Utilization of RSSI on Visitor's Cellphones in Calculating Distance to Wifi Transmitter in the Reading Room of the State Polytechnic of Malang Library

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Abstract—**The pandemic period caused by the coronavirus disease causes restrictions on the number of users in a room to minimize the spread, for example, libraries. The library is a room area that can cause virus transmission when crowds of visitors. A system is needed to provide information regarding the number of library visitors. Utilizing a network (wifi transmitter) available in the library can provide information on the number of visitors based on the number of network users in a room. Utilization of the network (wifi transmitter) can be in the form of a positioning system by utilizing the wifi signal beam received by the user in RSSI (Received Signal Strength Indicator). To calculate the estimated user position, a trilateration method is used based on the placement of three wifi transmitters. The library visitor positioning system consists of users as wifi transmitter users and admins. At the X-coordinate, the measuring point with a low deviation of the measurement value is indicated by points C and E with a value of 0.1. The large deviation of the measurement value is indicated by the P point of 4.5. At the Y coordinate, point O has a low deviation value of 1.25, and the largest deviation value is at point M of 5.6. The accuracy of the X coordinate shows a value of 97.647% and at the Y coordinate of 96.57%. Both coordinates have good accuracy for the points used as position measurements.**

Keywords—**WIFI transmitter, Positioning, Received-signal-strength-indicator, Libraries, Network.**

I. INTRODUCTION

The pandemic period caused by the coronavirus disease causes a room to be limited in the number of users. The room that can be a concrete example at this time is the library. The library is a room area that can cause virus transmission when crowds of visitors. We need a system that can provide information related to the position and the number of visitors to the library. Wireless network technology has an important role in making a system that can provide appropriate information during the pandemic era. The utilization of wireless network technology and communication media can also be used as an estimation medium for determining the location of an object [1]. Determining the location of an object is also known as the concept of indoor localization. Indoor localization uses a lot of Wireless Local Area Network (WLAN) technology because WLAN/wifi is almost available anywhere and can be integrated with smartphones easily[2], [3]. One of the pieces of information from wifi that can be used in indoor localization is RSSI (Received Signal Strength Indicator). RSSI works by measuring the signal strength of packets at the receiver. RSSI is often used to find the distance between transmitter and receivers [4]. Thus, the wireless network (wifi transmitter) can show user intensity based on RSSI reception, calculated using an integrated application on the library's wifi transmitter user's cell phone. Calculations are carried out on the application on the visitor's cellphone running on the Android operating system [5]. The calculation result is the distance between the user and the wifi transmitter. The main parameter of the position estimation calculation is RSSI [2], [6], [7]. A trilateration method calculates the estimated user position on the wifi transmitter. The trilateration method is commonly used to determine the estimated position of an object in the room. This method looks for position estimates based on references with a minimum of 3 references. The trilateration method has two important components in predicting position: distance and transmitter position. The distance can be calculated by taking the average signal strength value obtained. Users connected to the wifi transmitter will be visualized in the form of a wind speed chart on each user's cellphone [8].

II. LITERATURE REVIEW

A. Trilateration.

Trilateration is a method or algorithm to determine the position of an object (smartphone) based on simultaneous distance measurements from 3 access points located around the location. The position of the object (smartphone) can be. For example, the coordinates (x, y) can be detected by measuring the object's distance (smartphone) from the three access points. The basic principles of trilateration are:

$$(x - xi)^2 + (y - yi)^2 = ri^2 \ (i = 1,2,3) \quad (1)$$

Where:

- ri is the distance measured by the i-th point at position xi, yi, to the object (smartphone) at position x, y.
- x and y are the coordinates of the location of an object (smartphone)
- xi and yi are the coordinates of the location of the access point.

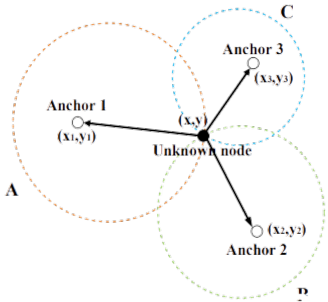


Fig. 1. Trilaterasi method.

B. Received-signal-strength-indicator

The RSSI technique uses a distance determination model by measuring the signal strength received by the receiver sent by the transmitter [9]–[11]. Signal strength in dBm is the signal propagation from one location to another. The relationship between RSSI and distance can be obtained from the formula:

$$[dBm] = A - 10 \times n \times \log 10\,(d) \quad (2)$$

$$d(m) = 10\,\frac{(A - RSSI)}{10^n} \quad (3)$$

With values as follows:

- A is the transmit power of the signal received by the client at a distance of 1 meter in dBm units.
- D is the distance between the transmitter (transmitter) and receiver (receiver) in meters.
- RSSI is the signal strength emitted by the receiver in dBm units.
- n is the path loss, which has different conditions in each environment, according to the conditions shown in the table.

C. Pathloss Exponent

Pathloss is generally defined as the overall decrease in field strength as the distance between the transmitter and receiver increases [12], [13]. The effect is very strong, causing a decrease in the power level of the received signal. Exponent path loss is a parameter n that is very influential in determining the critical limit of the coverage area and capacity of the cellular system.

D. Router

The router is a device devoted to handling connections between two or more networks connected via packet switching [4]. Routers work by looking at the origin and destination address of the packet that passes through it and deciding the route that the packet will take to get to its destination.

TABEL I
PATH LOSS EXPONENT

Environtment	Path Loss Exponent, n
Free Space	2
Urban area cellular radio	2.7 to 3.5
Shadowed urban cellular radio	3 to 5
In Building line of sight	1.6 to 1.8
Obstructed in building	4 to 6
Obstructed in factories	2 to 3

E. Mini Wireless N Router (Totolink N200RE)

N200RE is a mini wireless router that allows users to access and share high-speed internet.

F. Android Studio

Android Studio is an Integrated Development Environment (IDE) specifically for building applications that run on the Android platform. The main programming language used is Java [14]. To create a page in the android application, the XML language is used. Android studio is integrated with the Android Software Development Kit (SDK) to deploy to Android devices.

G. Database

The database represents a collection of interconnected facts stored together in such a way and without unnecessary repetition (redundancy) to meet various needs[15], [16].

III. SYSTEM MODEL

A. System design

In the system design subsection, block diagrams of the system will be explained, system workflows, hardware device settings, and android applications. This design aims to build a system with an android interface to be effective.

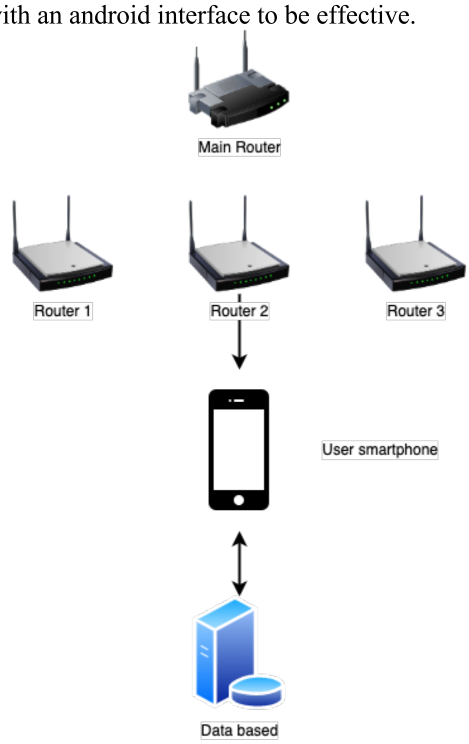


Fig. 2. The proposed system designs

B. Data Flow Diagram

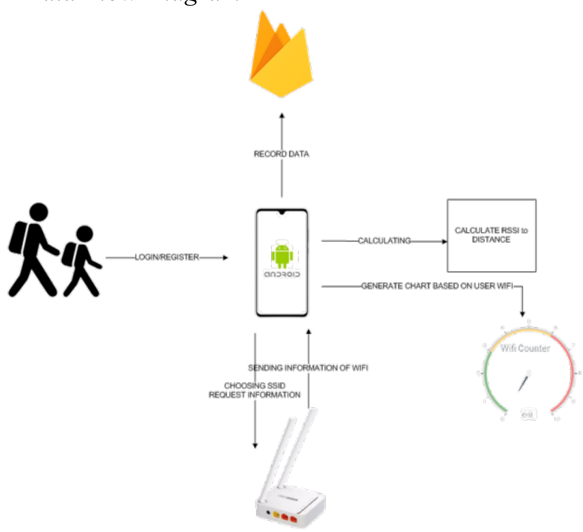


Fig. 4. Data Flow Diagram

In the wifi transmitter section, there is a process in the form of SSID broadcast by the router. There is input data in Student ID, Email, and Password in the user section as a key for storing data in the database. There is a calculation process for RSSI data in the application, which is then converted into distance data and then displayed on the main page. There is a process of calculating the number of users by using the SSID of the same wifi transmitter and then updating when there are changes to the number of users.

C. Research method

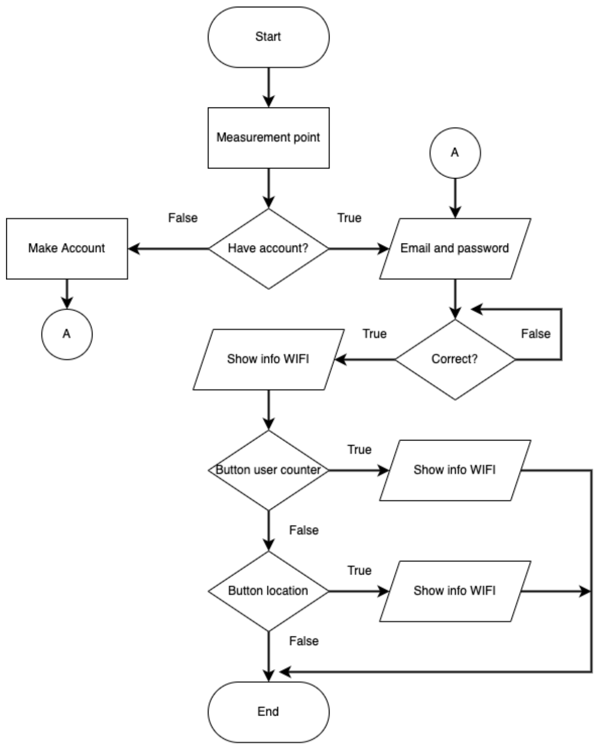


Fig. 5. Research procedure

There is a login page for users and admins. For users who do not have an account, the user presses the "Sign Up" button to register by entering your NIM, Email, and Password. If the account has been created, the user can log in on the User Login page by entering the Email and Password. When the user logs in, the next page will show detailed information from the wifi transmitter used by the mobile device. A "Locate Me" button calculates the distance between the user and the transmitter's position, and the data will be stored in the database—the "User counter" button functions to show the number of wifi transmitter fellow application users. To log in as an admin, enter your Email address and Password. The application will take the admin to a page that contains information about the user in the form of "NIM," "Email," "Mac Address," "Distance," and "Create at."

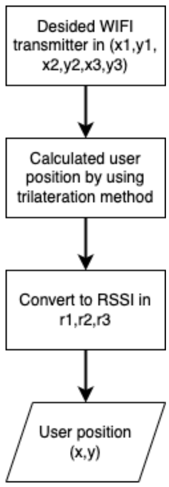
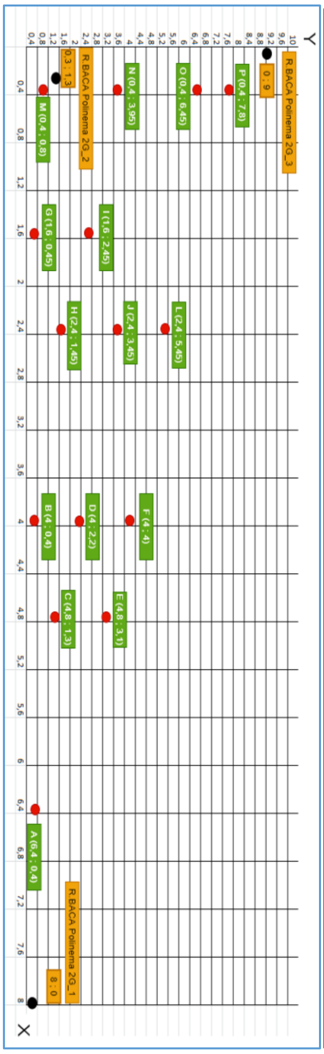


Fig. 6. Flowchart of Trilateration Method

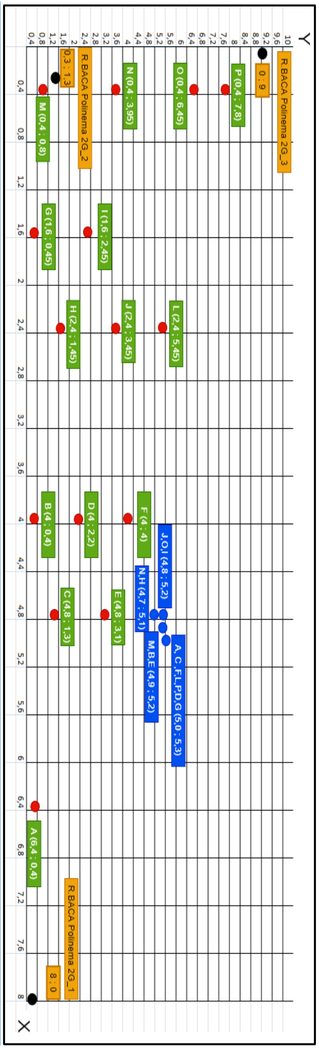
Three routers are placed based on the position x1,y1,x2,y2,x3,y3 according to the reading room of the Malang State Polytechnic library in the analogy of Cartesian coordinates. Next, perform calculations by applying the trilateration method by utilizing the RSSI value obtained from the application and converting using distance so that the value of r is obtained as the distance between the user and the wifi transmitter. These calculations will produce output in the form of the user's position in the x,y coordinates.

IV. EXPERIMENT RESULTS

The test was carried out in a room measuring 9.8 x 8 meters as shown in Fig. 7 and Fig. 8. Based on Fig. 7 and Fig. 8, the user's position taking on the transmit power from a wifi transmitter has varying values. The parameters used as a benchmark for calculating the actual user position are SSID of the wifi transmitter, the value of the A parameter of the wifi transmitter, the RSSI of the wifi transmitter and the distance of visitors to the wifi transmitter based on RSSI reception. It can be seen from Table 3 that the user distance test and Table 4 estimate the actual user position, the SSID of the wifi transmitter received by the user's cellphone will be the header in reading information from the wifi transmitter used and the user's distance to the wifi transmitter which will be read by the application on the user's cellphone. As library visitors. There are 3 (three) SSIDs from the wifi transmitter available in the library reading room, namely Polinema Hotspot R.BACA 2G_1, Polinema Hotspot R.BACA 2G_2, Polinema Hotspot R.BACA 2G_3. Each wifi transmitter will display the distance 1, distance 2, and distance three from positioning to measure the distance between the user and the wifi transmitter.



Gambar 7. Ruang Pengujian



Gambar 8. Posisi User Sebenarnya

The value of parameter A has an important role in calculating the actual user position. This also applies to the RSSI value obtained by the user's cellphone. When parameter A has a value greater than -30 dBm (close to a value of 0), it will indicate the distance the user is getting closer to the wifi transmitter. Based on (2), the RSSI value and the value of parameter A have a value that is directly proportional, when the value of A and the value of RSSI are getting bigger, the distance calculated in the application will produce a value according to the actual distance between the user and the wifi transmitter.

TABEL II
DISTANCE MEASUREMENT BASED ON RSSI

Measurement point	Position	Polinema Hotspot R.BACA 2G_1	Polinema Hotspot R.BACA 2G_2	Polinema Hotspot R.BACA 2G_3
	(x ; y)	RSSI(dBm)/distance (m)	RSSI(dBm)/distance (m)	RSSI(dBm)/distance (m)
A	6.4; 0.4	-26 / 0.86	-40 / 1.4	-44 / 1.6
B	4 ; 0.4	-32 / 1.2	-41 / 1.49	-50 / 2.0
C	4.8 ; 1.3	-34 / 1.15	-38 / 1.3	-38 / 1.3
D	4 ; 2.2	-45 / 1.72	-42 / 1.54	-40 / 1.44
E	4.8 ; 3.1	-43 / 1.46	-41 / 1.49	-47 / 1.85
F	4 ; 4	-38 / 1.3	-39 / 1.3	-39 / 1.3
G	1.6 ; 0.45	-39 / 1.38	-44 / 1.66	-45 / 1.72
H	2.4 ; 1.45	-46 / 1.79	-32 / 1.07	-38 / 1.33
I	1.6 ; 4.45	-50 / 2.07	-40 / 1.44	-47 / 1.85
J	2.4 ; 5.45	-41 / 1.49	-34 / 1.15	-44 / 1.66
K	-	-	-	-
L	2.4 ; 5.45	-38 / 1.33	-41 / 1.49	-37 / 1.29
M	0.4 ; 0.8	-44 / 1.66	-27 / 0.89	-40 / 1.44
N	0.4 ; 3.95	-49 / 2.0	-36 / 1.24	-48 / 1.92
O	0.4 ; 6.45	-52 / 2.23	-35 / 1.2	-42 / 1.54
P	0.4 ; 7.8	-36 / 1.24	-32 / 1.07	-26 / 0.86

TABEL III
POSITION ESTIMATION WITH TRILATERATION

User	Position (x,y)		Estimation position (calculation)	
	x	*y*	*x*	*y*
A	6.4	0.4	5.0	5.3
B	4	0.4	4.9	5.2
C	4.8	1.3	4.9	5.3
D	4	2.2	4.9	5.3
E	4.8	3.1	4.9	5.2
F	4	4	4.9	5.3
G	1.6	0.45	4.98	5.3
H	2.4	1.45	4.7	5.2
I	1.6	2.45	4.78	5.2
J	2.4	3.45	4.8	5.2
K	-	-	-	-
L	2.4	5.45	4.9	5.3
M	0.4	0.8	4.7	5.2
N	0.4	3.95	4.7	5.1
O	0.4	6.45	4.75	5.2
P	0.4	7.8	4.9	5.3
		$\bar{x}$	4.82	5.24

The closer the position of the wifi usage to the router, the RSSI value obtained is getting closer to 0 and indicates a position close to the actual point. The user's position at each measurement point only has a difference of ±1 meter with a total of 15 test points. Thus, the magnitude of the measured

RSSI value did not show a significant difference. The average reception power of the wifi transmitter or RSSI from several test points is -40.8 dBm on router 1, -37.4 dBm on router 2, and -41.6 dBm on router 3. measured on visitors' cellphones based on RSSI are 1.52 m on router 1, 1.31 meters on router 2 and 1.54 meters on router 3.

It can be seen in table 3 that the position estimation based on trilateration calculations shows the values referring to the center coordinates of the X and Y-axis. Half of the X-axis is 4.0, and Y is 4.9. Compared to the position calculation using trilateration, the average of the actual position calculation results shows 4.82 points on the X-axis and 5.24 points on the Y-axis. Positions close to half of the two X and Y axes are at point F, namely at 4 X coordinates. and 4 Y. At point F, the positioning calculation results are 4.9 X and 5.3 Y, with the best accuracy among the other positioning.

- Calculation of Data Accuracy

Calculation of accuracy is the average calculation of the distance from the router to the actual user minus the distance calculated from the estimated position. The smaller the deviation value of data accuracy, the more accurate the data. The level of data accuracy will be calculated using the Euclidean distance. Here is the Euclidean formula:

$$d = \sqrt{(x - xi)^2 + (y - yi)^2} \quad (4)$$

Where d is Euclidean distance, (x,y) is the true object position and (x',y') is object postion calculation.

TABEL IV
ACCURATION DATA

Meassurement Point	True position		Calculation position		error	
	X	Y	X	Y	X	Y
A	6.4	0.4	5.0	5.3	1.4	4.9
B	4	0.4	4.9	5.2	0.9	4.8
C	4.8	1.3	4.9	5.3	0.1	4
D	4	2.2	4.9	5.3	0.9	3.1
E	4.8	3.1	4.9	5.2	0.1	2.1
F	4	4	4.9	5.3	0.9	1.3
G	1.6	0.45	4.9	5.3	3.3	4.15
H	2.4	1.45	4.7	5.2	2.3	4.25
I	1.6	2.45	4.7	5.2	3.1	3.25
J	2.4	3.45	4.8	5.2	2.4	2.25
K	-	-	-	-	-	-
L	2.4	5.45	4.9	5.3	2.5	5.15
M	0.4	0.8	4.7	5.2	4.3	5.6
N	0.4	3.95	4.7	5.1	4.3	2.85
O	0.4	6.45	4.7	5.2	4.3	1.25
P	0.4	7.8	4.9	5.3	4.5	2.5
				$\sum e$	35.3	51.45
				$\bar{x}\, e$	2.353	3.43
			Accuration (%)		97.647	96.57

Measurements at the X coordinate show that two measuring points have a low deviation of the measurement value, namely at point C and point E, with a deviation value of 0.1. The large deviation of the measurement value in the X coordinate is at point P with a deviation of 4.5. While in the Y coordinate, the point with the lowest deviation of the measurement value is at point O with a value of 1.25, and the largest deviation is at point M with a value of 5.6. Deviation values if sorted from smallest to largest value based on each coordinate as follows coordinates X: C, E, B, D, F, A, H, J, L, I, G, M, N, O, P While the coordinates Y: O, F, E, J, P, N, D, I, C, G, H, B, A, L, M. The accuracy of the X coordinates shows the value of 97.647% and the Y coordinates show the value of 96.57%, which means that both coordinates have good accuracy on the points used as position estimation measurements. The area used to install three routers in line of sight to the measurement point affects the RSSI value received by the user, the measured distance from the user's position, and the accuracy of calculating the user's position to the actual position.

V. CONCLUSION

The selection of the SSID of the wifi transmitter used by the user as a library visitor plays an important role in displaying information related to the reception of the wifi RSSI, the measured distance and can affect the calculation of the actual position. Each router shows a value of -30dBm as far as 1 meter, with the average positioning calculation showing 4.82 on the X-axis and 5.24 on the Y-axis. The measurement point that shows a value close to the actual position is point F. The actual position of the measurement points of F is 4 X and 4 Y, with calculations showing 4.9 X and 5.3 Y. The accuracy of the X coordinates shows a value of 97.647%, and the Y coordinate shows a value of 96.57%, which means that both coordinates have the same accuracy. Well, to the points used as position estimation measurements.

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