 1015 records remain. Filtering the initial 51 blocks results in 37 blocks for the years 2021 and 2022, and 46 blocks for the year 2023. After clustering, the production outcomes for the year 2021 are as follows: cluster_0 has 34 blocks, cluster_1 has 10 blocks. For the year 2022, cluster_0 has 24 blocks, cluster_1 has 37 blocks. In the year 2023, cluster_0 has 44 blocks, cluster_1 has 27 blocks. The testing method employs the silhouette coefficient, and the silhouette score testing results indicate the formation of 2 clusters (K=2) with a value of 0.62, the results obtained from testing with 2 clusters indicate that the formed clusters are accurate. The findings of this study include patterns, graphs, and production tables generated using the K-Means Clustering method at Pt Arta Prigel.

Keywords – K-Means Clustering, Rapid Miner, palm, Silhouette Coefficient

I. INTRODUCTION

Technology, a single word that plays a pivotal role in the current development of human life. The proliferation of advancements and sophistication in technology at present brings about highly significant changes [1]. Big data is a collection of datasets in very large amounts [2] [3] Data mining, or data extraction, involves the analysis of data from various perspectives to transform it into valuable information that can be utilized to enhance profitability [4]. Data processed through data mining techniques will generate new scientific knowledge from old data, the results obtained from this data processing can be used to make decisions in the future [5]. The k-means algorithm is a method in unsupervised learning, it is utilized to cluster data into several groups [6]. K-Means is one of the widely used clustering algorithms for partitioning data into clusters [7]. Clustering is a machine learning method used to group data into appropriate clusters or clusters [8]. Referring to categorization such as notes, observations, or attention and forming classes of objects that have similarities. A cluster is a set of records that are similar and different from records in other clusters [6].

The application of the k-means algorithm is highly effective in addressing issues in clustering and managing big data to generate new information. Utilizing the k-means algorithm to cluster COVID-19 cases provides valuable insights for decision-making regarding the COVID-19 pandemic in Indonesia. [9]. The k-means algorithm can be employed as a tool for customer segmentation and marketing strategy development in retail stores [10], and the k-means algorithm can assist farmers in optimizing rubber production and improving resource utilization efficiency [5].

PT Arta Prigel is a palm oil plantation company that has been in commercial operation since 1983. The entire palm oil plantation operating area obtained the Right to Cultivate (HGU) in 2006 for a period of 35 years. PT Arta Prigel is located at the complete address of BBIP Palm Group, Padang Lengkuas Village, Lahat Sub-district, Lahat District, South Sumatra, Postal Code 31461.

Prior to this research, there had been previous research conducted by Pulungan et al in (2019) entitled "Implementation of K-Means Clustering Algorithm in Determining the Most Productive Palm Oil Plantation Blocks", the K-Means algorithm can assist companies in clustering productive and non-productive palm oil plantation blocks into 2 clusters: high cluster for the most productive blocks and low cluster for non-productive blocks. It was found that there are 14 highly productive palm oil plantation blocks and 26 non-productive ones.

Then next, the research conducted by Phitaloka in 2022, titled "Application of K-Means Clustering on the Effectiveness of Nutmeg Plantation", utilized the K-means algorithm for clustering the effectiveness of nutmeg plantation production in the Tanggamus region. This study employed 419 training data records with 4 features to create clusters using Weka 3.6.13. The k-means clustering method was employed to determine 2 clusters. This research demonstrates that this algorithm can assist in determining the effectiveness of nutmeg plantations.

Rapid Miner utilizes object-oriented methods within the Java hierarchy and can be employed across nearly all platforms .[11] The Silhouette Coefficient is an evaluation or validation method for clustering algorithms that measures the quality of formed clusters. It validates clusters by combining separation and cohesion methods and serves as a testing method for cluster quality used to determine the ownership level of each object within a cluster [12] [13] [14].

II. RESEARCH METHODOLOGY

This research employs data mining technique namely k-means clustering, and the CRISP-DM (Cross Industry

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Standard Process for Data Mining) development method, which is a standard data mining processing developed to ensure that existing data undergo structured and clearly defined stages efficiently. In addition to applying models in the data mining process, the selection of algorithms significantly influences the comparison of the performance of these data mining methods [15].

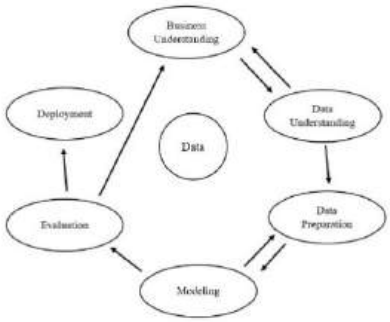

Fig 1 Metode Crisp-Dm

A. Business Understanding

In this stage, several tasks need to be carried out, namely understanding the needs and objectives from a business perspective, translating knowledge into the form of defining problems in data mining, and then determining plans and strategies to achieve the goals of data mining.

B. Data Understanding

In this stage, the first step to be elucidated is data collection, followed by data description, and evaluating data quality.

Table 1 Dataset used

No	Blocks	Ha	Results	Month	Year
1	1	21.09	5.772	10	2021
2	1	21.09	5.502	11	2021
3	1	21.09	9.120	12	2021
4	2	37.40	5.694	10	2021
5	2	37.40	7.921	11	2021
6	2	37.40	16.413	12	2021
7	13	39.97	8.899	10	2021
8	13	39.97	8.898	11	2021
9	13	39.97	11.131	12	2021
10	14	46.07	7.752	10	2021
……	….	…..	…..	……	……
1015	51	20.12	17.322	10	2023

C. Data Preparation

In this stage, constructing the dataset from raw data is undertaken. Several tasks need to be performed, including data cleaning, data selection, records, attributes, and data transformation, which will serve as inputs in the modeling stage.

D. Modeling

This stage will involve direct implementation of Machine Learning in determining techniques, tools, and data mining algorithms. The modeling approach adopted in this research is clustering method using the k-means algorithm.

1) Prepare the dataset
2) Determine the Number of Clusters
3) Cluster Center Points
4) Calculate Data Distances
5) Cluster Centers Update
6) Repeat steps 3 to 5

E. Evaluation

In this stage, the performance level of patterns generated by the algorithm is examined. The focus is on ensuring that the resulting model adheres to the standard k-means clustering and completes each stage without omission. The testing phase is conducted using the silhouette coefficient method.

F. Deployment

In this final stage, the creation of reports and journal articles is carried out using the model generated from the preceding stages. From the established patterns, it is possible to identify which blocks are productive, moderately productive, and unproductive.

III. RESULTS AND DISCUSSION

The results obtained from this research using the CRISP-DM development method can be seen as follows.

1. Business Understanding

In this stage, the process of determining objectives and search environments is carried out. The purpose of this search is to group production results based on blocks. The production data management process is still conducted manually or in a simple manner, where Excel is still used, hence there is a lack of detailed explanation regarding productive blocks.

2. Data Understanding

In the second stage, the data understanding process takes place. The data is obtained from the KrEstate division of Pt Arta Prigel, consisting of production results over 2 years from October 2021 to October 2023, totaling 1275 records and 5 attributes: Block, Hectares, Production, and Total. The data categories are received in Excel format, and upon obtaining the data, cleaning and selection processes of the data and its attributes are necessary.

3. Data Preparation

In the third stage, the data management process is conducted by directly implementing it on RapidMiner, as specified below.

3.1 Data Selection

The selection process for gathering information about the data must be carried out prior to commencing data mining. Attribute selection is performed, and some data within attributes are converted to facilitate the data mining process. The data selection process in this stage involves 5 attributes obtained from KrEstate Pt Arta Prigel, including Division, Block, Land Area, Production, and Total. The selection process is conducted in Excel using filters. After the data filtering process, the researcher utilizes Block, Hectares, Yield, Month, and Year. Initially, there were 51 blocks, which were then reduced to 37 blocks through

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selection. The production records, initially 1275, are cleaned, resulting in 1015 data points that constitute the dataset.

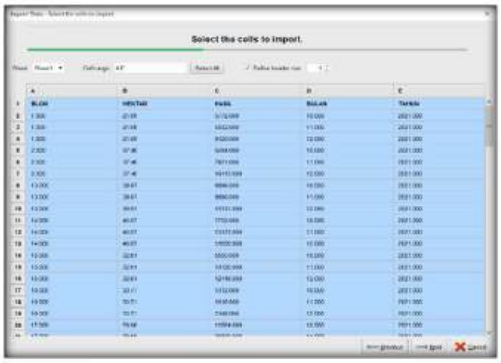

Fig 2 data selection process 2021

3.2 Data Processing

The processing process encompasses data cleaning and transformation. In this stage, the researcher has ensured that there are no more empty data. Figure 2 illustrates that if the attributes used have no empty data, with a count of 0 in the dataset for each month, they can be used for the next stage.

Fig 3 data processing process

3.3 Data Transformation

In the final stage, the process involves transforming the selected data so that it is suitable for the data mining process. The data transformation process conducted indicates the selected attributes processed in RapidMiner. From 1275 initial data points, they are transformed into 1015 data points, comprising 111 data points for the year 2021, 444 data points for the year 2022, and 460 data points for the year 2023. From 51 blocks, they are transformed into 37 blocks for the year 2021, 37 blocks for the year 2022, and 46 blocks for the year 2023. The production output data is transformed based on the predetermined criteria as follows.

Table 2 value criteria

Kriteria	Nilai
Tidak Produktif	C0
Produktif	C1

4. Modeling

The fourth process is where the model is utilized with the algorithm used in the clustering method, namely the k-means clustering model operator, which takes objects from the input port and sends copies to the output.

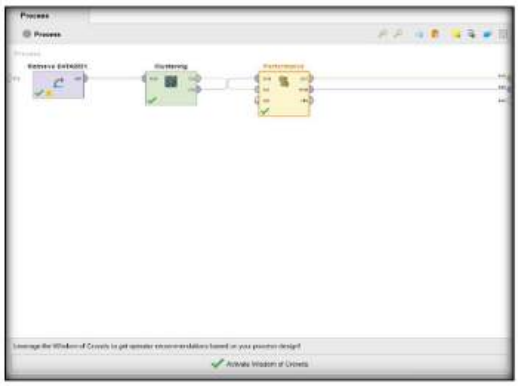

Fig 4 k-means algorithm model process

Next, in the modeling stage, the process of the k-means algorithm's steps is conducted, starting with the first step.

a) Determine the Number of Clusters
After the data has been collected, the determination of the number of clusters begins. Initially, experiments are conducted to ascertain the number of clusters that appear at the smallest cluster centroid.

Attribute	Cluster_0	Cluster_1
Hektar	31.513	36.413
Hasil	7296.750	27699.316
Bulan	10.957	11.211
Tahun	2021	2021

Figure 5 cluster experiment 2021

Attribute	Cluster_0	Cluster_1
Hektar	37.211	31.167
Hasil	31883.540	10832.036
Bulan	8.253	6.073
Tahun	2022	2022

Figure 6 cluster experiment 2022

Attribute	Cluster_0	Cluster_1
Hektar	30.266	32.070
Hasil	14701.136	35936.248
Bulan	5.150	6.479
Tahun	2023	2023

Fig 7 cluster experiment 2023

b) Random Centroid Points
The centroid points are randomly determined based on several clustering experiments in RapidMiner. Among these three trials, the smallest centroid point is chosen to obtain the best result.

c) Data Distance to Centroid

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After importing the dataset and the k-means algorithm into Rapid Miner, the data process is initiated by clicking "run" to display the data distance to the data center. Among these three trials, the smallest centroid point is chosen to obtain the best result. The data distance values for cluster_0 range from 0 to 10.00 for unproductive clusters, cluster_1 ranges from 10.00 to 32.00 for productive clusters.

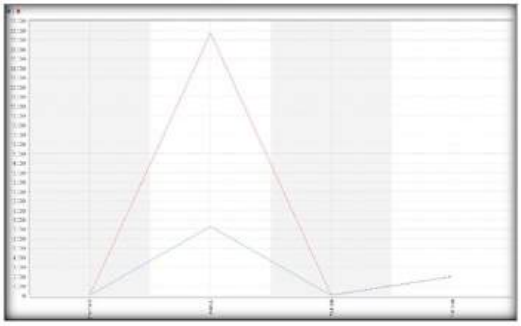

Fig 8 data distance to centroid 2021

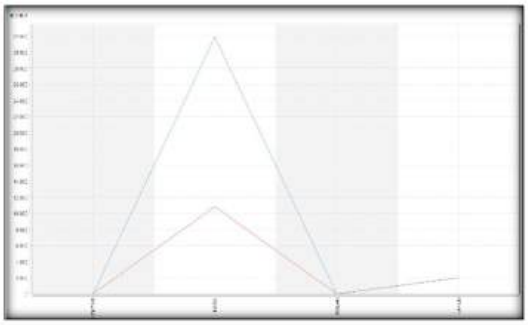

Fig 9 data distance to centroid 2022

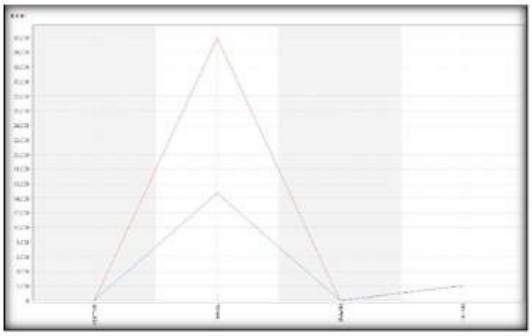

Fig 10 data distance to centroid 2023

d) Update Centroid Values
After several trials, the centroids of the 3 clusters remain unchanged. If the centroids shift, the iteration is repeated, but if there is no change, the repetition is stopped, and the results for each group are obtained. Based on the RapidMiner calculations, patterns are obtained, which will later be implemented in Python. The pattern used to group cluster data based on distance calculations is as follows
a. If C0 < C1 and C0 < C2, then cluster_0 is labeled as unproductive.
b. If C1 < C0 and C1 < C2, then cluster_1 is labeled as productive.
From the production data obtained through RapidMiner, using the k-means clustering method, the pattern of production results per block is derived as follows: cluster_0 indicates an unproductive level, cluster_1 indicates a productive level.

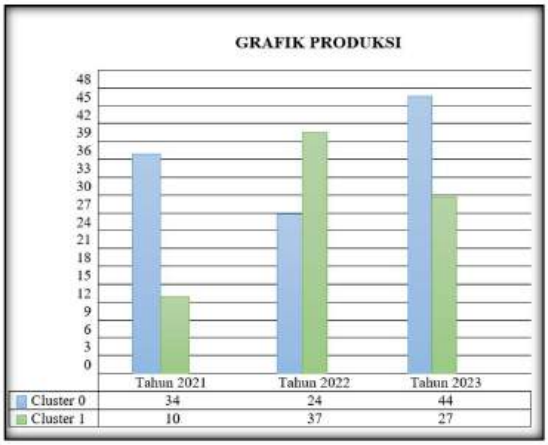

Fig 11 annual graphic results

5. Evaluation
Testing was conducted using the Silhouette Coefficient on the formed clusters with all 1015 records. The results obtained from the silhouette score after several attempts revealed that the suitable number of clusters is 2 (K=2), with a quality value of 0.62.

Fig 12 Test Results With Silhouette Coefficient

6. Deployment
In the deployment phase, which is the final stage, the obtained knowledge or information regarding the production patterns of Pt Arta Prigel over 2 years is presented, revealing the presence of 2 clusters. The resulting pattern for the year 2021 shows cluster_0 with 34 blocks, followed by cluster_1 with 10 blocks. In the year 2022, cluster_0 comprises 24 blocks, cluster_1 has 37 blocks. Lastly, in the year 2023, cluster_0 encompasses 44 blocks, cluster_1 contains 27 blocks. From the clustering process, it is observed that the level of productive production shows an increase in the years 2023, while for the production results at Pt Arta Prigel, the unproductive production level is more dominant.

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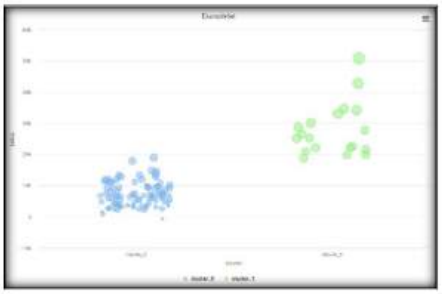

Fig 13 partitional clustering pattern results in 2021

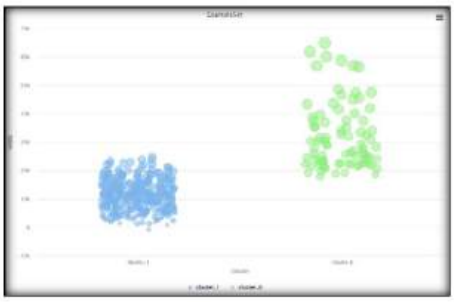

Fig 14 partitional clustering pattern results in 2022

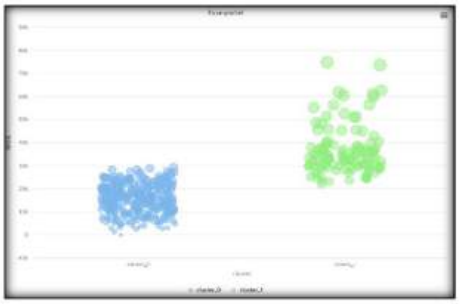

Fig 15 partitional clustering pattern results in 2023

IV. CONCLUSION

Based on the research conducted, the following results were obtained: This study yielded 2 Clustering Patterns of production results at Pt Arta Prigel, namely cluster_0 labeled as Unproductive, cluster_1 labeled as Productive. From the clustering results of Pt Arta Prigel's palm oil production, the production patterns for 2 years with a total of 51 blocks can be observed. It is known that the production for the year 2021 includes 34 blocks for cluster_0, 10 blocks for cluster_1. Furthermore, the production for the year 2022 includes 24 blocks for cluster_0, 37 blocks for cluster_1. For the year 2023, the production includes 44 blocks for cluster_0, 27 blocks for cluster_1. Then, the results of testing using the Silhouette Coefficient on the Google Colab application with the Python programming language to calculate the silhouette score obtained the suitable number of clusters as K=2 with a silhouette score value of 0.62, the results obtained from testing with 2 clusters indicate that the formed clusters are accurate. The value obtained in the silhouette score testing indicates that the quality of the clusters is appropriate. From these results, several insights are expected to be beneficial for Pt Arta Prigel, particularly for the Manager and Assistant Manager of the plantation, to support decision-making and further actions.

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Evaluating the Performance of ETSI-ITS Multi-Stack Protocols for V2V Communication in VANETs: A Simulation Study

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Abstract – The research evaluates various multi-stack protocols for Vehicular Ad-hoc Networks (VANETs), focusing on Vehicle-to-Vehicle (V2V) communication scenarios with Emergency Vehicle (EV) simulations. The study uses the ns-3 network and SUMO (Simulation of Urban MObility) traffic simulators to test these protocols in diverse scenarios, including fluctuating data rates and dense network conditions. By implementing the IEEE 802.11p protocol alongside vehicular message dissemination stacks compliant with ETSI (European Telecommunications Standards Institute) ITS (Intelligent Transport Systems) standards, the study performs simulation experiments with varying vehicle counts, ranging from 20 to 35. It employs two distinct data rate configurations while maintaining a constant transmission power of 23 dBm. The results indicate a decline in the average Packet Reception Ratio (PRR) as vehicle density increases, indicating heightened contention and interference. At the same time, there is an observed increase in average latency, contributing to increased message transmission and reception delays. The quantitative analysis demonstrates an inverse relationship between the average PRR and the total vehicle count when the SEND_CAM message is enabled. On the other hand, disabling SEND_CAM maintains a relatively consistent average PRR across scenarios. Additionally, a positive correlation between vehicle count and average latency underlines the impact of network congestion and interference on communication efficacy within VANETs. Despite suboptimal PRR values falling between 41% and 47%, latency performance remains satisfactory, with average latency durations ranging from 0.154 s to 0.187 s. Notably, the SEND_CAM parameter status shows negligible impact on protocol performance, suggesting that network density plays a more pivotal role. Finally, this study offers valuable insights into the trade-offs and challenges of multi-stack protocols in V2V communication within VANETs. Further optimization efforts are recommended to improve packet reception ratios, especially in high-vehicle-density environments, while maintaining acceptable latency levels. These findings contribute to the ongoing efforts to enhance the reliability and efficiency of communication protocols in VANETs, thus advancing the development of intelligent transportation systems. The study's quantitative protocol performance analysis under varying network conditions provides valuable guidance for optimizing V2V communication deployments in VANETs.

Keywords – *V2V communication, VANETs, Multi-stack protocols, ETSI-ITS, NS-3 simulator*

I. INTRODUCTION

The increasing demand for Intelligent Transportation Systems (ITS) applications has led to the development of Vehicular Ad-hoc Networks (VANETs), which enable Vehicle-to-Vehicle (V2V) communication between vehicles[1][2]. VANETs provide a flexible and dynamic communication infrastructure for ITS applications. Still, they also present complex and challenging communication requirements, such as high-speed communication, real-time support, and security and privacy[3], [4]. Various communication protocols have been proposed for VANETs, including single-stack and multi-stack protocols[5]. Multi-stack protocols offer advanced features and can handle a broader range of communication requirements, but they can also be more complex and challenging to manage. As such, the simulation of multi-stack protocols for V2V communication in VANETs is a crucial step in evaluating their performance and identifying areas for improvement and future research[6].

A multi stack protocol survey[7] found that Communication among vehicular nodes, which enable drivers to make appropriate decision needs high reliability; therefore the design of a routing protocol that ensures a certain level of QoS represents one of the most critical challenges of the vehicular networks. Related to the QoS performances, a new approach is proposed to improve the V2V communication in VANET[8]. Albattah [9] Analyzed the current vehicular communication research flow and their deployments and found that the emerging technologies in the upcoming markets will enable the development of high-featured VC technologies for a wide range of applications in the future. While Khan[10], Identifying multi-layer issues and possible solution in Wireless Access in Vehicular Environment (WAVE), a suite of communication and security standards in the Vehicular Area Networks (VANETs). Another study reports the evaluation performance of various VANET communication standards related to the connected vehicles problem [11]. In addition, to connect the vehicles through V2V communication in order to anticipate dynamic traffic,

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a Non-IP multi-stack protocol like WAVE and ETSI ITS G5 is essential to provide safety [12].

However, it is still the need for more knowledge and understanding of the performance of multi-stack protocols for Vehicle-to-Vehicle (V2V) communication in Vehicular Ad-hoc Networks (VANETs) in various scenarios such as various data rate communication, and dense networks. Despite the increasing demand for Intelligent Transportation Systems (ITS) applications and the development of VANETs to enable V2V communication, there need to be more comprehensive studies evaluating the performance of multi-stack protocols in these scenarios[13]. The study evaluates the performance of multi-stack protocols for Vehicle-to-Vehicle (V2V) communication in VANETs, specifically in the context of Emergency Vehicle (EV) simulations under various scenarios and provide valuable insights into the trade-offs and limitations of multi-stack protocols and inform the development of future VANET communication solutions.

The contribution of this study is significant to the field of VANET communication. The research provides an in-depth evaluation of the performance of multi-stack protocols for Vehicle-to-Vehicle (V2V) communication in Vehicular Ad-hoc Networks (VANETs) through Emergency Vehicle (EV) simulation. The study analyzes the performance of the protocols under various challenging scenarios, including various data rate communication and dense networks. It presents valuable insights into the trade-offs and limitations of multi-stack protocols. The simulation framework used in this study, which combines the ns-3 simulator and the SUMO (Simulation of Urban MObility) simulator, provides an open-source solution for V2V communication in VANETs. This study's findings will benefit researchers and practitioners interested in optimizing V2V communication in VANETs and inform future research and development in this field.

II. RESEARCH METHODOLOGY

A. The Simulation Environment

Simulation of Urban MObility (SUMO) GUI [14] *v.12*: SUMO allows users to model traffic systems that include road vehicles and public transport; even pedestrians can be modeled into the traffic systems, providing the GUI to visualize the mobility and improve the interaction with the user using the TraCI to make the simulation easier than standard SUMO simulation. TraCI interface has been used to couple the SUMO functionalities with NS-3

Network Simulator 3 (NS3) [15] *v3.35*: NS3 is a discrete-event simulator that allows users to model all the aspects of communication among the various entities, including the involved network stacks. It is an open-source application that can be combined with the other simulation, such as SUMO, to provide interactive and user-friendly network simulation.

NetAnim *v.1.18* [16] : NetAnim is an offline animator based on the Qt toolkit. We are animating the simulation using XML trace files collected during the simulation. In this study, NetAnim is used to visualize the connectivity between vehicle nodes based on the XML trace file generated from the NS3 simulation. If SUMO represents the movement mobility of the vehicle nodes, then NetAnim simulates the connectivity of the vehicle mobility, which is simulated on SUMO. Linux Ubuntu 20.02 was utilized as the operating system for the simulation environment.

B. V2V Communication Standard Model

The V2V communication model is based on the ITS standard defined by ETSI (European Telecommunications Standards Institute). The message exchange model for V2V communication on the ETSI-ITS[17] standard uses the Cooperative Awareness Message (CAM) and Decentralized Environmental Notification Message (DENM) schemes. CAM is a broadcast message periodically broadcast by vehicles containing information about the actual position, speed, and direction of movement of the vehicle at a frequency of 10 Hz. Meanwhile, DENM is an event-based message sent if there is an event, such as a collision warning, road hazard, *E.tc* [18].

The communication standard is based on IEEE 802.11p -WAVE, WAVE (Wireless Access Vehicular Environments), an NS3 module that is a refinement of the IEEE 802.11 model. The WAVE module with the IEEE 802.11p standard is designed to support ITS[19]. WAVE operates in the 5.9 GHz band using an OFDM (Orthogonal Frequency Division Multiplexing) multiplexing system and can achieve data transmission speeds of between 6 – 27 Mbps[20]. WAVE consists of seven channels at a frequency of 10 MHz, one control channel, and six service channels at 5.9 GHz bandwidth. The service channel is used for public safety and private services, while the control channel is used as a reference channel to build a communication link between RSU (Road - Side Unit) and OBU (On - Board Unit). Figure 1 Describe the V2V Communication based on 802.11p-WAVE.

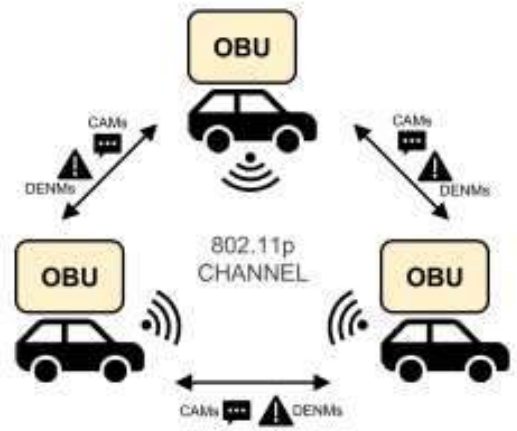

Fig 1. V2V Communication 802.11p WAVE-based Model[6]

Figure 1 shows that the OBU use the control channel for broadcast application services, warning messages, and safety status messages[21]. So, the main application of IEEE 802.11p is communication systems between vehicles, with the communication system used as DSRC (Dedicated Short Range Communication). In this study, we tested the performance of this WAVE on the ETSI-ITS standard.

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C. The ETSI Facilities Layer

Through ETSI TS 102 894-2 regarding the ITS facilities layer, ETSI has determined the standard facilities layer, which aims to support the distribution and processing of messages from an application within the ITS structure[22]. These Facilities, called CA and DEN Basic Services, manage the transmission and reception of CAM and DENM messages and are implemented in our framework following the ETSI standards on ITS messages[6].

ASN.1, which encodes CAM and DENM messages, allows the representation of complex data structures that any platform can read[23]. This notation is completely programming language-agnostic, allowing different platforms with different architectures to exchange information. We used ASN.1 inside the ETSI-ITS module to encode and decode the message to extract the relevant information and provide the V2V communication for ITS applications[24]. CAM and DENM modules are in charge of receiving a piece of relevant information for the ITS application. The process of encoding and decoding messages via CAM and DENM is one of the core functions implemented in this simulation[25]. This study does not use all of ETSI's core functions, such as security, Geo-Networking, and others. Figure 2 depicts the logical implementation of CA and DEN basic service to support ITS Station (ITS-S) define by ETSI facilities layer.

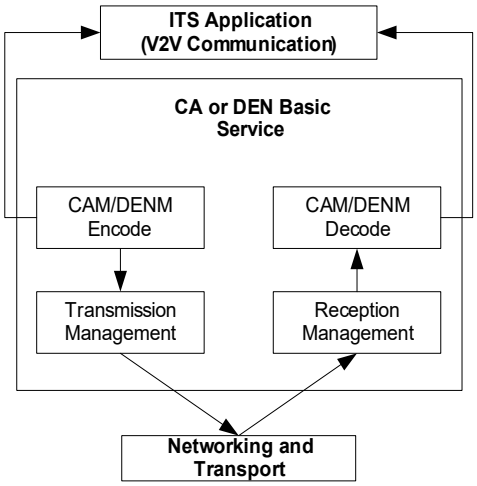

Fig 2. CA and DEN basic service to support ITS-S in ETSI facilities layer

In Figure 2, The CA Basic Service is responsible for encoding CAM (Cooperative Awareness Message) messages for ITS-S (Intelligent Transportation Systems-Services) applications and handling the dissemination process through the CAM Transmission Management. The service delivers the CAM message to the lower layers of the communication stack when it is ready to be sent. On the receiving side, the CA Basic Service manages the reception of the CAM message from the underlying layers. It decodes the message, encoded using ASN.1. Then the information included in CAM will be forwarded to the ITS-S application. The DEN Basic Service offers similar capabilities to the ITS-S applications for transmitting and receiving DENM messages.

D. The Simulation Scenario

The simulation demonstrates the V2V communication models through a scenario involving an Emergency Vehicle (EV) and passenger car, using IEEE 802.11p as the vehicle connectivity to transmit CAM and DENM messages. The simulation has two scenarios: first, communication between passenger vehicles such as buses and cars, and second, communication between passenger cars when an EV is present on the road. Following the standard, all vehicles exchange CAM messages to inform nearby vehicles about their status. The presence of EVs, however, requires a system in which they can move without being impeded by other vehicles. A vehicle performing emergency duties, such as an ambulance, police motorcycle, or fire truck, is referred to as an EV in this scenario. The simulation showcases the communication between three periodically transmitting EVs and nearby vehicles through DENM messages.

Upon receiving a meaningful message (DENM from an approaching EV), a typical vehicle will try to reduce its interference with the EV. If the passenger vehicle is in the same lane as the EV, it will speed up and change lanes as soon as possible. If on a different lane, it will slow down, allowing the EV to pass without being forced to reduce its speed. In this study, a modification was made to a previous research's network map to make it suitable for the SUMO simulation. The network map includes two intersections, highways, and typical urban roads, and its details can be viewed in Figure 3.

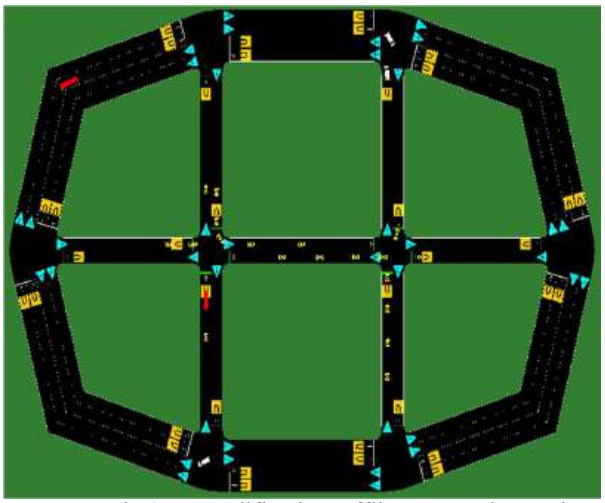

Fig 3. A Modification Offline Network Map in SUMO

In Figure 3, we simulated an urban environment, with passenger vehicles having a maximum speed ranging from 30 km/h to 60 km/h, while EVs can travel at a speed of up to 75 km/h. The simulation includes a circular road with two lanes for each direction of travel. In the simulation scenario, the red vehicle is an Emergency Vehicle (EV) broadcasting Distributed Emergency Network Management (DENM) messages, while the orange vehicles

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are nodes that have successfully received and processed the DENM message from the EV, causing them to slow down to allow for a safe overtake. The green vehicle is located on the same lane as the EV and thus attempts to speed up and change lanes as soon as possible to make way for the EV. The yellow vehicles are cars that do not need to respond to the approaching EV, as they may be traveling in the opposite direction, not directly affected by the EV's trajectory, or still too far away, and its details can be viewed in Figure 4.

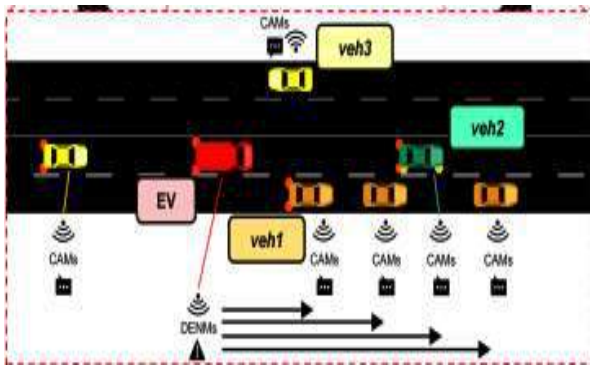

Fig 4. Implementation of V2V communication on SUMO

In Figure 4, every vehicle entering the scenario will send CAMs with a frequency between *1 Hz* and *10 Hz* (according to the ETSI standards). The vehicles are divided into "passenger" vehicles and emergency vehicles. When an emergency vehicle generates a CAM message, it sets the "*StationType*" Data Element to "special vehicles." Upon receiving a CAM message from an emergency vehicle, passenger vehicles evaluate their heading and distance from the emergency vehicle. If the heading is similar and the distance is close, the emergency vehicle is approaching. In response, the passenger vehicles either slow down on a different lane or try to change lanes as quickly as possible by accelerating for a short period if they are in the same lane as the emergency vehicle.

In Table 1, The simulation setting was based on the ETSI standard and involved a car-only network with a left-hand traffic representative of Indonesia. The simulation was run 100 times with a default road type and the total number of vehicles varying from 20 to 40. The node speed was set according to the 75 km/hour in highway area and 25 km/h in urban area and there were two traffic light junctions in the simulation. The vehicles' mobility was determined at the beginning of the simulation, with their travel routes set, and the data rate was also set in 4.5.

Table 1. Simulation Setting

Simulation Setting	Value
Traffic map name	ETSI Standard example with modification
Type of vehicles	Car-Only Network
Type of traffic	Left-hand Traffic, Indonesia
simulation time	100 second
Road type	Default
Total Vehicles Number	20, 25, 30, 35
Node speed	75 km/hour in highway area, 25 km/h in urban area
Traffic Light Junctions	2 area
Vehicles mobility	The vehicle travel route is determined at the beginning of the simulation
Data Rate	4.5 Mbit/s
Simulation speed	0.01 simulation step
Transmission power (Tx power)	23dBm

In Table 1, the evaluation is based on comparing the scenario in which the alert is enabled and the case in which it is not. We considered different vehicle densities and data rates to properly evaluate the proposed application, ranging from 5 vehicles/km up to more than 18 vehicles/km. For each density, we ran five simulations, each lasting 100 seconds, always using different mobility traces, including three EVs, one per travel direction. The result and evaluation criteria define in Table 2.

Table 2. The result and evaluation criteria[22]

Result Parameter	Result Indicator
Average PRR (Packet Reception Ratio); Packet Loss	0-2,9% (Ideal), 3 – 14.9 (Good), 15-24.9 (average), >=25% (bad)
Average Latency (ms)	<150 ms (Ideal), 150 ms-299 ms (good), 300 ms-449 ms (average), >450 ms (bad).

Table 2 summarizes the results and evaluation criteria for two performance parameters: the average packet reception ratio (PRR) and the average latency. The PRR is a measure of the percentage of successfully received packets, and it is categorized as ideal, good, average, or bad based on a range of values from 0 to 2.9%, 3 to 14.9%, 15 to 24.9%, and greater than 25%, respectively. The average latency, on the other hand, is a measure of the delay in message transmission and reception, and it is evaluated as ideal, good, average, or bad based on the time intervals of less than 150 ms, 150 to 299 ms, 300 to 449 ms, and more than 450 ms, respectively. These two parameters comprehensively evaluate the performance of the multi-stack protocols for V2V communication in VANETs.

III. RESULTS AND DISCUSSION

The experiments was conducted by varying the total number of vehicles from 20 to 35 and using two different data rate configurations while keeping the transmission power constant at 23 dBm. The Packet Reception Ratio (PRR) and latency were evaluated for each configuration. The results show in Table 3.

Table 3. Simulation Result of The V2V Communication

Vehicles (unit)	Data Rate (Mbit/s)	SEND_CAM status	Average PRR (Loss)(%)	Average PRR Criteria	Average Latency (s)	Average Latency criteria
20	12	TRUE	47%	Bad	1.86E-01	Good
25	12	TRUE	45%	Bad	1.86E-01	Good
30	12	TRUE	44%	Bad	1.87E-01	Good

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35	12	TRUE	41%	Bad	1.86E-01	Good
20	12	FALSE	47%	Bad	1.54E-01	Good
25	12	FALSE	47%	Bad	1.54E-01	Good
30	12	FALSE	45%	Bad	1.54E-01	Good
35	12	FALSE	44%	Bad	1.54E-01	Good

Table 3 analyses the relationship between changes in the number of vehicles and the average SEND_CAM and average latency in V2V communication using the multi-stack protocol compliant with ETSI-ITS standards. Under the scenario where the SEND_CAM message was enabled, the average PRR (Packet Reception Ratio) or packet loss decreased as the total number of vehicles increased, indicating that the performance of the multi-stack protocol improved in denser networks. Further explanation is in Figure 5(a) Figure 6, and Figure 7. In Figure 5 and (b), the average latency increased slightly with the increasing number of vehicles, indicating that the delay in transmitting messages increased in denser networks.

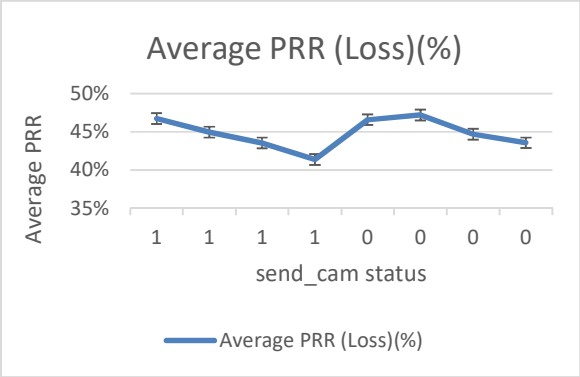

Fig 5. Average PRR Result

When the SEND_CAM message was disabled, the average PRR remained relatively constant across different scenarios, with a slightly higher average PRR for 25 vehicles.

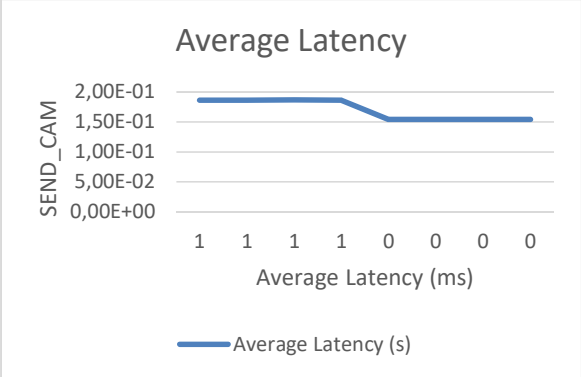

Fig 6. the average latency decreased slightly as the number of vehicles increased

However, in Figure 6, the average latency decreased slightly as the number of vehicles increased, indicating that the delay in transmitting messages improved in denser networks. A detailed correlation analysis between the total number of vehicles and the average PRR provided in Figure 7.

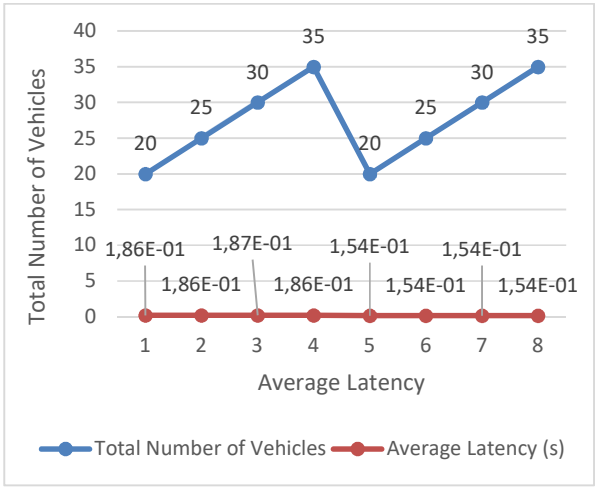

Fig 7. positive correlation between the number of vehicles and the average latency

Figure 7 illustrates a positive correlation between the number of vehicles and the average latency. For example, for a data rate of 12 Mbit/s and a transmission power level of 23dBm, the average latency increases from 154.17ms to 187.02ms when the number of vehicles increases from 20 to 30. Similarly, with the same data rate and transmission power level, the average latency increases from 154.17ms to 186.4ms when vehicles increase from 20 to 35. The findings suggest that the rise in the number of vehicles in the network can cause increased interferences and contention for the communication medium, leading to higher delays in message transmission and reception.

Table 3 summarizes the simulation results of a study on the performance of multi-stack protocols for V2V communication in VANETs. The simulations were conducted with different numbers of vehicles, data rates, and transmission powers, and the evaluation criteria were the average packet reception ratio (PRR) and the average latency. The protocols must be improved to achieve higher packet reception rates. For all simulations, the average PRR values were below the ideal range, indicating that the protocols struggled to maintain reliable communication under the given conditions. Specifically, the PRR values were all categorized as bad, ranging from 41% to 47%. The protocols are capable of providing satisfactory latency performance under the given conditions. On the other hand, the average latency values were all within the good range, indicating that the protocols could provide relatively low transmission delays. The average latency values ranged from 0.154 s to 0.187 s, corresponding to a good range of less than 150 ms.

Interestingly, the simulation results indicate that the status of the SEND_CAM parameter did not significantly affect the performance of the protocols, as the PRR and latency values were similar for both true and false states. However, the number of vehicles in the network affected the latency, as the average values increased as the number

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of vehicles increased. Overall, the simulation results suggest that the performance of multi-stack protocols for V2V communication in VANETs can be improved in terms of packet reception ratio while maintaining satisfactory latency performance.

IV. CONCLUSION

Our study delved into the performance of multi-stack protocols for V2V communication in VANETs. We discovered that when the SEND_CAM message was enabled, the Packet Reception Ratio (PRR) decreased as the total number of vehicles increased. This finding suggests that the protocol's performance is enhanced in denser networks. Conversely, when the SEND_CAM message was disabled, the PRR remained relatively stable across different scenarios, indicating that the protocol was less responsive to changes in network density. These insights have significant implications for the design and implementation of multi-stack protocols in real-world V2V communication scenarios.

The study also found a direct correlation between the number of vehicles and the average latency. This implies that higher vehicle densities lead to increased delays in message transmission and reception, underlining the impact of network congestion and interference on communication performance in VANETs.

Furthermore, the analysis of simulation results indicates that the protocols showed suboptimal PRR values below the ideal range. However, they demonstrated satisfactory latency performance within acceptable thresholds. Suggests an opportunity for improvement in achieving higher packet reception rates while maintaining low transmission delays.

Interestingly, the status of the SEND_CAM parameter did not notably influence protocol performance. The situation implies that other factors, such as network density, play a more significant role in determining communication effectiveness.

In summary, our study reveals that multi-stack protocols in V2V communication within VANETs face challenges and trade-offs. Notably, the SEND_CAM parameter did not significantly impact protocol performance, suggesting that other factors, such as network density, are more influential. We also found that the protocols demonstrated suboptimal PRR values but satisfactory latency performance, indicating room for improvement in achieving higher packet reception rates while maintaining low transmission delays. These insights contribute to the ongoing efforts to enhance the reliability and efficiency of communication protocols in VANETs, thereby advancing the development of intelligent transportation systems.

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Automating the Extraction of Words and Topics in Indonesian Using the Term Frequency-Inverse Document Frequency Algorithm and Latent Dirichlet Allocation

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Abstract – Keyword extraction and topic modeling in the analysis of Gojek user reviews in Indonesian are very important. By understanding user preferences and needs through keyword extraction, as well as grouping user reviews into different topics through topic modeling, stakeholders can use the information to further improve services. This research uses TF-IDF and LDA approaches to analyze text data from Gojek user reviews and feedback. The data spans from Nov 5, 2021, to Jan 2, 2024, totaling 225,002 rows. Each row includes username, content, time, and app version. The focus is on content reviews. The average length is 8 words, with a maximum of 104 and a minimum of a few words. The variability indicates a non-normal distribution. Preprocessing is conducted to maintain topic analysis accuracy. The TF-IDF method is used to extract relevant keywords, while the LDA approach is used to model the topics in user reviews. The topic analysis reveals patterns in Gojek user reviews. The first topic discusses experience, services, and affordable pricing. The second emphasizes app usability and benefits. The third relates to promos, discounts, and vouchers. The fourth reflects positive evaluations of service quality. However, the fifth topic highlights high costs and app issues. The sixth underscores overall user satisfaction and service convenience. Testing on the topic model yielded a coherence level of 0.509, indicating that the model's topics demonstrate a good level of consistency in finding relevant topics from Gojek user review data. The use of a combination of TF-IDF and LDA in Indonesian text analysis, particularly in the context of Gojek user reviews, is an important step in enhancing understanding and utilization of text data to improve overall user experience.

Keywords – word extraction; topic modeling; preferences; TF-IDF and LDA.

I. INTRODUCTION

The growth of digital data in Indonesia is very rapid, in 2022 experiencing a very high year-over-year (YOY) growth rate of 64.4% [1]. Driven by a variety of factors, including the popularity of digital platforms such as social media, online shopping trends (e-commerce), as well as online transportation service platforms [2]. One example is Gojek, recording the highest user growth in Indonesia, with an average application download reaching 957,000 every month [3]. Currently, Gojek is one of the largest online transportation service platforms in Indonesia, analyzing the usage patterns, preferences, and habits of Gojek users is crucial because it can provide valuable understanding for companies to improve user experience, improve services offered, and find new opportunities. A deep understanding of user behavior can be used to better respond to market needs, and enable the creation of more innovative solutions.

Keyword extraction and topic modeling have an important role, keyword extraction from Gojek user feedback reviews can help understand user preferences and needs better, and topic modeling allows to grouping of user reviews into various topics can provide knowledge about aspects that users want, such as service quality, convenience so that it can be used by stakeholders for service improvement. Various methods are used to extract words from a set of documents, including frequency-focused approaches. This research shows the success of TF-IDF in extracting stopwords in Indonesian [4]. Comparing InSet Lexicon and TF-IDF methods on Indonesian text emotion recognition datasets, the evaluation results of the two methods show that InSet Lexicon has an accuracy of 30% while TF-IDF reaches 62% [5]. Extracting sentence structure in Indonesian with a deep learning approach, resulted in an F1 score of 0.7 in testing [6]. Extracting mono lexical terms in Indonesian with a corpus method using AntConc for semi-automatic extraction, the results have the potential to create a broader bilingual terminology dictionary [7]. Collaboration between TF-IDF and linguistic knowledge is effective in extracting Uzbek stopwords with good accuracy [8]. In the application of RNN and transformers to extract attributions and statements of public figures in Indonesian, the test results on the RNN model were 81.34%, while the transformer was 81.01% [9]. Performing extraction in Indonesian to classify hate speech text data, testing the TF-IDF-ICSpF method, and improving KNN showed an average accuracy of 88.11%, 17.81% higher than KNN and TF-IDF [10]. The results show that TF-IDF is effective in extracting Indonesian words.

In solving the research problem, the TF-IDF and LDA steps will be used sequentially to overcome the challenges in Indonesian text analysis. Firstly the TF-IDF method will be used to extract the most relevant keywords from each user review, this will help identify words that have a high weight. Next, the LDA approach is used to perform topic modeling of the user feedback reviews, clustering certain topics to identify naturally occurring patterns and trends in the text data.

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II. RESEARCH METHODOLOGY

To extract, explore, and analyze Gojek user feedback reviews in Indonesian this research will involve a series of systematic stages, the stages are shown in Figure. 1 including data collection, and data preprocessing to prepare the data. Analyzing the distribution to understand emerging trends, word frequency analysis with TF-IDF, topic modeling using the LDA algorithm for clustering words into topics, and finally evaluating the performance of the model that has been developed to ensure the accuracy of the model in the context of extraction and topic modeling on Indonesian text case studies of Gojek application user reviews.

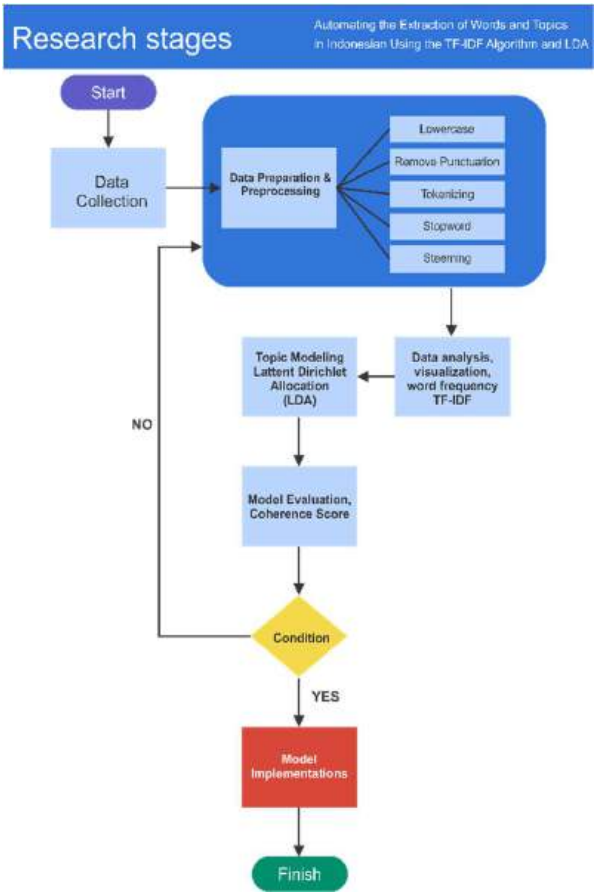

Fig. 1 Research stages

Figure. 1 shows the detailed steps in the research stages. The following is a further explanation for each stage:

1. Data Collection

This stage involves the process of collecting data from various relevant sources, the datasets used in this study are sourced from reviews of the Gojek application versions 4.0.0 to 4.9.3 from 2021 to 2024 [18]. The data spans from Nov 5, 2021, to Jan 2, 2024, totaling 225,002 rows. Each row includes username, content, time, and app version. The focus is on content reviews. The average length is 8 words, with a maximum of 104 and a minimum of a few words. The variability indicates a non-normal distribution. Preprocessing is conducted to maintain topic analysis accuracy.

2. Data preparation and preprocessing

After the data is collected, the next step is to clean and prepare the data for analysis, this stage involves five stages, namely lowercasing, removing punctuation, tokenizing, stopword removal, and stemming.

3. Descriptive Analysis and Data Visualization

This stage includes descriptive statistical analysis to understand the basic characteristics of the data, such as mean, median, and data distribution. In addition, data visualizations such as histograms, bar charts, or scatter plots are also used to visualize the distribution of the data.

4. TF-IDF word frequency

The application of the TF-IDF method in the context of Indonesian word extraction in the case of Gojek application user reviews, is an important step to decipher text complexity and extract information and knowledge. TF-IDF consists of TF measures how often a word appears in a document. The following TF formula (1) is [19]:

$$tf(t,d) = \frac{f_{t,d}}{\sum t^l \in d f_{f^l,d}} \quad (1)$$

Meanwhile, IDF aims to measure how unique or important a word is in the document corpus. The following IDF formula (2) is:

$$idf(t,D) = log\frac{N}{|\{d \in D: t \in d\}|} \quad (2)$$

5. LDA Modeling

In the topic modeling stage for the extraction of Indonesian from Gojek application user reviews, forming groups of interrelated words into meaningful topics using LDA. The LDA formula as described in (3) provides the mathematical foundation underlying the topic formation process.

$$P(z_i = j|z_{-i}, w_i, d_i) \propto \frac{C^{WT}_{w_{ij}} + \eta}{\sum_{w=1}^{W} C^{WT}_{wj} + W\eta} \frac{C^{DT}_{d_{ij}} + \alpha}{\sum_{t=1}^{T} C^{WT}_{d_{it}} + T\alpha} \quad (3)$$

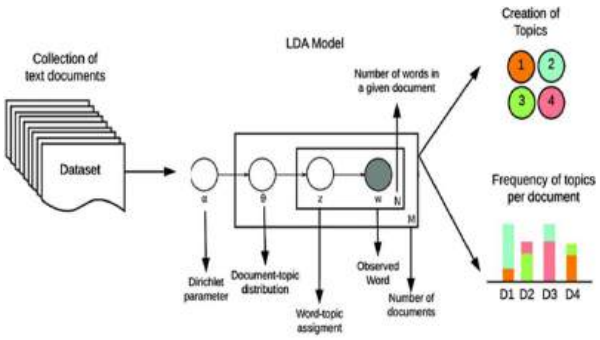

Fig. 2 Lattent Dirichlet Allocation Model [20]

The LDA stage, as described in Figure. 2, includes several important steps in the process. First, there is text to be analyzed, then processed by the LDA model. The Dirichlet parameter is used to define the topic distribution in the document known as document topic distribution, and is also the focus in this stage, it shows the proportion of each topic in the document. Each word in the document is assigned to a specific topic through the word topic assignment process. The words observed in the document are known as observed words. The number of words in a particular document, and the total number of documents in

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the dataset are also important considerations. Form topics from the distribution of topics in the documents and calculate the frequency of occurrence of each topic in the document set, known as the frequency of topics.

6. Topic model evaluation

Topic model evaluation using cohesion score involves measuring how cohesive or related the topics generated by the model are [21]. Once the topic model has generated topics, a cohesion score is calculated for each topic. This involves measuring how often words within each topic appear together in Gojek customer reviews.

III. RESULTS AND DISCUSSION

Descriptive analysis was conducted to explore the data to gain a deep understanding of the data shape, structure, and characteristics contained in the datasets. The amount of data contained in the dataset is 224,913 reviews starting from 2021 to 2024, 2021 is 28,174, 2022 is 124,420, 2023 is 65584, and 2024 is 6,824 reviews. Figure.3 shows the number of datasets by year.

Fig.3 Number starting from 2021-2024

In the app rating analysis, the data shows a varied distribution of ratings given by users. Rating 5 dominates with a percentage of 65%, followed by rating 1 at 20%, rating 2 at 6%, and rating 3 and 4 at 4% each, so in general the application provides high satisfaction to users. Figure.3 is the result of visualizing the level of satisfaction based on users towards the application.

Based on the results of the distribution analysis on the dataset described in Table.1, it is found that the dataset consists of 224,913 entries covering several attributes, including year of publication and score. The average publication year of the data is around 2022 with a standard deviation of 0.70, indicating limited variation in publication year. The year of publication distribution shows that most of the data was published between 2021 and 2024, with the second quartile (median) and third quartile (75%) in 2022 and 2023. The rating scores have an average of 3.93, with most of the data falling in the range of 3 to 5. The second quartile (median) and third quartile (75%) of the scores are 5, indicating a tendency for the majority of users to give high scores. The dataset reflects a varied distribution in its attributes, indicating the complexity of the observed cases.

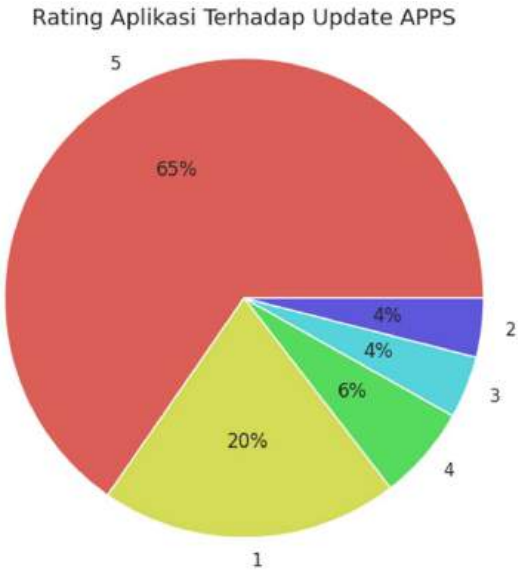

Fig.4 Application user satisfaction rating

Table 1. Data distribution

	Sore	***Publish Year***
Count	224913.000000	224913.000000
Mean	3.929061	2022.226959
Standar Deviasi	1.630582	0.697499
Minimum	1.000000	2021.000000
25%	3.000000	2022.000000
50%	5.000000	2022.000000
75%	5.000000	2023.000000
Maximum	5.000000	2024.000000

After going through the data preprocessing process, the text data is ready for further analysis. At this stage, each step aims to prepare the text optimally so that it can be processed efficiently and accurately. The next stage is making wordcloud for representative visualization of the dominant words in the text, as well as calculating the frequency of word occurrence using the Term Frequency-Inverse Document Frequency (TF-IDF) method to evaluate the importance of words in the text. Based on the results of wordcloud visualization in Figure. 5, it can be concluded that the keywords are very dominant in the analyzed text. Words that appear more often give the most prominent topics or themes in the text.

In the results of wordcloud analysis, the dominant words are Gojek, driver, already, thank you, promo, steady, disappointed, really, good, like, discount, please, difficult. In the wordcloud visualization, the analysis highlights the words that dominate in the text. However, there is no objective assessment because there is no weight on each word. To overcome this, it is necessary to analyze using the TF-IDF method to assess the importance of a word based on the frequency of occurrence of the word in the document as well as the uniqueness of the word among all documents.

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Fig. 5 Wordcloud visualization results

The results of analysis using the TF-IDF method provide a deep understanding of the importance of each word in the text being analyzed. Figure. 6 explains 20 types of words that have a high weight in analysis using TF-IDF. The TF-IDF visualization results provide a clear understanding of the order of keywords based on the highest weight, which includes words such as "gojek, application, helpful, driver, good, great, gopay, good, really, already, please, use, fast, accurate, expensive and difficult." By looking at these words, you can quickly identify the most dominant topics or themes in the document, thus providing valuable insight into understanding the essence of the text and allowing readers (stakeholders) to capture the essence of the message that application users want to convey.

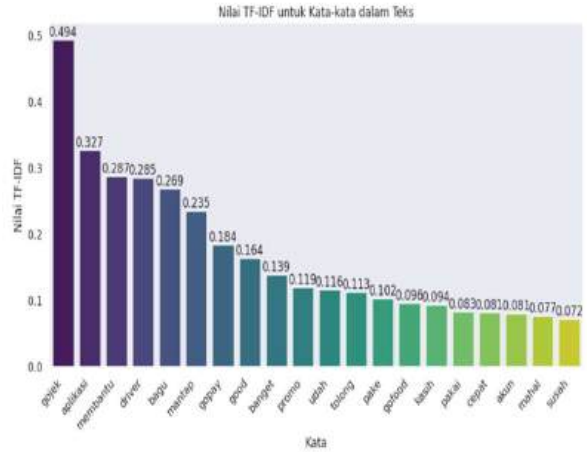

Fig. 6 Results of word weight analysis in the document

The choice is to proceed to the topic modeling stage using Latent Dirichlet Allocation (LDA) after analysis using TF-IDF to gain a deeper understanding of the underlying topic structure in the text. TF-IDF analysis provides insight into the importance of words in a text based on frequency of occurrence but does not provide an understanding of how these words are tied to each other in the context of a broader topic or theme. By involving LDA, hidden patterns in documents can be identified that group words into related topics. Further analysis by applying LDA makes it possible to get a more holistic picture of the text content and identify the main topics so as to gain deeper knowledge about the meaning of the text being analyzed. Table 2 Results of topic modeling into 7 topics with 10 words in each topic, showing variations in user sentiment and experience with Gojek services. While there are some topics that reflect positive sentiments, such as convenience, speed, and service benefits, there are also topics that describe negative experiences, such as high costs or difficulties with app features. Figure 4.5 is the result of the topic modeling visualization. This conclusion illustrates the importance of continually paying attention to user feedback and making necessary improvements to improve the overall user experience.

Table 2. Topic Modeling

Topic number	Word	Topic interpretation
Topic 0	0.059*"pua" + 0.038*"upgrad" + 0.038*"murah" + 0.036*"mantul" + 0.032*"layanan" + 0.030*"pelayanannya" + 0.027*"terbantu" + 0.027*"skrg" + 0.023*"jasa" + 0.023*"enak"	This topic relates to user experiences related to Gojek service improvements or upgrades, such as an increase in service quality at an affordable price. Words such as "pelayanan" and "terbantu" indicate that users feel helped or satisfied with the services they receive.
Topic 1	0.038*"bermanfaat" + 0.035*"senang" + 0.034*"nice" + 0.032*"gojek" + 0.030*"best" + 0.023*"mempermudah" + 0.020*"error" + 0.020*"menyenangkan" + 0.017*"menu" + 0.016*"muncul"	Keywords in this topic include "bermanfaat", "senang", "nice", and "mempermudah". This topic shows users' positive sentiments towards Gojek services, focusing on the ease of use and benefits provided by the application.
Topic 2	0.065*"promo" + 0.050*"gojek" + 0.047*"akun" + 0.031*"voucher" + 0.024*"pakai" + 0.022*"bintang" + 0.018*"promonya" + 0.018*"diskon" + 0.018*"kasih" + 0.017*"udah"	This topic includes key words such as "promo", "akun", "voucher", and "diskon". This topic relates to the use of promos or discounts in Gojek services, such as the use of promo codes or vouchers to get discounts.
Topic 3	0.070*"banget" + 0.045*"mahal" + 0.038*"biaya" + 0.035*"aplikasi" + 0.026*"pake" + 0.024*"harga" + 0.021*"ongkir" + 0.019*"beli" + 0.018*"gofood" + 0.018*"coba"	Key words in this topic include "banet", "mahal", "biaya", and "aplikasi". This topic describes negative user sentiments related to the high price or cost of using Gojek services, as well as problems or inconveniences in using the application.
Topic 4	0.353*"bagu" + 0.059*"pelayanan" + 0.036*"aplikasinya" + 0.032*"aplikasi" + 0.027*"banget" + 0.023*"jelek" + 0.017*"buruk" + 0.015*"payah" + 0.012*"parah" + 0.009*"siip"	This topic is dominated by the keyword "bagus", Other keywords include "pelayanan" and "aplikasi". This topic may relate to a positive evaluation or praise of Gojek's service quality or application.

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Topic 5	0.073*"gopay" + 0.048*"updat" + 0.038*"aplikasi" + 0.033*"gojek" + 0.029*"saldo" + 0.028*"masuk" + 0.021*"udah" + 0.020*"suka" + 0.017*"tolong" + 0.016*"buka"	Keywords in this topic include "gopay", "update", "aplikasi", and "suka". This topic relates to the use of the GoPay payment feature in the Gojek application, as well as updates related to the feature.
Topic 6	0.382*"mantap" + 0.079*"mudah" + 0.057*"memuaskan" + 0.039*"mantab" + 0.021*"jalan" + 0.021*"tingkatkan" + 0.013*"penumpang" + 0.010*"mantappp" + 0.010*"prose" + 0.009*"ngak"	This topic is dominated by the keywords "matap", "mudah", and "memusakan". Other keywords include "road" and "improve". This topic shows the positive sentiment of users regarding the easy and satisfying experience of using Gojek services.

With a coherence score of 0.509, it can be concluded that the LDA model has a moderate level of coherence. This shows that the topics generated by the model tend to have a fairly good relationship between the words in each topic. Nevertheless, improvement is still needed in terms of increasing the coherence of the model, either by adjusting the model parameters or performing better data preprocessing. Higher coherence will ensure that the topics generated are easier to understand and more meaningful, making it easier to analyze and interpret the result. The topic analysis uncovers patterns in Gojek user reviews. The first topic discusses experience, services, and affordable pricing. The second highlights app usability and benefits. The third relates to promos, discounts, and vouchers. The fourth reflects positive evaluations of service quality. However, the fifth focuses on high costs and app issues. The sixth emphasizes overall user satisfaction and service convenience. It effectively outlines the six main topics identified in the analysis, each focusing on different aspects such as user experience, pricing, app usability, promotions, service quality, and overall satisfaction. This summary offers a clear understanding of the key themes discussed within the reviews, highlighting both positive and negative aspects of the service.

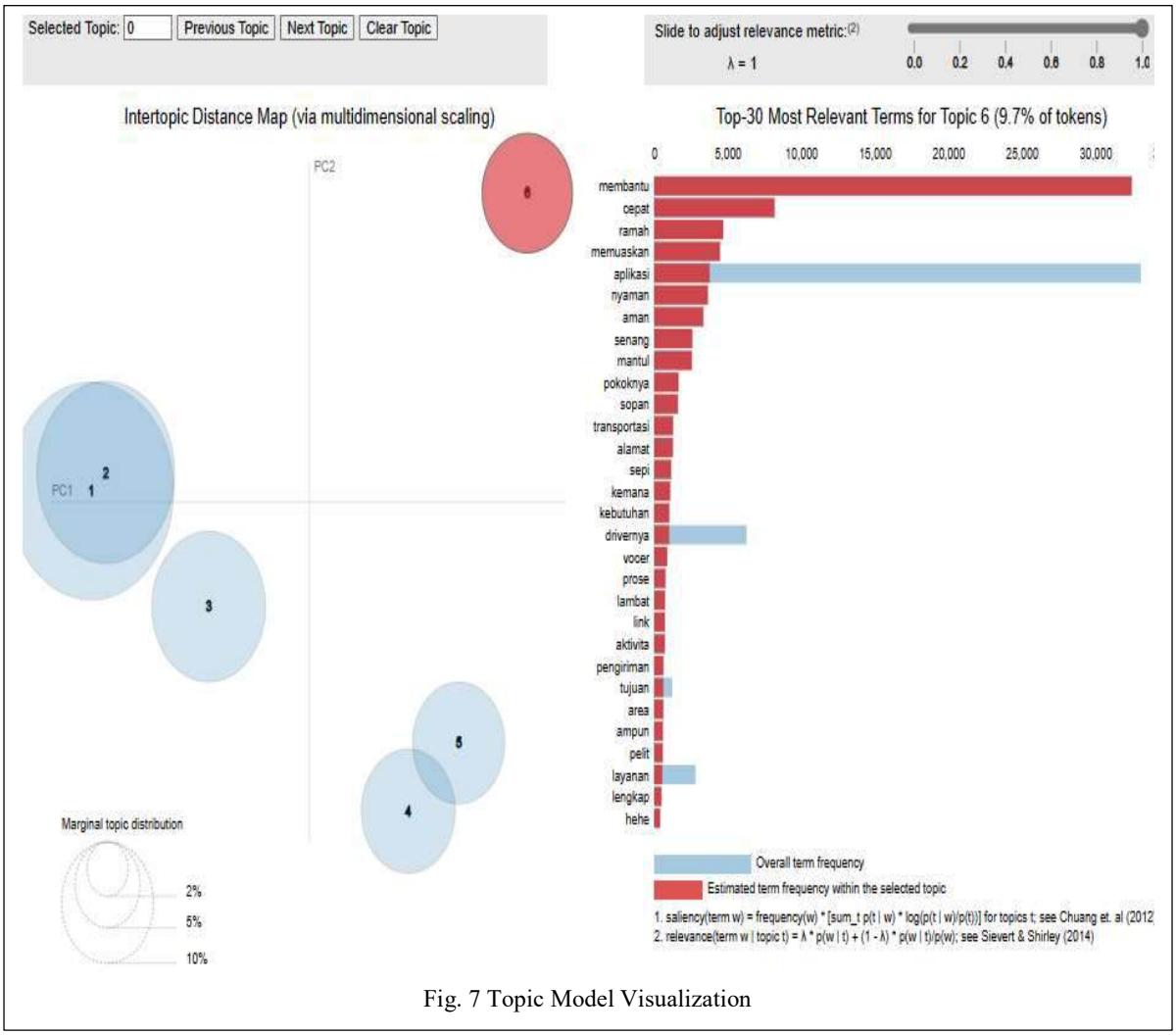

Fig. 7 Topic Model Visualization

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IV. CONCLUSION

This research highlights the rapid growth of digital data in Indonesia, particularly in the use of platforms such as Gojek, with annual growth reaching 64.4% by 2022. Driving factors include the popularity of social media, e-commerce, and ride-hailing services. Gojek is a clear example of this growth with an average of nearly one million downloads each month, making it one of the largest platforms in Indonesia. Analysis of Gojek's usage patterns and preferences is important to improve user experience and services. Text analysis, especially from user reviews, is crucial in understanding user preferences and needs. Keyword extraction and topic modeling play an important role in this regard. The combination of TF-IDF and LDA is proposed to address the challenges of text analysis in Indonesian. The results show the effectiveness of this combination in improving the understanding of text analysis, especially on Gojek user review data. Topic modeling results show variations in user sentiment towards Gojek services. While there are positive sentiments such as convenience and speed of service, there are also issues such as high costs and difficulties with application features. Nonetheless, improving the coherence of the LDA model is necessary to ensure more meaningful and understandable analysis results for readers or interested stakeholders.

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E-Catalog Promotion of Fishermen Business Group with User Centered Design Method

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Abstract – This research aims to design a promotional e-catalog for fishing business groups using the User Centered Design (UCD) method to improve the quality of their promotional services online. The partners in this research are the Fisheries Supervisory Community Group in Batu Basar Village, Nongsa District, Batam City, Riau Islands. So far, this group and fishermen have often faced obstacles in promoting their products effectively to potential consumers, especially in the rapidly developing digital era. The UCD method used in this research is a user-focused approach. The initial stage of research includes gathering information regarding the needs and preferences of potential users, including fishing business groups and potential consumers. This information was obtained through interviews, observations and literature studies. Based on the data collected, a promotional e-catalog was designed that took into account user needs and promotional objectives which included features such as complete product descriptions, product photos, price information, user testimonials and contact information. After the design is complete, the manufacturing stage is carried out and then continues to the testing stage involving potential users. This testing aims to maximize usability, efficiency and user satisfaction. The test results used the Nielsen model with five indicators with the results of Easy To Learn getting a score of 3.85, Efficiency To Use getting a score of 3.75, the Easy To Remember indicator getting a score of 3.85, and the Few Errors indicator getting a score of 4.05. Then the fun to use indicator has a value of 3.95.

Keywords – e-catalog, promotion, ucer centered design

I. INTRODUCTION

The Fishermen's Joint Business Group (KUB), a significant economic sector that provides food supplies from the sea, serves as the backdrop for this study. Nonetheless, they frequently run into difficulties trying to sell their goods to prospective customers. The effectiveness and accessibility of promotions is one of the key elements affecting marketing success.

Utilizing information technology and the internet has become crucial for fishing company groups looking to reach a wider market in the ever evolving digital age. Increasing their visibility and offering promotional services can be accomplished with the use of web-based promotional e-catalogs. However, in order to deliver sufficient quality services, a well-designed e-catalog must consider the requirements and preferences of potential users [1].

The development of the Banten Bahari E-Commerce Website, which the wives of fisherman in the Karangantu Nusantara Fishery Harbor community group employed as a marketing tool, has also been the subject of investigation. The Waterfall approach is used to create websites [2].

The user-centered design approach will be used in this study, which guarantees that the creation of new products or services is grounded in a thorough understanding of users and places a premium on the user experience [3]. This can reduce development risks, enhance the quality of the product or service, and give people more value. This study will give priority to better user experience using a UCD methodology. Designers are able to create intuitive, user-friendly, and visually appealing interfaces by having a thorough grasp of their users. This will boost user happiness, foster a sense of loyalty, and promote additional involvement in fishing company group marketing. Furthermore, by carrying out this research, fishing associations might get a competitive edge by offering superior advertising services compared to their rivals. This may assist expand the target market, improve visibility, and boost revenue. Through a PBL program involving relevant areas like web and mobile programming, this research will engage teacher and student teams.

II. RESEARCH METHODOLOGY

The User Centered Design (UCD) technique approach will be utilized in this study to create promotional e-catalogs for fishing industry associations. By ensuring consumers are actively involved in the design process and gathering copious amounts of data, the UCD technique enables researchers to comprehend user wants and preferences. It is envisaged that this will be able to address issues including improving user experience with developed apps, tailoring applications to the needs of users, and assisting users in making the most of current technology. As seen in Figure 1 below, the research methodology generally employs User Centered Design.

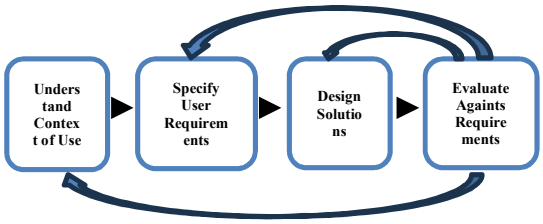

Fig. 1 User Centered Design Model.

The first step in the research process is gathering data on the issue that forms the basis of the study. This issue has to do with how technology can be applied to groups of fishermen to help them market their goods and enterprises

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more extensively. Finding a need to remedy this issue is the next stage. This entails gathering data via observations, interviews, and book reviews on fishing industry associations and prospective customers. Based on this information, promotional e-catalogs that are tailored to the interests and needs of users will be created.

Subsequently, a promotional electronic catalog was created, incorporating pertinent features like comprehensive product descriptions, high-quality product images, unambiguous pricing details, user reviews, and contact details for fishing associations. The user interface will also be designed using responsive and intuitive design concepts. Next comes the review of the produced design, in which the fishermen's group is involved as the party that will make sure the elements of the application that will be developed meet their needs.

III. RESULTS AND DISCUSSION

A. Context of Use

An in-depth understanding of the environment, traits, and requirements of the fishing group that is the subject of the research is necessary for analysis of the research context for the E-Catalog Promotion of Fisherman's Business Groups utilizing the User Centered Design (UCD) method. Interviews with a number of the group's fisherman were used to do this exercise. The interview questions covered topics such as their everyday lives outside of fishing, group activities, items they created other than seafood, side ventures they took on, and challenges they had when not at sea.

The findings show that some fishermen engage in side businesses such as physical labor, boat rentals, and the sale of processed fish items in addition to their maritime pursuits. In addition, there are a number of other issues that need to be addressed, such as the dearth of media outlets that can inform a wide audience about the companies run by fishermen, meaning that, up until now, the only people who can purchase or hire their services are those who are already aware that there is a fishing group and that there are

B. User Requirements

The research team conducted the next step, which involved analyzing and mapping fishermen's needs based on the issues they faced and adjusting to the original goal of the study, which was to provide solutions related to the application of technology to the issues faced by fishing groups, based on the findings of their search for problems among the group's members. The findings indicated a number of needs for users, including the need for an application that can reach a large number of people in order to promote the products of fishermen, the requirement for application features that must be in line with current issues and assist fishermen and the community in finding information on related goods and services. Secondly, a user-friendly system is required for fishers, particularly for those who are not tech-savvy. Additionally, a system that facilitates communication between fisherman and potential customers is required. We will construct an application design for the next stage as a remedy to current issues based on several user needs notes.

C. Design Solution

In order to facilitate the creation of application designs, we begin by classifying the demands of the application based on the users. Next, we generate an identification table of application user needs and use case diagrams for users. To ensure that the system satisfies the needs of both the creator and the user, the first step is to identify application users and define the system's features and operations from their point of view, as shown in Table 1.

Table 1. User Identification

User	Assigment
Admin	a. Log in via a page that only admins can see
	b. Admin can update or add products to be sold
	c. Admin can update contact information who can be contacted
	d. Admin can publish news articles about an event in the web application column
Visitor	a. see products for sale and ongoing events
	b. provide assessments or suggestions or criticism about the products being sold
	c. can search for the product you want to buy

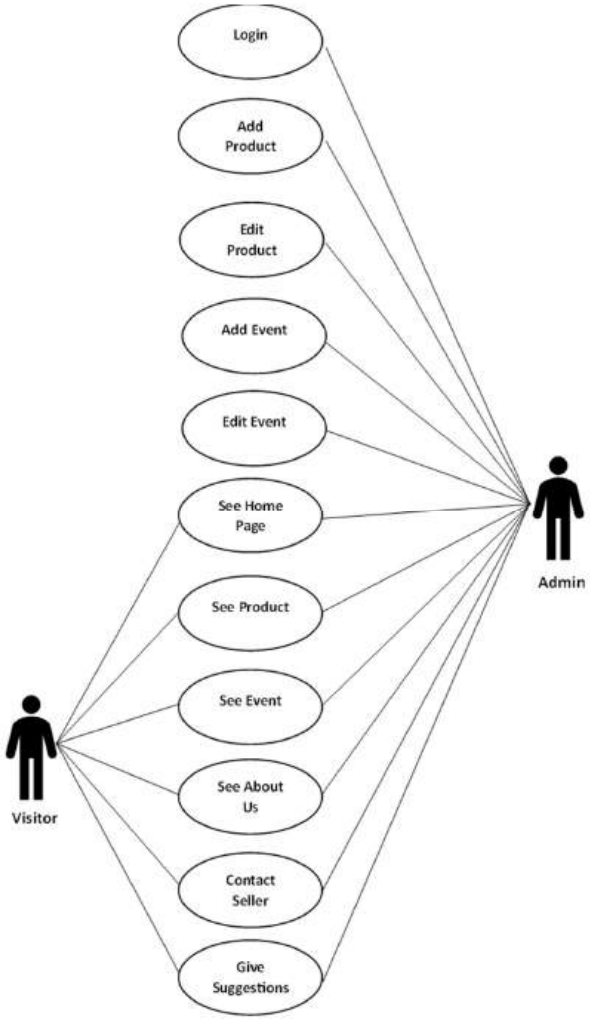

Fig. 2 Usecase Diagram.

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From user identification, we continue by creating a usecase diagram which is a graphic depiction of the possible interactions of a user with the system as in Figure 2. And we carried on designing the application interface.

Fig. 3 Homepage

Fig. 4 Login page.

Fig 5 Dashboard Admin.

Fig. 6 Add Product Page.

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Fig. 7 Catalogue Page.

Fig. 8 Detail Product Page.

D. Evaluation

Twenty members of the fishing group were given questionnaires, and the design that had been created was displayed as part of the evaluation process. A total of 21 questions with five usability indicators—simple to learn (3 questions), efficient to use (4 questions), easy to remember (5 questions), minimal errors (6), and pleasant to use (7)—were used in the data collection for this study. Using the Nielsen methodology, the test results for each Usability Testing indicator are as follows.

1. Easy to Learn Aspect

This aspect is an assessment of the user's ease in understanding the prototype design.

Table 2. Easy to Learn Aspect assessment results

Assessment Aspects	Alternative Answers	Number of Answers	Weight	Result
Easy to Learn	Very Agree	9	5	45
	Agree	36	4	144
	Rather Disagree	12	3	36
	Disagree	3	2	6
	Very Disagree	0	1	0
	Total	60		231
	Average		3.85	

2. Efficiency to Use Aspect

This aspect is an assessment of the user's ease in understanding the use of features in the prototype.

Table 3. Efficiency to Use Aspect assessment results.

Assessment Aspects	Alternative Answers	Number of Answers	Weight	Result
Efficiency to Use	Very Agree	16	5	80
	Agree	36	4	144
	Rather Disagree	20	3	60
	Disagree	8	2	16
	Very Disagree	0	1	0
	Total	80		300
	Average		3.75	

3. Easy to Remember Aspect

This aspect is an assessment of the user's ease in remembering the layout of features in the prototype.

Table 4. Easy to Remember Aspect assessment results

Assessment Aspects	Alternative Answers	Number of Answers	Weight	Result
Easy to Remember	Very Agree	25	5	125
	Agree	45	4	180
	Rather Disagree	20	3	60
	Disagree	10	2	20
	Very Disagree	0	1	0
	Total	100		385
	Average		3.85	

4. Few Errors Aspect

This aspect is an assessment of the interference in understanding the use of features in the prototype.

Table 5. Few Errors Aspect assessment results

Assessment Aspects	Alternative Answers	Number of Answers	Weight	Result
Few Errors	Very Agree	18	5	90
	Agree	30	4	120

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	Rather Disagree	9	3	27
	Disagree	3	2	6
	Very Disagree	0	1	0
	Total	60		243
	Average		4.05	

5. Pleasant to Use Aspect
This aspect is an assessment of the ease of understanding the use of the prototype.

Table 6. Pleasant to Use Aspect assessment results

Assessment Aspects	Alternative Answers	Number of Answers	Weight	Result
Pleasant to Use	Very Agree	30	5	150
	Agree	60	4	240
	Rather Disagree	24	3	72
	Disagree	6	2	12
	Very Disagree	0	1	0
	Total	120		474
	Average		3.95	

IV. CONCLUSION

According to Nielsen, the model generates distinct values for each indication in the outcomes of usability testing calculations. For example, the Easy To Learn indicator receives a positive interpretation of 3.85. Next, Efficiency To Use received a score of 3.75, which puts it at the bottom of all the indicators currently in use, but based on the interpretation score, this score is still quite good. Easy To Remember received a score of 3.85, and Few Indicator Errors received a score of 4.05, which puts it at the top of the list of indicators. With a value of 3.95, the pleasant to use indication is deemed good as well.

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Implementation of Load Balancing With PCC Method And Failover Using Mikrotik At PT. Maxpower Indonesia

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Abstract – In connecting to a single Internet Service Provider (ISP), one must consider the possibility of network congestion due to high traffic as well as potential disruptions in the internet connection. Load Balancing Per Connection Classifier (PCC) is a method used in combining two ISP services. In supporting day-to-day operational activities, a reliable internet connection is crucial for any company. Therefore, it is also necessary to have an internet connection that remains standby without interruption when there are disruptions in the ISP. This paper discusses the merging of two internet services and the addition of failover techniques. In the first test, a load test was carried out with 1 ISP service. The second test was carried out using two ISP services with the PCC method in high internet traffic conditions. By using the ISP and PCC method, traffic can be reduced and charged to both ISPs so that the network is not burdened by just one ISP. In the second test, it can also be proven that the use of two ISP services with failover techniques is much better when a problem occurs at one of the ISPs, thereby reducing the company's operational impact**.**

Keywords – ISP, *Load Balancing*, PCC, *Failover*, *Bandwidth***.**

I. INTRODUCTION

Current developments in information technology greatly influence company business patterns and strategies. Many companies are trying to improve their performance to be superior in business competition. One way is to utilize the internet, with the clear intention of connecting hosts on different networks, or perhaps geographically separated in large areas [1]. The rapid development of computer networks and the internet as an information medium must of course have good connection quality. The performance of a network is very much needed at PT. Maxpower Indonesia is very dependent on Internet Service Providers (ISP) to support the company's business processes. Currently PT. Maxpower Indonesia still uses one CBN internet provider with a bandwidth of 100 Mbps, but when there are many users connecting to the internet and the network server becomes very burdened which can hamper ongoing business processes. Research [2] states that when there are many requests from users, network devices will be burdened because they must serve many processes for user requests.

Other problems occur when there are problems with ISP services such as fiber cuts, mass disruptions which can hinder work because they require internet access. Research [3] states that using two or more ISP services with PCC load balancing and failover methods is necessary to prevent connection failure when only using one internet service. Because it will be implemented using several links, the load balancing technique will be accompanied by a failover technique. A technique called load balancing, namely distributing a load, and setting the client connection path to a service on the server by utilizing a connection distribution method using the Per Connection Classifier (PCC) method [4]. Several previous studies have focused on implementing load balancing for networks aimed at users. Research [5] aims to find out and use optimal ways to distribute network workload to web servers. Research [6] aims to try a solution if one of the two internet lines is down, is the other line active and if both lines are active then they can run together. Then research [7] aims to compare the performance of Mikrotik routerOS with OpenWRT using load balancing techniques. To compare performance, a Quality of Service (QoS) analysis is carried out using throughput, packet loss and delay parameters, which will then determine the service category using the Telecommunications and Internet Protocol Harmonization Over Network (TIPHON) standard. The suggested resolutions entail enabling VPN on MikroTik and bolstering the capacity of database storage [8]. MikroTik, a software that serves as a router, has been widely utilized by various organizations and institutions to provide network access services [9].

Research [10] aims to design a load balancing scheme using the per connection classifier (PCC) method to overcome the problem of traffic density on the network. The research results show that the application of the load balancing technique on the Mikrotik router using the PCC method can separate internet connections via two available ISP lines so that it can overcome the problem of traffic buildup on one of the ISP links to reduce latency and improve the performance of the existing network. Research [11] focuses on network configuration methods to maximize internet bandwidth usage for all users. Quality of Service is used to view network traffic performance as indicated by the parameter values of delay, throughput, and packet loss. The results of testing and research carried out before and after using PCC load balancing, the delay value decreased from 180.26 ms to 148.36 ms and throughput increased from 1.76% to 2.03%, then packet loss decreased from 25, 37% to 18.59% according to TIPHON standardization.

II. RESEARCH METHODOLOGY

The method used in this research is PPDIOO [12]. This method is a method implemented by Cisco which is designed to support growing networks [13]. This method consists of six closely related phases consisting of the

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Prepare, Plan, Design, Implement, Operate and Optimize stages [14]. The primary benefit of PPDIOO is reducing TCO (total cost of ownership). PPDIOO also enhances network availability by employing a robust network operation validation approach [15].

Preparation Stages
At this stage, data collection was carried out during the research. The author conducted research for three months at PT. Maxpower Indonesia to collect data related to running computer networks.

Plan Stages
This phase begins with identifying the needs of the system to be developed. Information was gathered through research and interviews. Next, the author analyzes the advantages and disadvantages of computer networks to determine the parts that need to be optimized to improve the network's performance.

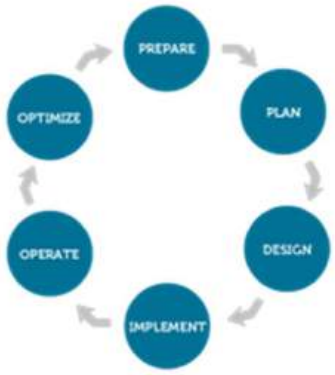

Fig. 1 PPDIOO Research Methods

Design Stages
In this step, the proposal network design is carried out. This network design plan is a complete detailed picture, meets relevant business and technical requirements, and incorporates guidelines to ensure the availability, reliability, security, growth capabilities, and performance required throughout the implementation process.

Implementation Stages
At this stage the implementation is carried out by applying the Load Balancing method with the Per Connection Classifier to equalize the load on the two ISPs on the prepared proxy devices.

Operate Stages
At this stage, after implementing Load Balancing the author applies the failover technique. This technique is used if one of the ISPs experiences problems, then the proxy will automatically divert traffic to a connection that is still active.

Optimaze Stages
At the optimization stage, this is done by checking again on devices that have been configured and implementing load balancing and failover techniques to ensure that optimal network performance and high service availability are maintained.

III. RESULTS AND DISCUSSION

Based on research conducted at PT. Maxpower Indonesia uses one CBN internet provider with a bandwidth of 100 Mbps. The computer network used is a WAN type. A system consisting of computers, software and other network devices that work together to achieve a common goal. In order to achieve these goals, each part of a computer network requests and provides services. The party who requests or receives services is called the client and the one who provides or sends the service is called the server. This architecture is called client-server and is used in almost all computer network applications. The network topology used at PT. Maxpower Indonesia is a star topology, which uses several switches and two routers to connect computer networks. Especially for networks in branch offices or remote areas of PT. Maxpower Indonesia uses routers and Multi Protocol Label Switching (MPLS) services to form a WAN network. The switch used for computer networks at PT. Maxpower Indonesia is a computer network component that has many ports which will act as links for many network points or nodes so that it will form a LAN computer network in a star topology.

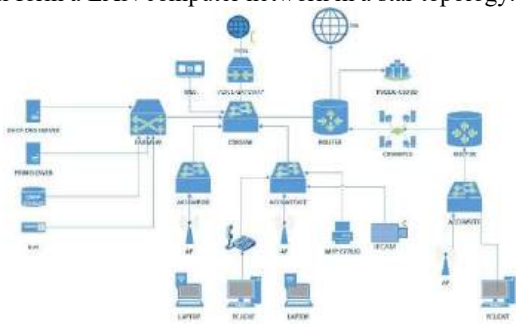

Fig. 2 Running Network Scheme

From the schematic in Figure 2, the connection between computers is centered on the core switch which is connected to another access switch. The core switch is in the head office server room, while the DHCP, DNS, Wireless Controller (WLC), Printserver and Storage server servers are connected via the switch farm. To access public cloud resources using a router using azure tunneling or azure site-to-site Virtual Private Network (VPN). This is a model where the local network relates to a virtual network in azure using VPN protocol. The connection allows secure and encrypted traffic between the two networks.

The following IP addresses are used to uniquely identify each device on a network, allowing these devices to exchange data with each other over the internet or local network and to communicate with each other within the network.

IP configuration is a crucial part of network management because it ensures that devices on the network have the right addresses and are properly connected to communicate with each other.

Table 1. Network IP Address

No	Device Name	IP Address	Subnet Mask
1	Mikrotik CCR	192.168.10.1	/24
2	Cisco Core sw	192.168.19.20	/24

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3	Cisco Farm sw	192.168.19.21	/24
4	Cisco Access	192.168.19.22	/24
5	DHCP Server	192.168.10.142	/24
6	Cisco WLC	192.168.10.18	/24
7	Cisco AP	192.168.10.0	/24
8	Cisco VG	192.168.30.200	/24
9	Cisco CM	192.168.30.5	/24
10	IP Phone	192.168.30.0	/24
11	BOD Client	192.168.15.0	/24
12	Staff Client	192.168.10.0	/23

While observing PT. Maxpower Indonesia, the author found several problems that often occur. One of them is when there is a spike in traffic during rush hour before noon. The problem that often arises is internet connection problems which cause downtime.

3.1 Proposed Network Design

The topology proposed for PT Maxpower Indonesia is no different from the previous topology because it still uses a star topology. The following is the proposed network scheme at PT. Maxpower Indonesia has been updated using two ISPs for load balancing and failover.

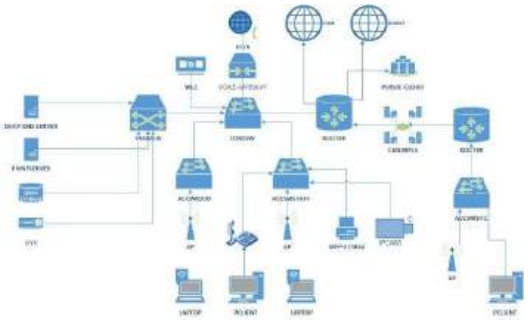

Fig 3. Proposed Network Scheme

In figure 3 there is the addition of one Biznet ISP service which will be combined with the load balancing method, namely ISP2. This load balancing will distribute internet traffic evenly between the two ISPs. This can reduce the load on one ISP and ensure more stable and guaranteed internet availability.

Apart from that, using two ISPs, if one ISP experiences interference or downtime, the internet connection can remain active through the other ISP. This creates a higher level of redundancy and minimizes the risk of losing connectivity.

3.2 Implementation

The implementation is carried out through the Load Balancing method with PCC separating traffic based on certain criteria such as IP addresses, ports, or protocols used in the connection. This allows the system to distribute the traffic load evenly across the various available paths or connections. PCC is a load balancing method that can be applied on MikroTik to divide the traffic load efficiently.

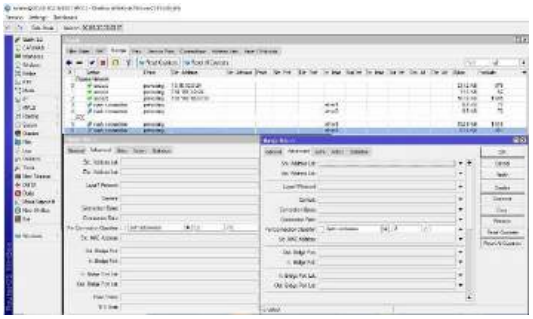

Fig 4. PCC Mangle Rules Settings

Furthermore, combining load balancing with failover techniques, this method is used to maintain system availability by automatically switching to backup resources when a failure occurs at one of the ISPs. This technique is very important to maintain smooth operations, especially in network and system environments that require high availability. Redundancy with failover techniques can be a solution when downtime occurs on nodes in the network.

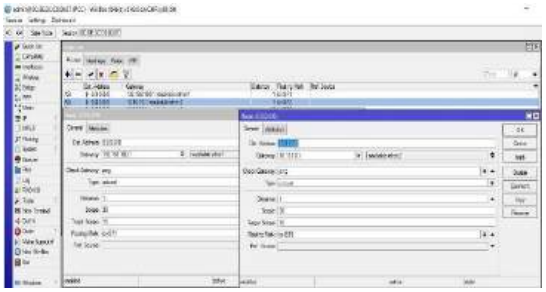

Fig 5. Failover Routing Settings

3.3 Testing the Proposed Network

This test is carried out load testing when the client is using Microsoft Teams and carrying out other activities using ISP1 and ISP2 running or load balancing with PCC.

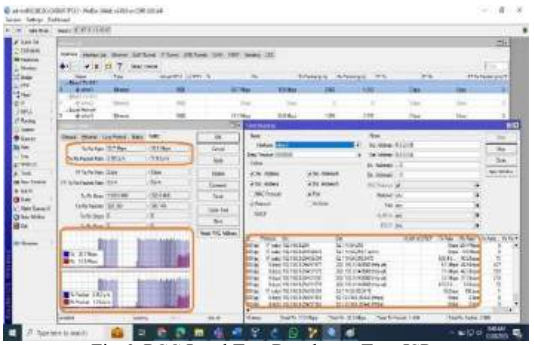

Fig 6. PCC Load Test Results on Two ISPs

From the monitoring results, testing on the ISP1 interface shows that traffic is shared with ISP2 when using the internet and making Teams calls. From figure 6 it can also be seen that sending traffic passes through ISP1 and receiving traffic passes through ISP2. So, it can be explained that the client traffic load can pass through the two ISPs that use the PCC load balancing method.

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IV. CONCLUSION

From the research findings and discussions outlined earlier, the author can conclude that the use of two ISPs in load balancing methods in computer networks can effectively distribute data traffic evenly among multiple paths or connections, thus preventing network overload during high traffic periods. The implementation of the PCC method automatically divides traffic from both ISPs to ensure balanced utilization.

Load balancing with PCC and failover techniques has been proven to enhance network availability, optimize resource utilization, and ensure continuous data flow even in the event of disruptions in one path or ISP. PCC load balancing and failover techniques can be relied upon to support the business processes of PT. Maxpower Indonesia.

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Empowering Diagnosis: A Review On Deep Learning Applications for COVID-19 and Pneumonia in X-Ray Images

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Abstract – The emergence of COVID-19, a highly contagious virus capable of infecting both the upper and lower respiratory tracts, has led to one of the deadliest pandemics in modern history, claiming millions of lives worldwide. Early and accurate detection of this rapidly spreading disease is crucial for effective containment and saving lives. Chest X-ray (CXR) stands out as a promising diagnostic tool due to its accessibility, affordability, and long-term sample preservation. However, distinguishing COVID-19 pneumonia from other respiratory ailments poses a significant challenge. This article delves into various approaches utilized for COVID-19 detection and the hurdles encountered in this endeavor. The imperative for developing automated detection systems to mitigate virus transmission via contact is underscored. Notably, deep learning architectures such as ResNet, Inception and Googlenet have been deployed for COVID-19 detection, albeit with a focus on identifying pneumonia cases. Discriminating between COVID-19-induced pneumonia and pneumonia caused by other pathogens remains a formidable task, demanding innovative solutions for accurate and timely diagnosis.
Keywords – COVID-19, Pandemic, Detection, Chest X-ray (CXR), Deep learning.

I. INTRODUCTION

In December 2019, the global crisis of COVID-19 erupted from Wuhan, China, rapidly becoming a major public health concern due to its highly contagious nature. This pandemic, caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), marks a novel addition to the coronavirus family, which includes viruses responsible for ailments like the common cold, Middle East Respiratory Syndrome (MERS), and severe acute respiratory syndrome (SARS) [1] . COVID-19, believed to have zoonotic origins, is transmitted from animals to humans, similar to its predecessors like SARS-CoV and MERS-CoV. The virus primarily spreads through respiratory droplets and physical contact, with asymptomatic or mildly symptomatic individuals posing significant transmission risks. Alarmingly, a quarter of COVID-19 cases show no symptoms at all. As of April 7, 2020, there have been approximately 1,359,010 confirmed cases globally, resulting in 75,901 fatalities and 293,454 recoveries. The mortality rate stands at 5%, while 95% of infected individuals have a chance of recovery [2]. COVID-19 primarily affects the respiratory system, manifesting symptoms such as dyspnea, fever, and cough, with severe cases progressing to pneumonia, septic shock, and organ failure, often resulting in death. Men are more susceptible to infection due to increased exposure, while mortality among children aged 0-9 years remains uncommon [3].

Notably, COVID-19-induced pneumonia progresses more rapidly than other forms of pneumonia. Given its respiratory impact, chest radiology scans, particularly Chest X-rays (CXR), play a pivotal role in early diagnosis and management. CXR serves as a frontline diagnostic tool in several countries, offering rapid assessment of lung conditions and disease progression. Radiologists have observed various abnormalities in COVID-19 patients' CXR images, including bilateral ground-glass opacities (GGO) and consolidations. Deep learning (DL) techniques, particularly Convolutional Neural Networks (CNNs), have shown promise in enhancing the analysis of medical images, including CXR scans. Since the onset of the pandemic, DL approaches have been extensively explored to aid in COVID-19 diagnosis via CXR images. This paper reviews recent research endeavors in applying DL for COVID-19 detection from CXR scans, examining existing technologies, addressing challenges, and outlining future research directions. Through the critical assessment of preprint and published reports spanning the last five years, this review aims to elucidate how CNNs and DL architectures can facilitate the diagnosis of COVID-19 using CXR images [4].

The aim of this paper is to review recent research endeavors in applying Deep Learning (DL) techniques, particularly Convolutional Neural Networks (CNNs), for the detection of COVID-19 from Chest X-ray (CXR) scans. The COVID-19 pandemic, caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2), has highlighted the urgent need for efficient diagnostic tools due to its highly contagious nature and significant impact on global public health. With CXR serving as a frontline diagnostic tool for assessing lung conditions, this review seeks to explore the effectiveness of DL approaches in enhancing the analysis of CXR images for COVID-19 diagnosis. By critically assessing preprint and published reports, the paper aims to elucidate the potential of CNNs and DL architectures in facilitating early and accurate diagnosis, addressing existing challenges, and outlining future research directions in this critical area of medical imaging.

Section two offers an extensive examination of deep learning (DL) applications in analyzing CXR images for COVID-19, covering the employed architectures and datasets [5]. Section Three outlines the methodological analysis and performance evaluations across different DL models. Section Four emphasizes existing challenges, addressing issues such as the establishment of public datasets, model optimization, handling model uncertainty, and understanding the opaque decisions made by DL

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models. Lastly, Section five provides suggestions for future research directions, concluding the paper.

II. LITERATURE REVIEW:

While vaccines have been created, the most effective approach to containing the disease remains isolating individuals who are infected. Yet, swiftly distinguishing between healthy and infected individuals poses a challenge. Since the onset of the COVID-19 pandemic, scientists have endeavored to leverage machine learning and deep neural networks for automated detection of the virus. The following sections provide an overview of recent studies concerning COVID-19 detection and the use of DL classifiers. In [16] explored three comprehensive transfer scenarios for detecting pneumonia disease, encompassing normal cases, COVID-19, bacterial, and viral pneumonia. They employed three deep transfer models: AlexNet, GoogLeNet, and ResNet18. To address the challenge of limited training data, they leveraged Generative Adversarial Networks (GANs) to generate X-ray images effectively. In the initial scenario, the dataset was divided into four classes, with GoogLeNet serving as the primary transfer model. The second scenario focused on three classes, with AlexNet chosen as the base model for deep transfer. The third scenario narrowed down to two classes, normal and COVID-19, with GoogLeNet as the base architecture. The achieved accuracy for the classification of three classes reached 85.2%.In [17] conducted a study to assess the effectiveness of a multi-CNN (Convolutional Neural Network) system in automatically detecting COVID-19 in X-ray images. They employed a multi-CNN combined with Correlation Feature Selection (CFS) and a Bayes net classifier for COVID-19 prediction. The proposed methodology was tested on two distinct public datasets, yielding promising outcomes in both cases. The initial dataset consisted of 453 COVID-19 images and 497 non-COVID images, achieving an Area Under Curve (AUC) of 0.963 and an accuracy of 91.16%. When applied to the second dataset, which comprised 71 COVID-19 images and seven non-COVID images, the method achieved an AUC of 0.911 and an accuracy of 97.44%.The researcher [18] conducted an initial experiment employing image texture feature descriptors, specifically the Gray Level Co-Occurrence Matrix (GLCM) and Local Binary Patterns (LBP), alongside a feed-forward network and a CNN. They utilized newly constructed datasets comprising COVID-19 images, with the aim of laying groundwork for the future development of a system capable of automatically detecting COVID-19 in chest X-rays and CT images of the lungs. Integration of two distinct databases was performed, and the most effective technique achieved an accuracy of 97.40% on the validation set. This was achieved by utilizing a feed-forward neural network and incorporating flattened images along with texture information as inputs.In [19] introduced a novel approach for automated detection of COVID-19 using deep neural networks. Their framework employed generative adversarial networks in conjunction with transfer learning and Long Short-Term Memory (LSTM) networks, eliminating the need for feature extraction in COVID-19 diagnosis. This method effectively distinguished COVID-19 cases from the healthy group with a remarkable accuracy of 99%. Additionally, various other deep transfer learning networks such as VGG16, Inception-ResNet V2, VGG16, and MobileNet, which have been extensively utilized in pneumonia detection research, were compared to the proposed model. The results demonstrated that the suggested model exhibited significant promise in terms of accuracy, precision, sensitivity, and specificity compared to existing deep transfer learning systems. In [20] introduced a computerized approach aimed at optimizing hyperparameters. They investigated the individual tuning of learning rates for each layer of the network to refine the parameters. Additionally, the authors addressed the high computational demand of deep models by employing memory- and computationally-efficient mixed-precision training, thereby reducing the training time. Despite the limited availability of datasets, the model demonstrated outstanding performance and generalization. Specifically, the proposed Model 11 achieved a validation accuracy of 96.83% and sensitivity and specificity rates of 96.26% and 95.54%, respectively. Moreover, the model attained an accuracy level of 97% when tested on a completely new dataset without undergoing any additional training. Lastly, the model showcased its potential to aid radiologists in rapidly screening patients for COVID-19 symptoms.In the researcher [21] proposed a model utilizing chest radiographs due to the widespread use of these imaging modalities in clinical diagnosis, owing to their rapidity and cost-effectiveness. The study utilized a dataset comprising 1428 chest radiographs, encompassing healthy cases (no infection), as well as cases with common bacterial pneumonia and COVID-19 positivity. Furthermore, the study assessed the VGG-16 model's capability for categorization. Employing transfer learning with fine-tuning, the network was trained on the dataset of small chest radiographs. The experimental results showcased an accuracy of 96% for cases with two output classes and 92.5% for cases with three output classes, respectively. The research conducted by [22] improved the Snapshot Ensemble technique for classifying COVID-19 chest X-rays using deep learning. This approach also utilized the ResNet-50 model, which is pre-trained, as the foundation for transfer learning. A publicly available dataset comprising 2905 images, including COVID-19, normal, and pneumonia chest X-rays, was employed. The model demonstrated a 95% correct classification rate. Furthermore, it achieved a multi-class micro-average of 97% specificity, along with 95% f1-score and classification accuracy. The results indicate that the proposed approach outperforms several existing methods.In [23] introduced a novel approach to utilizing CXR images for improved screening and classification of COVID-19 disease in patients. Departing from the conventional heavy reliance on extensive datasets and the intricate features extracted by deep learning models, their strategy combined generative adversarial networks (GANs) with traditional data augmentation methods to address data limitations. Additionally, they employed Sobel, Laplacian of Gaussian (LoG), and Gabor filters to extract additional features from the data. This methodology was applied to various deep transfer models, and the results were compared. The

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researchers utilized a dataset of 4560 CXR images encompassing patients with viral, bacterial, fungal, and other diseases to train the models. Among these, 360 images were classified as COVID-19 cases, while the rest represented other diseases. The test results indicated an accuracy increase of up to 32% within 45 iterations when utilizing the Gabor filter bank, based on evaluation criteria. Their proposed model utilized the DenseNet-201 architecture and its detection accuracy was evaluated against 10 existing COVID-19 detection methods, achieving a two-class classification accuracy of 98.5%. In [24] introduced a deep learning architecture (DLA) along with optimization algorithms aimed at streamlining the automated detection of Covid-19. They proposed models utilizing convolutional neural networks for feature extraction from images. Deep-feature-based methods, including data augmentation and fine-tuning, were employed to enhance the model's performance. Additionally, the authors utilized two factors, namely the degree of opacity and geographic area, to improve visualization and quantify the disease severity level through image enhancement and saliency maps. Various parameters of Otsu thresholding and contrast-limited adaptive histogram equalization were explored to evaluate their impact on visualization outcomes. The proposed technique was compared against other pre-trained DLAs, showcasing outstanding classification accuracy (97.36%) and sensitivity (95.24%). The performance metrics of DenseNet were particularly noteworthy, demonstrating high efficacy for the proposed work and rendering them comparable to other models. The [25] developed an X-ray-based approach for diagnosing coronavirus infection. They utilized the DenseNet169 Deep Neural Network (DNN) to extract features from X-ray images obtained from patients' chests. Subsequently, the Extreme Gradient Boosting (XGBoost) technique was applied to these features for classification purposes. The proposed method demonstrated higher accuracy and efficiency compared to existing approaches, exhibiting satisfactory performance in detecting COVID-19 cases from X-ray images when assessed and compared with recent methodologies. In the experiments, the proposed approach achieved accuracies of 98.23% and 89.70%, and sensitivities of 92.08% and 95.20% for two- and three-class scenarios, respectively. In [26] the author introduced COVDC-Net; a classification approach based on Deep Convolutional Networks. This method aims to identify individuals infected with SARS-CoV-2 among healthy individuals and pneumonia patients by analyzing chest X-ray images. COVDC-Net employs two modified pre-trained models, MobileNetV2 and VGG16, originally trained on ImageNet, but without their classifier layers. These models are then combined using the Confidence fusion method to enhance classification accuracy on publicly available datasets. Through extensive testing, it was found that COVDC-Net achieved an overall classification accuracy of 96.48% when applied to three-class classification tasks involving COVID-19, Normal, and Pneumonia cases. The experimental results indicate that COVDC-Net outperforms existing deep learning methods proposed for similar tasks in ongoing COVID-19 competitions. In [27] introduced Conv-CapsNet, a novel model that combines Capsule Networks and convolutional layers for detecting COVID-19 in X-Ray scans. The proposed model achieves high accuracy rates of 96.47% for multi-class and 97.69% for binary classification. By utilizing a shallow architecture with 23M parameters, the model demonstrates effectiveness in classifying X-Ray images into COVID-19, No Findings, and Viral Pneumonia classes. The study concludes that Capsule Networks outperform Convolutional Neural Networks for smaller datasets, offering promising results for accurate COVID-19 detection in medical imaging. The study [28] presented "RADIC" an automated tool utilizing three deep learning (DL) models trained on radiomics-derived images to detect COVID- Initially, four radiomics methods analyze original CT and X-ray images. Subsequently, each DL model is trained on distinct sets of radiomics, X-ray, and CT images. Deep features are extracted from each DL model and transformed using Fast Walsh Hadamard Transform to generate a time-frequency representation of COVID-19 patterns. The discrete cosine transform combines these features, and four classification models are employed for classification. RADIC achieves 99.4% and 99% accuracy on two benchmark datasets for CT and X-ray respectively, outperforming related studies. The results demonstrate that DL models trained on radiomics-generated images are more effective for COVID-19 detection than those trained on original images. Additionally, incorporating deep features from DL models trained on various radiomics methods enhances diagnostic accuracy. The researcher in [29] explored the potential of combining X-ray imaging with deep learning algorithms to quickly and accurately diagnose COVID-19 patients. The proposed method enhances detection accuracy by fine-tuning established transfer learning models with appropriate layers. The study used a dataset of 2000 COVID-19 X-ray images for experimentation. Remarkable accuracy rates were achieved, ranging from 97.32% to 100% across various models, with EfficientNetB4 demonstrating outstanding performance. Furthermore, EfficientNetB4 showed excellent results in identifying lung diseases using a separate dataset of 4,350 Chest X-ray images. The findings underscore the effectiveness of fine-tuned transfer learning for efficient lung detection in medical imaging, particularly with X-ray images. This research presents a valuable tool for radiologists to aid in rapid and precise COVID-19 diagnosis and provides essential support for healthcare professionals in accurately identifying affected patients. In [30] the author investigated available CXR image datasets, comprising a total of 15,153 (dataset 1) and 4575 (dataset 2) images, were utilized. Three neural network models were trained using balanced subsets of dataset 1 (1345 images per class), balanced dataset 2 (1525 images per class), and an unbalanced full dataset 1. These models, including VGG16 and Inception Resnet (IR) utilizing transfer learning, alongside a custom-made Convolutional Neural Network (CNN), were employed. The accuracy, sensitivity, specificity, and F1 score for each model were assessed. VGG16 achieved an accuracy, sensitivity, specificity, and F1 score of 96%, 97.8%, 95.92%, and 97% respectively. IR attained an accuracy, sensitivity, specificity, and F1 score of 97%, 98.51%, 97.28%, and 99% respectively. The CNN model, identified as the top performer, yielded an accuracy, sensitivity, specificity, and F1 score of 97%, 98.21%,

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96.62%, and 98% respectively. These performance metrics were evaluated using the balanced dataset 1, and all models underwent 80:10:10 cross-validation. The highest accuracy rates of 97%, 96%, and 93% across all three datasets respectively were demonstrated by CNN. To ensure authentic pathology markers were employed for generalization, Gradient-weighted Class Activation Mapping (Grad-CAM) was utilized. The authors [31] introduced three advanced deep-learning models designed to detect specific lung ailments using chest X-rays. The first model, dubbed "CovCXR-Net," focuses on identifying COVID-19 (with two possible outcomes: COVID-19 present or normal). The second model, labeled "MDCXR3-Net," extends its scope to detect both COVID-19 and pneumonia (with three potential outcomes: COVID-19, pneumonia, or normal). Lastly, the "MDCXR4-Net" model is tailored to recognize COVID-19, pneumonia, and pulmonary opacity (with four potential outcomes: COVID-19, pneumonia, pulmonary opacity, or normal). These models outperform existing ones and achieve impressive accuracies of 99.09%, 97.74%, and 90.37% respectively across three benchmarks. In [32] introduced a robust method for classifying lung diseases from chest X-ray (CXR) images. To achieve accurate classification, three finely-tuned models are presented. Their effectiveness is assessed using a recently constructed CXR image dataset. Experimental results demonstrate that these fine-tuned models surpass existing lung disease classification methods, achieving an accuracy of 98%. The proposed approach shows promise for effective lung disease categorization. The researcher in [33] introduced a transfer learning method for predicting pneumonia using a collection of chest X-ray images. These images will be categorized into two groups based on specific parameters. The proposed model achieved an average accuracy of 94.54% on the dataset. Compared to prior quantitative and qualitative research, the proposed model (PDTLA) demonstrated strong performance. The modified model, named Pneumonia Detection Transfer Learning Algorithm (PDTLA), showed notable effectiveness in pneumonia detection.

III. RESEARCH METHODOLOGY

2.1 Deep Learning

In recent years, neural networks have made significant strides, particularly in computer vision tasks like image classification, generation, and object detection. Deep learning, characterized by networks with numerous layers of processing units, has been pivotal in these advancements. These networks, by passing the output of one layer to the input of the next, can extract complex hierarchical features from large datasets[6] . Feature extraction is fundamental to deep learning, utilizing multiple layers to pinpoint specific characteristics in incoming data. Unlike traditional models with fixed equations, deep learning algorithms directly extract valuable insights from data through computational methods, resembling human learning through experience. This approach has greatly improved the effectiveness of machine learning. Additionally, advancements in computer hardware have accelerated the pace of deep learning, enabling more efficient processing of vast amounts of data [7].

2.2.1 Convolutional Neural Networks

CNNs, widely utilized for image recognition tasks, are highly efficient deep learning models adept at handling high-dimensional data like images and videos[37]. They function similarly to ANN, employing two-dimensional filters to automatically detect important spatial and temporal features within image data. Comprising layers of convolutions and filters, CNNs serve as feature extractors, with lower layers identifying basic features such as edges, middle layers extracting color and shape information, and deeper layers recognizing objects [8]. Their success stems from their capability to learn hierarchical representations, mirroring the hierarchical learning process in biological brains. Input images are transformed into feature maps through convolutional layers, and CNN models are trained and evaluated by passing images through layers containing kernel-based filters, pooling, fully connected layers, and softmax for classification[36].

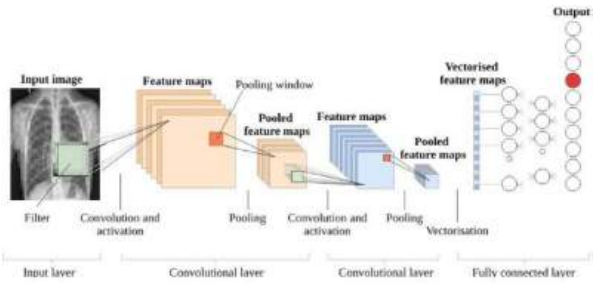

Fig. 1: Building blocks of CNN architecture

2.2.2 Pre-trained CNN Models

In the realm of deep learning, CNNs undergo initial training tailored to specific tasks, such as classification, utilizing large datasets to efficiently extract crucial image features. However, in medical data analysis, like pneumonia or COVID-19 detection, dataset sizes can be constrained, impeding accurate feature extraction and classification. Transfer learning addresses this obstacle by retraining models previously trained on akin tasks, improving learning in new challenges by transferring knowledge. This involves repurposing pre-trained weights in model layers as a starting point, adjusting them to suit the current task [9]. Transfer learning proves particularly advantageous in CNN implementations with limited data, enabling models trained on expansive datasets like ImageNet to serve in applications with smaller datasets.

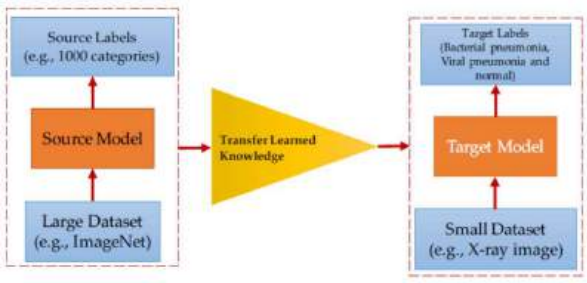

Fig 2: Diagram of Transfer Learning

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Many popular CNNs have been pre-trained using DL, like VGG-16, ResNet, AlexNet, DenseNet, XceptionNet, and MobileNet, have been used for COVID-19 and pneumonia detection.

2.2.2.1 VGG

The VGG (Visual Geometry Group) pre-training model is a convolutional neural network architecture developed by the University of Oxford, renowned for its depth and uniform structure. Featuring typically 16 or 19 layers, it employs small 3x3 filters in convolutional layers and 2x2 filters in max-pooling layers. Pre-trained on vast datasets like ImageNet, it learns general image features, facilitating transfer learning for specific tasks with smaller datasets. This versatility and effectiveness make VGG a widely used tool in computer vision, particularly for image classification and object detection tasks [10].

2.2.2.2 ResNet

The ResNet (Residual Network) pre-training model, introduced by Microsoft Research, addresses the challenge of training very deep neural networks by incorporating skip connections or residual connections. These connections allow information from earlier layers to bypass certain layers and be added directly to later layers, mitigating the vanishing gradient problem. The ResNet architecture consists of convolutional layers followed by residual blocks containing multiple convolutional layers with shortcut connections[35]. Typically, pre-trained on large datasets like ImageNet, ResNet models learn general features that can be fine-tuned for specific tasks. This approach, known as transfer learning, enhances performance on new tasks with limited data. ResNet is recognized for its effectiveness in training deep networks and its versatility in various computer vision tasks [11].

2.2.2.3 AlexNet

AlexNet is a landmark convolutional neural network architecture that revolutionized the field of computer vision with its exceptional performance in the ImageNet Large Scale Visual Recognition Challenge (ILSVRC) in 2012. Developed by Alex Krizhevsky, Ilya Sutskever, and Geoffrey Hinton, AlexNet features five convolutional layers followed by three fully connected layers, incorporating max-pooling layers and ReLU activation functions. Notably, it introduced dropout regularization to combat overfitting and leveraged parallel computing resources using multiple GPUs for efficient training on the massive ImageNet dataset. AlexNet's success demonstrated the effectiveness of deep learning for image classification tasks and laid the foundation for subsequent advancements in the field [12].

2.2.2.4 DenseNet

DenseNet, also known as Dense Convolutional Network, is a deep learning framework distinguished by its dense interconnection structure among layers. Developed by Gao Huang et al. in 2017, DenseNet combats the vanishing gradient problem by establishing direct links between all layers, allowing each layer to access feature maps from every preceding layer. This dense connectivity promotes effective feature propagation, encourages feature reuse, and facilitates gradient flow across the network, resulting in improved performance and parameter efficiency. DenseNet comprises densely connected dense blocks, featuring multiple layers with direct connections, often followed by transition layers to manage feature map growth. Typically, during training, DenseNet models are pre-trained on large datasets like ImageNet, where they learn general features adaptable to specific tasks through fine-tuning. This pre-training, alongside dense connectivity and efficient parameter sharing, enhances DenseNet's efficacy across a range of computer vision tasks, encompassing image classification, object detection, and segmentation [13].

2.2.2.5 XceptionNet

XceptionNet, abbreviated from Extreme Inception, is an advanced deep learning framework developed by François Chollet in 2017 as a refinement of the Inception architecture, aimed at enhancing efficiency and efficacy in image classification tasks. It distinguishes itself with its utilization of depthwise separable convolutions, which segregate spatial and channel-wise operations within convolutional layers. This segregation serves to decrease computational complexity and parameter count while preserving or enhancing model performance [14]. The XceptionNet structure comprises sequences of depthwise separable convolutional blocks, interspersed with max-pooling layers, and optionally followed by fully connected layers for classification purposes. Typically, XceptionNet models undergo pre-training on extensive datasets like ImageNet to grasp general features, subsequently fine-tuning for specific tasks. The integration of depthwise separable convolutions, coupled with pre-training and fine-tuning processes, underpins XceptionNet's efficacy across a spectrum of computer vision applications, encompassing image classification, object detection, and segmentation.

2.2.2.6 MobileNet

MobileNet is a convolutional neural network architecture optimized for mobile and embedded devices with limited computational resources, devised by Andrew G. Howard et al. in 2017. It employs depth wise separable convolutions to reduce computational complexity and model size while maintaining performance. Depth wise convolutions apply filters per input channel, followed by pointwise convolutions to combine outputs, significantly cutting down computation compared to traditional convolutionsClick or tap here to enter text.. MobileNet architectures typically feature a sequence of depth wise separable convolutional layers with optional down sampling layers to decrease spatial dimensions. These models are often pre-trained on large datasets like ImageNet for general feature learning, with subsequent fine-tuning for specific tasks. MobileNet's lightweight design and efficiency make it suitable for deployment on mobile and embedded devices, enabling tasks such as image classification, object detection, and semantic segmentation with constrained resources [15].

A. Table Description

The comments and results of related works of Deep Learning Techniques are summarized in Table (1).

Table 1. summary table

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	Study	Dataset Case Classify	Techniques Performance (Accuracy %)	
	Loey et al., 2020	69 COVID-19, 79 Normal, 79 Pneumonia bacterial, and 79 Pneumonia virus. Three classes	GAN and Transfer learning (Alexnet, Googlenet, and Resnet18)	Acc = 85.19% Acc = 81.48% Acc = 81.48%
	Abraham and Nair, 2020	Two dataset X-ray 950 and 78 Covid-19 = (453&71) Normal = (497&7) Binary class	CFS technique and Bayesnet classifier	Dataset1 = 91.2 % Dataset2=97.36 %
	Varela-Santos and Melin, 2020	Cohen's and Kermany's database 255 COVID-19 X-rays and 255 No Findings X-rays Binary class	GLCM+CNN	Acc = 97.4 %
	Sheykhivand et al., 2021	X-ray images COVID-19 = 371 Pneumonia Bacterial = 2778 Pneumonia Viral = 2840 Normal = 2923 Binary class	GANs and Transfer learning and LSTM	Acc= 99 %
	Adedigba et al., 2021	oseph Cohen, two dataset X-ray Covid-19 = (258&219) Normal = (4&1341) Binary class	DFT and Transfer learning	Acc= 97%
	Pandit et al., 2021	X-ray images COVID-19 = 224, Pneumonia = 700, and Normal = 504 Three classes	Transfer learning (VGG16)	Acc = 92.53%
	P and Annavarapu, 2021	219 COVID-19, 1345 Pneumonia, and 1341 Normal. Three classes	ResNet-50 model	Acc = 95.18%
	Barshooi and Amirkhani, 2022	X-ray images COVID-19 = 360 Normal = 4200 Binary class	Preprocessing (Gabor filter, Sobel, and LoG), DenseNet-201	Acc=98.50%
	Syarif et al., 2022	X-ray images COVID-19 = 676 Normal = 804 Binary class	Preprocessing CLAHE, UNAS-Net (CNN)	Acc=97.36%
	Nasiri and Hasani, 2022	Chest X-ray images: COVID-19 (125), Pneumonia (500), and no findings (500). Three classes	DenseNet169 and XGBoost	Acc = 89.70%
	Sharma et al., 2022	Chest X-ray images: COVID-19 (1784), Pneumonia (1345), and Healthy (1755) Three classes	COVDC-Net	Acc = 96.48%
	Verma, B et al., 2023	Radiography Database, which includes chest X-Ray scans of COVID-19, Normal, and Viral Pneumonia. Binary class		

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	Study	Dataset Case	Classify	Techniques Performance (Accuracy %)
	And three classes Conv-CapsNet Acc=96.47% for multi class Acc=97.69% for binary Attallah et al., 2023 two benchmark datasets (CT and X-Ray) for COVID-19 are employed Three classes RADIC Acc= 99% For First dataset Acc=99.4% For second dataset Talukder et al., 2023 used a dataset of 2000 COVID-19 X-ray images Binary class Xception InceptionResNetV2 ResNet50 ResNet50V2 EfficientNetB0 Proposed (EfficientNetB4) Acc= 99.55%, Acc= 97.32%, Acc=99.11%, Acc=99.55%, Acc=99.11% Acc=100% Mohan et al., 2024 uses two open source CXR image dataset having a total of 15,153 (dataset 1), and 4575 (dataset 2) Three classes VGG16 and Inception Resnet (IR) Acc= 96% Acc=97% Bennour et al., 2024 CIDC, CXRP, CRD dataset Binary classes and Three classes CovCXR-Net, MDCXR3-Net MDCXR4-Net 99,09 %, for binary class 97.74 %, for multi class and 90,37 for multi class Shimja et al., 2024 CXR image dataset Multi classes VGG-16 98% Baig et al., 2024 uses a public dataset available on Kaggle [34] Binary classes PDTLA model 94.54%		

IV. Results And Discussion

This paper delves into the utilization of deep learning (DL) techniques for diagnosing COVID-19 and pneumonia through the analysis of X-ray images, synthesizing findings from 18 studies from (2020 to 2024) show cased in Table The common thread across these studies is the adoption of DL convolutional neural network CNN pre-training algorithms, which is instrumental in improving detection accuracy and overall performance. A notable observation is the disparity between binary and multi-class classification approaches: binary classification consistently demonstrates superior accuracy and performance metrics compared to its multi-class counterpart. employing binary classification leverage a diverse array of DL models, including Xception, InceptionResNetV2, and Efficient NetB4, achieving remarkable accuracy rates ranging from 97.32% to a perfect 100%. Conversely, multi-class classification poses inherent challenges, employs the RADIC technique to attain commendable accuracy rates of 99% and 99.4% across two distinct datasets. While binary classification excels in precision, multi-class classification offers opportunities for refinement through innovative methodologies like RADIC. These insights underscore the transformative potential of DL in medical imaging, promising enhanced diagnostic accuracy and patient care outcomes in combating infectious diseases.

V. Conclusion

The emergence of COVID-19 as a global pandemic has underscored the critical need for accurate and timely detection to mitigate its spread and save lives. Chest X-ray (CXR) imaging offers a promising avenue for diagnosis due to its accessibility and preservation capabilities. However, distinguishing COVID-19 pneumonia from other respiratory ailments presents a formidable challenge. This comparative analysis of deep learning (DL) techniques in COVID-19 diagnosis highlights the pivotal role of binary and multi-class classification approaches. While binary classification consistently outperforms in accuracy and performance metrics, multi-class classification, particularly through innovative techniques like RADIC, shows potential for refinement. The deployment of sophisticated DL models such as Efficient NetB4 demonstrates remarkable accuracy rates, emphasizing their efficacy in

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discerning COVID-19 and pneumonia. Moving forward, integrating the strengths of both classification approaches is essential for advancing DL-based medical image analysis and empowering clinicians with robust diagnostic tools to combat infectious diseases effectively.

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Improving Biology Learning Through Augmented Reality Technology in Indonesia: A Review

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Abstract – Biology is always considered difficult either to teach or to learn. As a field of study that learning about living subjects, biology has very broad and abstract concepts. Many students find the abstract concepts of biology are hard to understand. Some students even feel that studying biology is a dull experience. This type of perception in students subsequently led to low academic achievement. Hence, an innovative and attractive learning approach is needed for teaching biology. Augmented Reality (AR) technology has a great possibility to improve biology learning experience due to its ability to concretize the abstract concepts in biology by providing natural interaction between virtual and real-time situations simultaneously. In the last decade, numerous research of implementing AR in education including biology learning have been studied globally and nationally. In order to evaluate the effectiveness of AR in improving biology learning especially for students in Indonesia, this literature review research is conducted. The reviewed articles are retrieved through Google Scholar database with the assigned criteria published between 2020 to 2024, AR implemented, biology learning, student perception, and/or achievement in biological studies. The analysis shows that implementing AR in biology learning increases students' interest, learning motivation, involvement, collaboration, independent learning, knowledge retention, and achievement. However, the conflicted finding is reported regarding the influence of AR on students' critical thinking ability. Technical problems related to downloading and distributing AR applications are the main challenge that has been reported when using AR in biology learning.

Keywords – biology learning, student perception, student achievement, augmented reality (AR)

I. INTRODUCTION

Biology is dubbed as one of the most difficult subjects, either to teach or to learn. Numerous studies have been conducted to investigate why students find biology hard to learn. The interesting thing is that after decades of research, the problem persists globally [1-4] and nationally [5-8].

While students' difficulties in learning biology is a known issue, it is important to understand the contributing factors that make learning biology is a hard task. The broadness field of study in biology, with many abstract and invisible contents [4] along with frequently used of scientific terms, are the most prominent issue regarding biology learning difficulties [8]. Many students also find that the subject is boring [1, 9] or less attractive either to be learned or as a related future career [10]. These factors can easily lead to students' low academic achievement. Hence, an innovative and attractive teaching and learning techniques are needed to overcome these learning problems in biology.

Augmented Reality (AR) is a technology that enables users to experience realistic interaction with both virtual and real-time situations simultaneously. The technology was termed as "Augmented Reality" in 1993 [11]. An overview study of AR by [12] shows that the technology has been implemented in many areas including tourism, archaeology, art, commerce, industrial manufacturing and restoration, education, emergency management, entertainment, and leisure. AR is especially valuable in situations where the objects or the even to be thought are not visible, demonstrating dangerous situations, concretizing abstract concepts, and presenting confusing levels of information [Yilmaz et.al., 2018 *in* 2]. Augmented Reality also has a great possibility to replace or enhance laboratory experience in students learning [13-15]. However, some still feel that cadavers and real experimental animals when related to studying anatomy cannot be replaced by virtual objects presented by AR [2].

Nevertheless, recent studies of implemented AR in teaching and learning show the possibility and ability of AR to improve the learning process and eventually improve students' perception and achievements. This paper will evaluate the effectiveness of implementing AR in biology learning especially in Indonesia.

II. RESEARCH METHODOLOGY

A literature review [16] type of research is presented in this paper. The research is conducted by reviewing published research articles regarding Augmented Reality (AR) in teaching and learning biology in Indonesia. The order of tasks in conducting the research consists of collecting the library material, studying the presented data, managing the data, and analyzing it so it can be concluded and reported. The articles are analyzed qualitatively with Miles and Huberman Model [17], where the collected data will be reduced, analyzed, and then concluded.

The articles are selected through Google Scholar and should meet the designed criteria which are published within 2020 to 2024, AR implemented, biology learning, students' perception, and/or achievement in biological studies. Initially, 30 articles were selected. However, further inspection showed that although the AR-integrated media were successfully created, their effectiveness in biology learning process (indicated either by students' academic achievement or observed scholastic learning behavior before and after using AR media) had not been studied. Another reason for eliminating the initially selected articles was the science concepts, which were reported to be taught by using AR, were not part of the

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biology concepts. This case mostly applied to articles that implement AR at preschool and elementary levels of education. Ultimately, only 12 research articles were qualified to be reviewed.

III. RESULTS AND DISCUSSION

The articles analysis (Table. 1) showed that Augmented Reality (AR) technology had been implemented into different types of learning media, biology concepts, types of students, and levels of education. The AR technology has been incorporated into marker books/sheets [9, 18, 19, 21, 23-28], text book [18], learning module [20], and e-comic [22]. It was used to teach the names of fruits in pre-school [19], digestive [21, 25] and human circulatory system [22, 26] in elementary school, human reproductive system in middle school [20], arthropod [18], plant life cycle [9], sense of hearing [24], structure and function of plant and animal tissues [28] in high school and the concept of cell [23] in university for undergraduate students. The AR technology was able to help both regular students [9, 18, 19, 21-28] and students with special needs [20] in learning biology. The AR learning media was mostly developed to teach students in high school [9, 18, 21, 24, 27, 28] and elementary school [21,22,25,26] which are 50% and 25% of the total figure respectively.

Generally, AR has shown a lot of benefit in supporting biology learning in Indonesia education. The students' achievements and perception toward biology has been improved when AR is introduced to the learning process. However, some articles report that difficulties and problems are also found and encountered while teaching biology with AR.

Table 1. Implemented Augmented Reality in Biology Learning

Research Article	Result of Study
[18]	Augmented Reality is very feasible in supplementing practical work for learning Arthropod in Islamic-based science for High School students. **The implemented technology increases student motivation and enthusiasm in learning.** However, technical problems such as weak signals, unsupported devices, and unavailability of the application in Play Store/App Store make the downloading process difficult.
[9]	**Augmented Reality able to improve high school student's understanding of plant life cycle concepts** but does not improve student's creative thinking skills. Augmented Reality is suitable to be used in teaching high level cognitive concepts.
[19]	**Augmented Reality Book statistically helps improve children's motivation and understanding in learning fruit names in pre-school.**
[20]	**Augmented Reality learning media is quite effective in increasing middle school student's enthusiasm and understanding, including students with special needs, in learning reproduction concepts.** However, adjustment is still needed because the incorporated videos are less effective for students with hearing impairment.
[21]	**Implementation of Augmented Reality technology through a scientific approach statistically increases high school student's critical thinking in learning the digestive system concept.**
[22]	**Integrated Augmented Reality in Electronic Comic Books significantly increases elementary student's interest in learning the human circulatory system.**
[23]	**Implementing smartphone-based Augmented Reality technology able to increase undergraduate student learning motivation, understanding, scientific vocabulary, discussion participation, and critical thinking skills in learning the concept of Cell.** Augmented Reality Technology makes the visualization of cell materials that are invisible to the five senses possible
[24]	The android-based Augmented Reality (AR) application successfully displays the 3D object of the ear organ. **The AR technology increases student interest in learning the sense of hearing concept and helps high school students understand the structure and function of the ear.**
[25]	Augmented Reality media in learning digestive system initiate positive feelings in elementary students. **The using of AR increases student interest and learning motivation.** However, support from educators, the government, parents, and schools are needed to successfully implement AR as Interactive learning media.
[26]	**Augmented Reality in learning media effectively increases elementary student's post-test scores in the circulatory system concept.**
[27]	**Implementing Augmented Reality in Biology learning improves high school student motivation and knowledge retention. Student involvement, collaboration, and independent also reportedly strengthen.**
[28]	**Augmented Reality (AR) incorporated into biological learning effectively improve high school student motivation in learning structure and function of plant and animal tissue.** However, the motivation to learn using AR technology does not linear with student motivation in learning science.

3.1 Benefit of Augmented Reality (AR) in Biology Learning

Based on the review result, there are some main advantages to incorporating AR into biology learning environment. [18] in her study observed that AR technology increased student interest, enthusiasm, and motivation in learning. It also provided and encouraged independent learning in students. The same findings also reported by [20], [21] and [27], seeing real images of objects virtually in 3D piqued student interest in learning and subsequently encouraged the student to be actively involved in the learning process.

The ability of AR to visualize abstract concepts in the real world engages student attention and interest. Motivating students to learn and enhancing student understanding and knowledge retention. When subjected to the same concept of study student who learned with AR tend to score higher than their counterpart who learned through the conventional method. This finding was observed by [19] in preschool students, [26] in elementary school students, and [9] in high school students. In their research, [27] stated that student knowledge retention was increased by AR. The 3D technology in AR can maximize the information processing and deliver it to the long-term memory.

Another benefit that was also reported by researchers who implemented AR in biology learning was the increase in student collaboration and critical thinking skills. [23]

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observed that using smartphone-based AR in the learning process increased student interest and led to an increase in participation in class discussions and critical thinking skills. The ability of AR to increase student critical thinking was also reported by [21]. They saw that in the learning environment where augmented reality was used as learning media, students were encouraged to investigate and collaborate which then led to the development of their creative thinking skills. Student actively and independently tried to find information in AR by implementing learning media to solve the predetermined problem without relying on their teacher. However contradictory result was reported by [9], while AR able to improve student knowledge and understanding, it was failed to improve student's creative thinking skills due to time limitation in learning.

3.2 Limitation of Augmented Reality in Biology Learning

Even though implementing AR technology has been reported to improve biology learning, some problems and difficulties are also detected in the learning process. Two main issues of AR implementation in biology learning were reported in the selected research articles of this review paper. (1) learning with AR is time-consuming [9] and (2) technical problems with AR applications. The technical problems were mainly related to downloading and distributing the AR application which consisted of the size of the APK file being quite big [20], unsupported device, problems with the internet signal [18], and app unavailability in the app store/play store [18, 24].

IV. CONCLUSION

In conclusion, Augmented Reality (AR) technology has been positively implemented in biology learning from pre-school to university level of education. It shows a positive impact either on typical students or students with special needs. Incorporating AR into biology learning media can improve student motivation and interest in biology learning, subsequently improving their knowledge and understanding of biology concepts. However, some issue, mainly related to technical problems, still needs to be addressed for successfully implementing AR into the biology teaching and learning process.

Another issue that also came to light when conducting this research is the fact that the successfully designed AR as teaching and learning media has not been tested in the actual learning environment. Thus, future research should be conducted to evaluate the ability of these AR media to improve students' learning achievement and experience. It is also necessary to conduct an intensive study on which concepts in biology that teachers find difficult to teach and/or students find difficult to learn. The information will be beneficial to decide the concepts that the AR technology is necessary to be implemented.

To summarize, AR technology, with its vast development, has ~~a~~ great potential to be one of the best tools to be incorporated in biology future learning. However, it also has issues and limitation. In order to be successfully implemented into Indonesia's learning system it will need support from the government, schools, teachers, students, and parents.

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Network Intrusion Detection Based on Machine Learning Classification Algorithms: A Review

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Abstract – The worldwide internet continues to spread, presenting numerous escalating hazards with significant potential. Existing static detection systems necessitate frequent updates to signature-based databases and solely detect known malicious threats. Efforts are currently being made to develop network intrusion detection systems that can utilize machine learning techniques to accurately detect and classify hazardous content. This would result in a decrease in the overall workload required. Network Intrusion Detection Systems are created with a diverse range of machine learning algorithms. The objective of the review is to provide a comprehensive overview of the existing machine learning-based intrusion detection systems, with the aim of assisting those involved in the development of network intrusion detection systems..

Keywords: Intrusion Detection Systems, Machine learning, SVM, Random Forest.

I. INTRODUCTION

Currently, the intrusion detection systems provides a key component when it comes to making sure the systems owners are safe against the cyber-threats. IDS (Intrusion Detection System) is a forms of gather and analyze network data to classify types of attacks[1]. For the network traffice, it is the used of many day-to-day features creation in the form of detecting many types of attacks [2]. Due to the rapid increase in the data that is being generated via the internet in daily life, the industry faces a severe challenge[3]. Datasets are sets ofs situation which includemany features and they are relating to the response of the intrusion detection system[4]. Understanding the type of data that is being collected becomes more important because it has attack types and attributes[5]. The KDD'99 cup is the most widely used dataset for intrusion detection systems. It is used to construct predictive models that can distinguish between different types of intrusions or attacks [6]. The intrusion detection system constructs the model using security datasets such as KDD99 and NSL-KDD [7]. The system has many features, akin to a predictor, that differentiate between normal attacks and aberrant ones. These features are the focus of the system [8] .The categorization model divides the data set into two parts: a training stage and a testing stage [9]. The abundance of characteristics with large dimensions results in intricacy during the training process and consumes valuable time. Hence, it is necessary to carefully choose a subset of valuable and pertinent features from the complete set of features in order to enhance the model's performance during the testing phase [10]. Data preparation is a crucial step in enhancing the quality of a classification model's performance, as stated by machine learning algorithms[11]. The process of solving various forms of large data sets is a highly important phase [12].Machine Learning (ML) techniques, which are commonly employed in computer security data sets, have lately gained popularity in the field of security technology [13]. It aids in the examination and management of large volumes of data and identifies the crucial characteristics that are employed in different feature selection strategies [14]. Intrusion Detection System (IDS) is a widely employed machine learning classifier that is utilized to differentiate between different types of attacks inside a given class [15]. Several supervised classification algorithms are commonly used in Intrusion Detection Systems (IDS), including Decision Trees, Naïve Bayes, K-Nearest Neighbor, Tree C4.5, Random Forest, Support Vector Machine, and Logistic Regression [16]. Assessment of different classifiers is based on the list of statistical measures above all, the results of the confusion matrix-dependent diagnoses are considered to distinguish the kind of dangers [17]. The goal of the article is to contribute to the network intrusion detection system development process by providing an exhaustive study of the present machine learning-based intrusion detection systems.

The remainder of the review is arranged as follows: In Section 2, the types of intrusion detection systems are described, as are network attacks and the types of them, additionally, the algorithms of machine learning and classical system architecture are explained. In Section 3, the study provide a review of the literature on intrusion detection systems. Section 4, compares and discusses intrusion detection systems. In Section 5, the conclusion is presented in the final part.

II. INTRUSION DETECTION SYSTEM

Intrusion detection systems (IDS) monitor network traffic data on systems or networks through the use of hardware or software. An Intrusion Detection System (IDS) typically reports any instances of policy violations or security breaches. Figure 1 displays a standard block diagram of an Intrusion Detection System (IDS) [18]. An intrusion detection system includes a static database that contains information about known malicious activity. The input is compared to the records in this database, which encompass system activity or network traffic. If the input is malicious, the

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severity of the threat is determined and a suitable countermeasure is implemented. The countermeasures range from simple notifications to halting the potentially hazardous activity. The two predominant varieties of intrusion detection systems (IDS) are host-based IDS and network-based IDS. In networking contexts, Intrusion Detection Systems (IDS) are employed as a means to detect and locate unauthorized access attempts. It detects instances of malicious utilization of computer network resources. This feature is essential for recognizing internet threats that originate from hosts and networks[19].

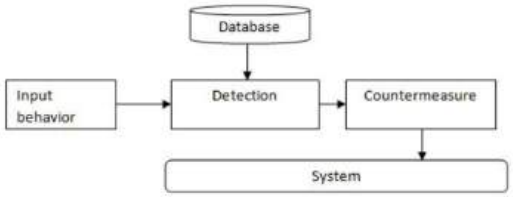

Fig 1: Block Diagram of IDS*[20]*

2.1. NETWORK ASSAULTS AND THEIR KINDS

Network assaults refer to unauthorized actions aimed at governmental or commercial IT assets, with the objective of causing destruction and pilfering confidential information. Attacks can be classified into two distinct categories: aggressive and passive. Presently, hackers are engaged in the act of altering confidential information or fortifying computer systems with excessive security measures. Some examples of cyber threats include Trojan horses, worms, viruses, code injections, network data probing, and login information theft. The prevalent and widely recognized active attacks include denial of service, replay, repudiation, masquerade, and message alteration [19]. A "passive attack" is an attempt to access important data by observing and monitoring sensitive information without causing any disruption to system resources. Two prevalent and widely recognized passive attacks are traffic analysis and message content release.

The attack can manifest in several forms, and it can be either proactive or passive.

- The Definition of Service Denial (DoS) is a DDOS|DDoS| Denial of Service(DOS), its purpose is to starve network and system resources for computer networks or to just send lots of unnecessary data to the network to make its termination.
- Scanning attacks' investigations require the following two steps: identification of network weaknesses and attackers. Next, the victim will get DMCP bypass which leads to all legitimate procedures.
- Remote to Local (R2L): Such a scenario implies that an intruder tries to make a remote login directly, therefore it is a hacking attempt that is likely going to be a brute force attack that pretends to be a genuine user.
- User to Root (U2R): An intruder who has user-level access in an attempt to take over the high-level authority.

2.3. CLASSICAL SYSTEM ARCHITECTURE

The typical IDS architecture consists of five essential modules: talk about data gathering, data experience, categorizing or gunning and invading prevention. The preprocessing module of our system takes on all necessary data from benchmark datasets that find use in wavelet transform and applies a sequence of preprocessing operations. The very first step in any analysis process is data purification, and it is in this module data preparation takes care of it. Data preparation involves a set of fundamental stages such as: data combination, cleansing, standardization, alteration, really the degree of data reduction and the binning of categorical data. The feature selection module employed resilient and intelligent algorithms to identify the crucial traits required for enhanced classification. By utilizing the selected attribute for categorization, the classifications exhibit enhanced precision. The decision manager, who is responsible for each module, uses the rules recorded in a rule base. Usually, the rules are saved in the form of IF-THEN expressions (Fig. 2) [21].

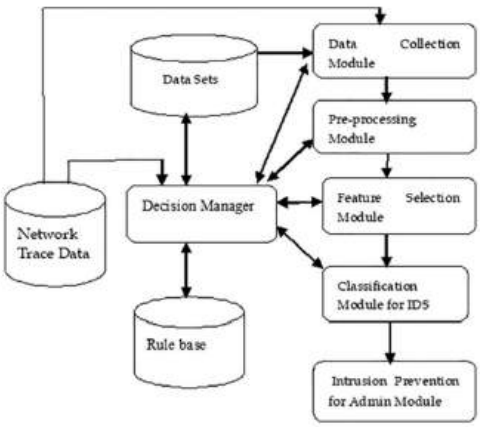

Fig 2. Classical System Architecture of IDS.

2.4. MACHINE LEARNING ALGORITHMS

The learning algorithm extracts the pertinent data from the training sets. Machine learning algorithms can be classified into two categories: semi-supervised and supervised. While an unsupervised learning algorithm navigates through unfamiliar data, a supervised learning system [22] acquires information from tagged samples. Prior to developing a decision model, the classifier goes through a training step. Below, we

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present a detailed description of the pivotal machine learning classifier that is capable of detecting network flow attacks.

2.4.1. SUPPORT VECTOR MACHINE.

Finding boundaries in multidimensional space is accomplished by categorization and guesswork using the Support Vector Machine (SVM) supervised learning technique. It uses a hyperplane to separate data points into two classes, +1 and -1. Therefore, ordinary data is represented by a +1, and dubious data by a -1.The hyperplane can be expressed as follows: WX + b = 0, where b is a scalar and W= {w1, w2,..., wn} is the weight vector for n attribute values{x1, x2, x3,..., xn}. One of SVM's preferred features is its ability to

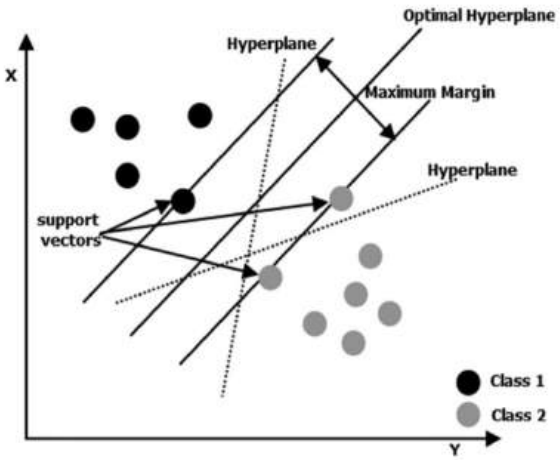

Fig 3. Multiclass Support Vector Machine.

classify using support vectors instead of the complete dataset, which makes it incredibly resilient to outliers and allows for exceptionally accurate guessing. Discovering the linear optimal hyper plane is the goal of the support vector machine in order to amplify the partition boundary between the two classes .It is decided that the hyperplane with the peak margin is the best one[23]. This machine does multiclass classification [24], which is achieved by creating a support vector machine (SVM) for each of the two classes together "Figure. 2".

2.4.2. DECISION TREE ALGORITHM (DT)

DT algorithms generally deduce relevant classifications. The decision tree consists of leaf nodes, edges, and root nodes. The initial node is the root node, which does not have any incoming nodes; the second node is an internal node, and the rest of the nodes are referred to as decision nodes (leaf). We evaluate the internal nodes using a diverse range of criteria and characteristics. When constructing a decision tree based on attribute features and information gain values, we choose the decision node that has the maximum information gain value. Decision trees [25]exhibit a high level of accuracy and efficiency in classifying data.

2.4.3. NEAREST NEIGHBOR ALGORITHM (K-NN)

Comparing the K-NN classifier to other classification algorithms, it is incredibly easy to learn and straightforward. It determines the separation between data points and assigns an unlabeled data point to the student who is closest to it [26]. The data is allocated to the fellow citizen's class if k = 1. When the K value is high, classification and prediction take a long time (lazy learners). The value of k will therefore depend on the classification time. Numerous studies employ various formulas, including Manhattan, Murkowski, and x Euclidean, to calculate the distance between neighboring nodes. When two data points with m quantitative features are separated by a Euclidean distance, with x=(x1, x2,..., xn) and y=(y1, y2,..., yn),

$$d(x,y) = \sqrt{\sum_{i=1}^{m}(x1 - y1)^2} \quad (1)$$

Assume y is the data point that is closest to x. The steps of the K-NN algorithm

1. Keep the labeled NSL-KDD Training data set in storage.
2. K is the quantity of nearby nodes.
3. Determine the distance between the test and training samples (x, y) and the two data points (x', y'). Then, designate the node that is closest to its neighbor in terms of distance.
4. Carry out step 4 for every data point in the testing dataset.
5. Come to an end. These types of indolent learners take longer to categorize and perform the best in predictions.

2.4.4. RANDOM FOREST (RF)

A decision forest classifier, which is randomly generated, is capable of handling both regression and classification tasks. This classification technique generates a multitude of decision trees by employing a random feature selection process. Utilize the voting methodology from different decision trees to allocate each desired value. The upper echelon of voters decides the definitive and more precise forecast [27]. This technique exhibits a higher accuracy rate and prediction capability due to its ability to create fewer classification errors [28].

2.4.5. NEURAL NETWORK ALGORITHM (NN)

The neural network algorithm consists of three layers: the input layer, the hidden layer, and the

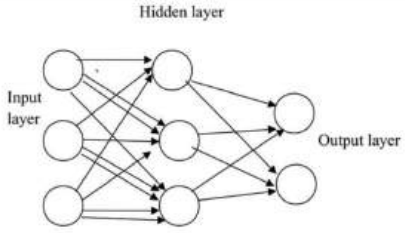

Fig 4. Neural Network

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output layer. Upon completion of data processing, the output layer receives the data from the hidden layer. A multi-layer perceptron algorithm effectively detects and accurately recognizes several threats. This algorithm utilizes the back-propagation technique, which is rooted in the principles of feed-forward and back-propagation. The neural network illustrated in "Figure 3" consists of input, hidden, and output layers.
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III. LITERATURE REVIEW

This article examined recent studies on machine learning methodologies for detecting intrusions. This study specifically examines recent publications from the years 2020 to 2024 as shown in “Table 1”. In addition, this article examines various machine learning techniques, such as single, hybrid, and ensemble classifiers that are employed in the field of intrusion detection. Further investigation is still necessary to develop machine learning algorithms for intrusion detection systems, using the comparative findings from relevant studies.

Abrar et. al. in 2020 [29], created a highly efficient intrusion detection system (IDS) by employing machine learning classifiers to identify and prevent network intrusions, safeguarding network assets. The study utilized a range of machine learning classifiers, such as Support Vector Machines (SVM), k-Nearest Neighbors (KNN), Logistic Regression (LR), Naive Bayes (NB), Multi-Layer Perceptron (MLP), Random Forest (RF), Extra Trees Classifier (ETC), and Decision Trees (DT), to assess their effectiveness on the NSL-KDD dataset. The study conducted preprocessing on the dataset to eliminate extraneous attributes, and subsequently trained and evaluated the model using various feature subsets. The test results demonstrated that the RF, ETC, and DT classifiers achieved an accuracy rate of 99% for all sorts of attacks, employing various feature sets. This demonstrates the efficacy of the proposed approach in accurately predicting network intrusions while also minimizing the required workload.

Kiran et. al. in 2020 [30], developed an IoT-specific intrusion detection system (IDS) using machine learning to detect future threats. The procedures encompassed constructing a test platform to replicate an Internet of Things (IoT) setting, developing a hostile system to generate malicious assaults, collecting the flow of data within the network, and generating machine learning algorithms to categorize the attacks. The Sensor480 dataset consists of 480 records and includes attributes that represent both normal and attack scenarios. The classifiers, including SVM, Naïve Bayes, Decision Tree, and Adaboost, exhibited accuracy levels ranging from 97.89% to 100%. Among them, the Decision Tree model had the best accuracy, attaining a perfect score of 100%. In summary, the study proved the efficacy of machine learning algorithms in accurately categorizing attacks in IoT networks.

Elmrabit et. al. in 2020 [31], assessed twelve machine learning (ML) algorithms to identify abnormal behaviors that suggest cyber assaults. The evaluation was conducted using three datasets: UNSW-NB15, CICIDS-2017, and ICS cyber-attack. The approach entailed utilizing both traditional machine learning algorithms and deep learning algorithms to train and test the data. Subsequently, the performance was assessed using diverse metrics. The study attained the highest level of accuracy using the Random Forest (RF) approach, with 88.5% accuracy for binary classification in the UNSW-NB15 dataset and 99.9% accuracy for binary classification in the CICIDS-2017 dataset. RF attained an accuracy of 73.6% in the UNSW-NB15 dataset and an accuracy of 99.9% in the CICIDS-2017 dataset for multi-class classification. The study revealed that RF had superior performance compared to the other algorithms in the majority of situations, therefore confirming its efficacy in identifying abnormal behaviors.

Injadat et. al. in 2020 [32], suggested a multi-stage optimized architecture for network intrusion detection system (NIDS) that utilizes machine learning to decrease computational complexity while preserving detection performance. The study employed two contemporary intrusion detection datasets, namely CICIDS 2017 and UNSW-NB 2015, and assessed their performance using diverse measures including accuracy, precision, recall, and false alarm rate. The proposed framework incorporates data pre-processing, feature selection, and hyper-parameter optimization strategies to improve the performance of the NIDS. The findings demonstrated that the BO-TPE-RF optimized random forest classifier, employing Bayesian optimization with Tree Parzen Estimator, achieved a superior detection accuracy of more than 99% for both datasets. Furthermore, it exhibited a higher level of precision compared to alternative optimization techniques and recent scholarly articles, with an improvement of 1% to 2%. Additionally, it demonstrated a reduced rate of false alarms by the same percentage. In addition, the feature selection approaches successfully decreased the size of the feature set by over 60% and further reduced the necessary training sample size by 33-50% compared to the training sample size after implementing the oversampling methodology.

Mebawondu et .al. in 2020 [33], a network-based Intrusion Detection System (NIDS) was created utilizing machine learning algorithms for the purpose of identifying and thwarting network intrusions. The study employed the UNSW-NB15 benchmark network intrusion dataset and applied feature weighting techniques such as information gain and gain ratio to determine the most significant features. The study constructed classification models utilizing the Naive Bayes (NB) and C4.5 algorithms, employing the

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chosen features. The findings demonstrated that the C4.5 algorithm surpassed NB, attaining a 90.44% accuracy compared to NB's 75.09% accuracy in a two-class model simulation. The trials demonstrated that the accuracy of the technique for real-time network intrusion detection rose as the training ratio grew, indicating its feasibility.

Thaseen et.al.in 2020 [34], network breaches were identified using machine learning methods, including Naive Bayes, Support Vector Machine, Random Forest, and KNearest Neighbors, without the need to decrypt the packet contents. The dataset was generated by employing Wireshark to collect packets transported across a network. Subsequently, the study scrutinized their characteristics to categorize them as encrypted, unencrypted, malicious, or normal. The study obtained accuracy scores of 83.63%, 98.23%, 99.81%, and 95.13% for the Naive Bayes, Support Vector Machine, Random Forest, and KNearest Neighbors models, respectively. The Random Forest algorithm was determined to be the optimal classifier, achieving a remarkable accuracy rate of 99.81%. In summary, the study highlighted the efficacy of machine learning methods in categorizing network packets and identifying intrusions without the need to decrypt their contents.

Islam et. al. in 2021 [35], proposed a system based on learning to identify and safeguard IoT infrastructures from assaults. The study examined various intrusion detection systems (IDS) that utilize both shallow and deep machine learning models. The methodologies utilized included data analysis approaches, preprocessing of datasets, and the utilization of several machine learning and deep learning algorithms for training sets. The models' performance was assessed using benchmark datasets including NSL-KDD, IoTDevNet, DS2OS, IoTID20, and the IoT Botnet dataset. The performance of these models was evaluated using multiple performance metrics including accuracy, precision, recall, F1-score, Mathew correlation, and Cohen's Kappa coefficient. The findings demonstrated that deep machine learning (IDS) surpassed shallow machine learning in detecting IoT assaults. The Bi-LSTM model demonstrated superior performance compared to the other four deep learning models (DNN, DBN, LSTM, and stacked LSTM) in terms of both train and test accuracy. The SVM model achieved exceptional performance, exhibiting 99.44% accuracy in both training and testing, which is on par with the performance of NSL-KDD, IoTDevNet, and DS2OS. The stacked LSTM model attained a high accuracy of 98.19%, which was similar to the results obtained using a cascaded RNN-based technique.

Xu.in 2021 [36], machine learning approaches were used to detect intrusion traffic, hence enhancing the security of computer networks. The study examined a subset of data from the KDD99 dataset and implemented both supervised and unsupervised learning algorithms. The effectiveness of different classifiers, including as Naive Bayes, decision trees, support vector machines, and logistic regression, was assessed and compared to identify the most efficient method for identifying network intrusions. The investigation determined that the decision tree classifier exhibited superior performance, with a detection accuracy rate of 0.9207 and an F1-score of 0.91. The study also examined the potential of an enhanced K-means clustering algorithm for detecting changes, and demonstrated its superior performance in identifying network intrusions in probing, U2R, and R2L attacks.

Carneiro et. al.in 2021 [37], the performance of two machine learning models, Random Forest (RF) and K-Nearest Neighbors (KNN), trained with two different labels (class and attack type), was compared in the CIDDS-001 dataset for network-based intrusion detection systems. Initially, the dataset underwent a process of cleaning. Subsequently, the RF and KNN models were trained using both sets of labels. Finally, the models were evaluated using metrics such as accuracy, precision, recall, and F1-score. The CIDDS-001 dataset is a collection of network traffic data that includes both regular network activity and various forms of cyber-attacks, including ping scans, port scans, brute force attacks, and denial of service attacks. The study's near-100% accuracy for the class label was likely influenced by overfitting. The RF model achieved an accuracy of 95.60% and an F1-score of 91.34% for the AttackType label, whereas the KNN model achieved an accuracy of 96.94% and an F1-score of 91.61%. The results suggest that the AttackType label shown favorable performance for intrusion detection.

Kumar and Bhatnagar.in 2021 [38], created an advanced intrusion detection system (IDS) with improved capabilities for detecting network threats. In order to accomplish this, the authors suggested a structure for an Intrusion Detection System (IDS) that is implemented on the KDD Cup99 dataset, utilizing machine learning algorithms including Random Forest, Support Vector Machine (SVM), and Naïve Bayes to enhance the precision, accuracy, and recall value of the detection process. Upon conducting a performance analysis of each method, it was concluded that Random Forest exhibited the highest suitability, with an accuracy of 99.99% and a detection rate of 0.999. The dataset underwent preprocessing using techniques of component analysis and was subsequently divided into separate training and testing datasets. The study determined that Random Forest had the highest precision and detection rate out of all the classifiers that were proposed.

Amanoul et. al. in 2021 [39], assessed the efficacy of different machine learning (ML) and deep learning (DL) algorithms for intrusion detection systems (IDS) by analyzing the KDD Cup 99 dataset. The study utilized machine learning (ML) techniques such as Bayes Net and Random Forest, as well as deep learning

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(DL) algorithms like Neural Network, RNN, and LSTM. The ML algorithms exhibited accuracy levels ranging from 98.7869% to 99.9824%, with Random Forest attaining the best accuracy. Conversely, the DL algorithms demonstrated decreased accuracy, with LSTM surpassing RNN. In summary, the study concluded that the Random Forest algorithm demonstrated the highest level of accuracy when applied to Intrusion Detection Systems (IDS) using the KDD Cup 99 dataset.

Krishnaveni et.al.in 2021 [40], created a very effective intrusion detection system for the cloud environment by employing ensemble-based feature selection and classification approaches. The study employed real-time honeypot datasets, feature selection approaches, and ensemble classifiers to attain optimal accuracy and minimize false alarms in detecting network intrusions. The Univariate Ensemble Feature Selection (UEFFS) method was utilized on three intrusion datasets (Honeypot, NSL-KDD, and Kyoto) and shown superior accuracy rates compared to other feature selection measures. The study employed precision-recall analysis and ROC-AUC analysis to evaluate the efficacy of the suggested strategy in enhancing the accuracy and reliability of intrusion detection systems.

Pise.in 2021 [41], utilized machine learning techniques to detect intrusions by applying them to the KDD99 benchmark dataset. Additionally, I assessed the effectiveness of various classifiers in this task. The tactics employed encompassed feature selection procedures to diminish the quantity of characteristics, alongside the utilization of machine learning algorithms such as ZeroR, J48, Naive Bayes, and Random Forest. The study obtained a precision rate of 99.92% for the Random Forest algorithm and 99.91% for the J48 algorithm when applied to the KDD99 dataset. The findings indicated that tree-based classifiers such as J48 and ensemble approaches like Random Forest demonstrated superior performance, with Random Forest achieving the highest level of accuracy. Furthermore, the study emphasized the significance of feature selection in enhancing the effectiveness of the intrusion detection system.

Aziz and Abdulazeez.in 2021 [42], proposed doing a comparative examination of several Machine Learning (ML) approaches employed in Intrusion Detection Systems (IDS) with the aim of identifying intrusions. The approaches the study prioritized were Support Vector Machine (SVM), J48, and Naive Bayes. The study utilized the KDD CUP 99 dataset and the WEKA tool. The study evaluated the algorithms using several performance metrics. The results revealed that J48 achieved the best accuracy rate of 99.96%, closely followed by SVM with a rate of 99.89%. On the other hand, Naive Bayes had the lowest accuracy rate. The experts have determined that no single learning machine algorithm can successfully handle all forms of attacks with precision. In addition, they emphasized the need for varied strategies to be employed in response to various types of attacks.

Azizan et. al.in 2021 [43], proposed a machine learning-based model for a network intrusion detection system (NIDS) and evaluated the performance of three machine learning methods (decision jungle, random forest, and support vector machine) in detecting anomalous network traffic. The study examined the efficacy of the knowledge discovery in databases (KDD) approach with the intrusion detection assessment dataset (CIC-IDS2017). The mean accuracy findings indicated that the support vector machine (SVM) attained the maximum accuracy of 98.18%, followed by random forest (RF) with 96.76% and decision jungle (DJ) with 96.50%. Similarly, the average precision findings showed that the Support Vector Machine (SVM) had the highest precision rate of 98.74%, followed by Random Forest (RF) at 97.96% and Decision Tree (DJ) at 97.82%. The study determined that the Support Vector Machine (SVM) algorithm exhibited the highest efficacy in identifying intrusions within the system.

Ahmed et. al.in 2022 [44], established a Network Intrusion Detection System (NIDS) utilizing machine learning methods for the purpose of identifying network intrusions. The study utilized the UNSW-NB15 dataset, which comprised a substantial volume of network traffic data and encompassed nine distinct categories of network attacks. The study utilized a range of pre-processing approaches, feature selection strategies, and class balance methods. A total of five classification models were employed, namely Random Forests, Decision Trees, Logistic Regression, K-Nearest Neighbors, and Artificial Neural Networks. The Random Forest algorithm attained the maximum accuracy rate of 89.29%. Subsequently, by implementing the SMOTE methodology, the Random Forest classifier demonstrated an accuracy of 95.1%, utilizing 24 selected features obtained from the Principal Component Analysis method.

Mekala et. al.in 2022 [45] ,provided a machine learning-based network intrusion detection solution specifically designed for virtualized data. The techniques utilized encompassed pre-processing, feature selection, feature reduction, and classification utilizing support vector machines (SVM) and Naïve Bayes algorithms. The classifiers were trained and tested using the NSL-KDD dataset. The study obtained a precision rate of 98.2% for Support Vector Machines (SVM), 64.7% for Naïve Bayes, and 53.3% for random tree classifiers. The results unequivocally showcased the efficacy of the suggested methodology in precisely identifying intrusions in virtualized systems.

Singh et. al.in 2022 [46], a powerful Intrusion Detection System (IDS) was created utilizing machine learning methods to identify rare cyber-attacks in network data. The study employed the CIC-IDS 2017 dataset and implemented supervised machine learning classifiers including Random Forest, Decision Tree, Extra Tree, and K-Nearest Neighbor. The model

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attained an average accuracy of 99% and a recall of 100% for all four classifiers. The findings indicated that the Random Forest classifier surpassed the other classifiers, with an impressive accuracy of 99.61% while maintaining a false positive rate of 0.0%. The study sought to tackle the difficulty of identifying sophisticated cyber threats and showcased the efficacy of the suggested machine learning-based Intrusion Detection System (IDS) in precisely categorizing rare attacks in network data.

Chishakwe et. al.in 2022 [47], created an intrusion detection system (IDS) specifically designed for Internet of Things (IoT) scenarios by utilizing advanced machine learning algorithms. The techniques utilized involved creating a simulated IoT environment using an IoT testbed, detecting abnormalities, classifying attacks, and generating notifications upon the detection of intrusions. The UNSW-NB15 dataset was utilized for the purpose of training and assessing machine learning models. Among these models, the Random Forest classifier demonstrated the highest level of accuracy, reaching a score of 87%. The study effectively created a web-based application that can detect unauthorized access in an Internet of Things (IoT) network. It utilizes the Random Forest classifier to recognize abnormal activities and promptly inform users.

Yilmaz.in 2022 [48], suggested an enhanced approach utilizing machine learning to identify unauthorized access in computer networks. The proposed approach consisted of four distinct stages: preprocessing, feature selection, parameter optimization, and classification. The Correlation-Based Feature Selection technique was utilized to identify relevant features. Particle swarm optimization was employed to optimize the parameters. Four machine learning methods, namely Random Tree, AdaBoost, K-Nearest Neighbor, and Support Vector Machine, were employed for the purpose of classification. The suggested methodology underwent testing on two datasets: NSL-KDD and CIC-DDoS2019. The experimental results demonstrated that the suggested method exhibited a high detection rate and surpassed existing machine learning techniques in classifying intrusions, achieving a detection rate of over 99% for all classifiers. These findings indicate the method's potential for practical applications.

Tahri et. al.in 2022 [49], presented an Intrusion Detection System (IDS) that employs the machine learning algorithms of Naive Bayes (NB), Support Vector Machine (SVM), and K-Nearest Neighbors (KNN) to identify harmful network traffic. The model's performance was evaluated by conducting experiments on two datasets, namely UNSWNB15 and NSL-KDD. The algorithm that performed the best out of the three was chosen for the second stage of processing the database, resulting in the most efficient algorithm. According to the study, SVM demonstrated superior performance, irrespective of the dataset's attack size or kind. The SVM achieved accuracy rates of 97.78% and 97.29% on the UNSWNB15 and NSL-KDD datasets, respectively.

Rajput .et al.in 2022[50], analyzed the efficacy of machine learning methods in detecting network attacks by analyzing the KDD Cup99 dataset. The procedures encompassed preprocessing the dataset, training and testing the machine learning models, and assessing their performance based on accuracy, F1-score, and cross-entropy loss. The study revealed that the Random Forest method attained a remarkable accuracy rate of 100%. Additionally, Decision Trees, Support Vector Machine, Linear Regression, Gradient Boosting, and Deep Neural Networks also shown commendable accuracy scores. The findings demonstrated that machine learning algorithms have the capability to precisely categorize both benign and malevolent network data, rendering them highly efficient for detecting unauthorized access in the field of cybersecurity.

Chua and Salam.in 2022 [51], assessed the enduring effectiveness of intrusion detection systems (IDS) based on machine learning by utilizing distinct datasets for training and testing, replicating real-life situations. The study included six machine learning models: decision tree (DT), random forest (RF), support vector machine (SVM), naïve bayes (NB), artificial neural network (ANN), and deep neural network (DNN). The utilized datasets included the CIC dataset and the LUFlow dataset. The models' accuracy was tested using metrics such as accuracy, precision, recall, and F1-score. The findings indicated that Artificial Neural Network (ANN) exhibited superior performance in the long run, whereas Decision Tree (DT) was found to be more appropriate for firms that are less frequently targeted by attacks. The study also emphasized the significance of regularly updating Intrusion Detection Systems (IDS) with more recent data in order to uphold accuracy.

Mehmood .et al.in 2022 [52], presented a novel hybrid approach for intrusion detection and attack classification that effectively tackles the issue of high false positives and low false negatives in intrusion detection. In order to accomplish this goal, the study employed the NSL-KDD dataset and implemented data transformation, feature selection, and classification algorithms including FGSVM and ANFIS. The suggested technique attained a binary class classification accuracy of 99.3% and Mean Square Error (MSE) values of 0.084964 for training data, 0.0855203 for testing data, and 0.084964 for validation in multiclass categorization. In summary, the study conclusively showed that the hybrid approach is highly effective in precisely identifying and classifying network intrusions.

Ahmad .et al.in 2022 [53], created a highly effective network intrusion detection system utilizing the UNSW-NB15 dataset. The approach utilized

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feature selection through the utilization of a correlation matrix and a decision tree classifier based on AdaBoost. The dataset comprised 49 input variables, and the suggested system attained a remarkable accuracy of 99.3% in categorizing regular network traffic and network hazards. The results indicated that the suggested system surpassed other existing methods, highlighting its efficacy in network security applications and research sectors.

Chua and Salam.in 2023 [54], conducted experiments on six machine learning models to evaluate their effectiveness in detecting intrusions. The experiments utilized a dataset that was created specifically for testing purposes, separate from the dataset used for training. The purpose of this was to facilitate a comparative analysis of the long-term performance of these models and to effectively demonstrate the variations in attack types and network infrastructure over time. The six models assessed were decision tree, random forest, support vector machine, naïve Bayes, artificial neural network, and deep neural network. The evaluation of the study was conducted using three datasets: CIC-IDS2017, CSE-CIC-IDS2018, and LUFlow. The trials demonstrated that Support Vector Machines (SVM) and Artificial Neural Networks (ANN) had the highest resistance to overfitting, whilst Decision Trees (DT) and Random Forests (RF) experienced the greatest susceptibility. Nevertheless, all models exhibited satisfactory performance when the disparity between the training and testing datasets was minimal. The precision of all models varied between 93% and 100%, with the exception of the UNSW-NB15 dataset. The study determined that the suggested approach for evaluating intrusion detection systems based on machine learning, utilizing a progressive dataset, may more effectively evaluate their performance over a lengthy period of time.

ANAND et. al.in 2023[55], suggested an Intrusion Detection System (IDS) that employs eBPF and machine learning algorithms to identify Denial of Service (DoS) and Distributed DoS (DDoS) threats. The study employed the CIC-IDS-2017 dataset and conducted preprocessing, feature extraction using the ANOVA F-test, and analysis utilizing machine learning techniques such as Decision Tree, Random Forest, Support Vector Machine (SVM), and TwinSVM. The experimental results demonstrated that the machine learning algorithms suggested in this study surpassed the performance of previous relevant work. The Decision Tree algorithm achieved an accuracy of 99.38%, the Random Forest algorithm achieved an accuracy of 99.44%, the SVM algorithm achieved an accuracy of 88.74%, and the TwinSVM algorithm achieved an accuracy of 93.82%. Upon evaluation, it was determined that the eBPF implementation exhibited superior performance compared to the userspace implementation, achieving a greater packet processing rate per second.The beginning or uppermost part

Bacevicius and Paulauskaite-Taraseviciene.in 2023 [56], assessed the efficacy of machine learning models in categorizing network intrusions by utilizing imbalanced raw data from the CIC-IDS2017 and CSE-CIC-IDS2018 datasets. A range of machine learning models, such as Logistic Regression, Random Forest, Decision Trees, CNNs, and Artificial Neural Networks, were utilized. The findings revealed that decision trees implemented with the CART algorithm had superior performance, attaining an average macro F1-score of 0.96878. The study also examined the potential of explainable AI (XAI) techniques such as LIME and SHAP to interpret the results and identify the significant elements of the dataset that greatly influence the classification outcomes.

Paricherla et. al.in 2023 [57], created a machine learning framework to precisely classify and detect intrusions in computer networks. The approach utilized a hybridization of ant colony optimization (ACO) and the firefly algorithm for feature selection, in conjunction with machine learning algorithms including AdaBoost, gradient boost, and Bayesian networks for classification. The study included three datasets: NSL-KDD, UNSW-NB15, and CICIDS 2017. When the ACO (Ant Colony Optimization) algorithm and the firefly method for feature selection were combined, the experimental results demonstrated a significant increase in classification accuracy. The gradient boost method demonstrated superior performance in detecting and categorizing intrusions. The performance of the classification techniques was evaluated using accuracy, precision, recall, and F1 score. The findings showed that the accuracy and precision were high.

Somashekar and Boraiah.in 2023 [58], created a fusion model at the prediction level to identify and classify intrusions using machine learning techniques. The main focus was on improving the performance of the intrusion detection system (IDS) by retraining the model to handle unexpected threats. The researchers employed machine learning techniques, including tree ensemble, gradient-boosted tree, and random forest, to perform experiments on the NSL-KDD dataset. The classification accuracy varied from 90.03% for a basic model to 96.31% for the combined and retrained models, demonstrating a notable enhancement in IDS performance. The proposed model showcased the capability of integrating machine learning techniques with a fusion model to enhance the accuracy and security of IDS.

Alotaibi.in 2023 [59], developed an advanced model that utilizes integrated machine learning approaches to identify and prevent early-stage network intrusions, safeguarding networks against malicious attacks. The methodology consisted of two phases: training and validation. In both phases, a fused machine learning model was employed for intrusion detection, utilizing both Naive Bayes and SVM algorithms. The

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simulation results demonstrated the efficacy of the suggested intrusion detection model, achieving an accuracy of 0.909 and a miss rate of 0.091 in identifying early-stage network intrusions. The study utilized a dataset sourced from the UCI Machine Learning Data Repository, which was partitioned into training and validation sets at a ratio of 7:3. The system's performance was evaluated using statistical measures of precision, sensitivity, specificity, and accuracy.

Abeshek et. al. in 2023 [60], explored the efficacy and feasibility of utilizing machine learning methods for detecting network intrusions. The dataset underwent preprocessing to guarantee its integrity and appropriateness. The applicability and efficacy of three distinct machine learning models, specifically the XGBoost classifier, the Extra Trees classifier, and the Artificial Neural Network (ANN), were assessed for their application in network intrusion detection classification systems. The XGBoost Classifier demonstrated good performance in spotting abnormalities, achieving an accuracy of 0.988, precision of 0.982, recall of 0.995, and an F1-score of 0.989. Both the XGBoost classifier and the Extra Trees classifier are suitable options for network intrusion detection, as they yield comparable outcomes according to the comparison analysis.

Güney.in 2023 [61], conducted an analysis to evaluate the effects of various data preprocessing methods, such as normalization, feature selection, and classifier optimization, on the classification accuracy of support vector machines (SVM) for intrusion detection datasets. The performance of various approaches was evaluated using three benchmark datasets: NSL-KDD, UNSW-NB15, and CICIDS2017. The log-scaling normalization technique was determined to be the most effective method. By employing SVM with feature selection and classifier optimization, accuracy rates of 81.51% and 85.27% were achieved for the NSLKDD and UNSW-NB15 datasets, respectively, using 2 and 32 features. Similarly, an accuracy of 99.43% was attained for the CICIDS2017 dataset using 16 features. This work offered valuable insights into the process of data preprocessing in machine learning (ML) applications and demonstrated the critical importance of data pretreatment in constructing IDSs (Intrusion Detection Systems) that are both precise and efficient.

Sulaiman and Abdulazeez.in 2024 [62], explored the utilization of machine learning techniques for identifying anomalies and detecting misuse in intrusion detection systems. Additionally, investigated the effectiveness of ensemble learning models including AdaBoost, LightGBM, and XGBoost. The study employed the KDD Cup 99 dataset as a standard to evaluate and contrast the efficacy of various models, with a specific emphasis on detecting smurf attacks. According to the study, XGBoost demonstrated superior performance compared to the other two models in terms of accuracy. XGBoost achieved an accuracy of 0.99985, whereas AdaBoost earned an accuracy of 0.99076 and LightGBM achieved an accuracy of 0.99925. The study determined that the combination of machine learning approaches and a thorough comprehension of cybersecurity threats is crucial for developing efficient and robust intrusion detection systems.

Table 1Literature Review

Ref.	***Years***	***Dataset***	***Technique***	***Classifier***	***Accuracy***
[29]	2020	NSL-KDD	Various ML	SVM, KNN, LR, NB, MLP, RF, ETC, DT	RF, ETC, DT: 99%
[30]	2020	Sensor480	ML	SVM, NB, DT, Adaboost	DT: 100%
[31]	2020	UNSW-NB15, CICIDS-2017, ICS cyber-attack	ML & DL	RF	UNSW-NB15: 88.5% (binary), 73.6% (multi-class); CICIDS-2017: 99.9% (binary), 99.9% (multi-class)
[32]	2020	CICIDS 2017, UNSW-NB 2015	ML	BO-TPE-RF (optimized RF)	>99% (both datasets)
[33]	2020	UNSW-NB15	ML	NB, C4.5	C4.5: 90.44%
[34]	2020	Custom generated dataset	ML	NB, SVM, RF, KNN	RF: 99.81%

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Ref.	*Years*	*Dataset*	*Technique*	*Classifier*	*Accuracy*
[35]	2021	NSL-KDD, IoTDevNet, DS2OS, IoTID20, IoT Botnet	ML & DL	Bi-LSTM, SVM	SVM: 99.44%
[36]	2021	KDD99	ML	Decision trees	92.07%
[37]	2021	CIDDS-001	ML	RF, KNN	RF: 95.60% (AttackType)
[38]	2021	KDD Cup99	ML	Random Forest	99.99%
[39]	2021	KDD Cup 99	ML & DL	Random Forest	99.9824%
[40]	2021	Honeypot, NSL-KDD, Kyoto	ML	UEFFS	Superior to other feature selection methods
[41]	2021	KDD99	ML	J48, Random Forest	Random Forest: 99.92%
[42]	2021	KDD CUP 99	ML	J48, SVM, NB	J48: 99.96%
[43]	2021	CIC-IDS2017	ML	SVM, RF, DJ	SVM: 98.18%
[44]	2022	UNSW-NB15	ML	Random Forest	SMOTE-RF: 95.1%
[45]	2022	NSL-KDD	ML	SVM, Naïve Bayes, Random Tree	SVM: 98.2%
[46]	2022	CIC-IDS 2017	ML	Random Forest	99%
[47]	2022	UNSW-NB15	ML	Random Forest	87%
[48]	2022	NSL-KDD, CIC-DDoS2019	Feature selection, Parameter optimization, Classification	Random Tree, AdaBoost, K-Nearest Neighbor, Support Vector Machine	>99% for all classifiers
[49]	2022	UNSWNB15, NSL-KDD	Intrusion Detection System with Naive Bayes, Support Vector Machine, K-Nearest Neighbors	Support Vector Machine	97.78% (UNSWNB15), 97.29% (NSL-KDD)
[50]	2022	KDD Cup99	Preprocessing, Training, Testing, Various ML models	Random Forest, Decision Trees, SVM, Linear Regression, Gradient Boost, Deep Neural Networks	100% (Random Forest)
[51]	2022	CIC dataset, LUFlow	Comparison of 6 ML models for IDS	ANN	Varies, but ANN showed superior long-term performance
[52]	2022	NSL-KDD	Hybrid approach with FGSVM and ANFIS	FGSVM, ANFIS	99.3% (binary class), 0.084964 (MSE)
[53]	2022	UNSW-NB15	Feature selection, Decision Tree Classifier based on AdaBoost	Decision Tree (AdaBoost)	99.3%

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Ref.	*Years*	*Dataset*	*Technique*	*Classifier*	*Accuracy*
[54]	2023	CIC-IDS2017, CSE-CIC-IDS2018, LUFlow	Evaluation of 6 ML models over time	SVM, ANN	93% to 100% precision
[55]	2023	CIC-IDS-2017	IDS using eBPF and ML algorithms	Decision Tree, Random Forest, SVM, TwinSVM	88.74% to 99.44%
[56]	2023	CIC-IDS2017, CSE-CIC-IDS2018	ML models for imbalanced data classification	Decision Trees (CART)	Avg. macro F1-score: 0.96878
[57]	2023	NSL-KDD, UNSW-NB15, CICIDS 2017	ACO, Firefly Algorithm, Machine Learning Algorithms	Gradient Boost	High accuracy and precision
[58]	2023	NSL-KDD	Fusion model for IDS with ML techniques	Tree ensemble, Gradient-boosted tree, Random forest	90.03% to 96.31%
[59]	2023	UCI Machine Learning Data Repository	Fused ML model for intrusion detection using Naive Bayes and SVM	Naive Bayes, SVM	0.909
[60]	2023	-	XGBoost, Extra Trees, ANN for network intrusion detection	XGBoost, Extra Trees, ANN	0.988
[61]	2023	NSL-KDD, UNSW-NB15, CICIDS2017	SVM with preprocessing methods	SVM	81.51% to 99.43%
[62]	2024	KDD Cup 99	Ensemble learning models for IDS	AdaBoost, LightGBM, XGBoost	Accuracy: 0.99985 (XGBoost)

IV. COMPARISON AND DISCUSSION

The review paper thoroughly analyzes the effectiveness of different machine learning classification methods in network intrusion detection across multiple investigations. [29] Demonstrated the efficacy of machine learning classifiers such as Random Forest (RF), Extra Trees Classifier (ETC), and Decision Trees (DT) in detecting network intrusions. Their proposed method had an impressive 99% accuracy rate, highlighting its effectiveness. [30] Conducted a study on an intrusion detection system specifically designed for IoT. They achieved accuracy levels ranging from 97.89% to 100%, with the Decision Tree model performing better than other models. [31] Evaluated twelve machine learning algorithms and emphasized the better performance of Random Forest in detecting deviant behaviors with an accuracy of up to 99.9%. [32] Proposed a multi-stage optimized architecture that utilized the BO-TPE-RF optimized random forest classifier to achieve a detection rate of above 99%. The results indicate that machine learning techniques, particularly Random Forest, are highly effective in predicting and preventing network intrusions in various datasets and scenarios.

V. CONCLUSION

The literature analysis on network intrusion detection systems (NIDS) utilizing machine learning classification algorithms uncovers a wide range of methodology and approaches designed to accurately detect and thwart network invasions. The research have used different machine learning classifiers, such as Support Vector Machines (SVM), Decision Trees (DT), Random Forest (RF), Naive Bayes (NB), and ensemble approaches, to evaluate how well they can detect aberrant behaviors and classify network attacks. The results routinely show high accuracy rates, frequently over 90%, with certain algorithms obtaining almost flawless accuracy in particular situations. The key findings highlight the superiority of specific classifiers, such as Random Forest, in accurately predicting incursions while limiting computational complexity. Moreover, research emphasizes the importance of preprocessing methods, feature selection approaches, and model tuning in improving the effectiveness of NIDS. In summary, the paper

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highlights the effectiveness of machine learning methods in enhancing network security by offering strong intrusion detection capabilities, thus protecting important network assets from unwanted activity.

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