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ANALYSIS OF WLAN NETWORK HANDOVER PERFORMANCE USING RSSI AND THRESHOLD ON MOBILE DEVICES

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Abstract

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Random user mobility on the WLAN network allows the user to move away from the access point (AP) that serves it so which has an impact on the possibility of the user losing connectivity to the communication network it will have an impact on the QoS (Quality of Service) received by the user. The implementation of the handover algorithm in this study can accommodate the transfer of communication service connectivity on the WLAN network caused by the user mobility factor. This can be seen from the results of testing the RSSI comparison method with the threshold occurring at a distance of 15 meters, based on the results of the comparison of the RSSI AP1 value which experienced a decrease in value below the RSSI AP2 value with a comparison of values of -64.35 dBm and -62.75 dBm, respectively. The same handover distance occurs in the threshold method. RSSI AP1 has a value of -64.35 dBm, this value is below the threshold, namely -64 dBm so user connectivity services will be switched to AP2 with a better value. This study aims to provide information about the quality of WLAN network services through mobile devices in the Faculty of Science and Technology.

Keywords: WLAN, Access Point, RSSI, Threshold, Handover, Mobile Equipment

1. Introduction

The need for good wireless communication services is increasingly needed by mobile device users. This refers to the guaranteed quality of connection stability expected by mobile device users [1]. The quality of the communication network describes the resistance of the communication network to interference and can accommodate high user mobility without having to lose connection to the communication network. Users can perform mobility randomly, both in outdoor and indoor areas using mobile devices. In the indoor area, the installation of WLAN (Wireless Local Area Network) communication network devices can be done at several points in a room or building. A WLAN communication network device that has a central role in facilitating users to connect to a communication network is called an access point. An access point that is installed in a room will provide transmission power (power transmitter) through radio waves by the coverage area. Users who are in the coverage area of an access point will be connected to the communication network. Despite getting a connection, the coverage area of an access point has limitations [2]. This allows for a decrease in the value of the RSSI (Received Signal Strength Indicator) on the user. RSSI illustrates the value of receiving power to the user which is influenced by several factors including obstacles that are in the wave propagation path, as well as the mobility of users moving away from the coverage area of the access point.

The obstacle factor is oriented to the presence of walls, interior devices, and even humans who are on the wave propagation path. The existence of an obstacle will cause the waves to experience the phenomenon of reflection, diffraction, and scattering so that it has an impact on the attenuation of the RSSI value received by the user [3]. Meanwhile, the user mobility factor has contributed to the weakening of the user's RSSI value as the distance between the user and the access point that provides connection services to the communication network increases. To maintain user connectivity during mobility, more than one access point on the WLAN network will be installed. So the user will always have connectivity options from two or more access points to stay connected to the communication network. Along with the weakening of the RSSI value received by the user, there is a transfer of connection services from the access point that is serving the user to another access point that has a better RSSI value than before. The procedure for transferring user connectivity services to several access point options is called handover. The handover will compare the RSSI value of several access points around the user, this aims to guarantee user connectivity with the communication network during the mobility process [4]. The choice of connectivity between the user and several access points is oriented to the comparison of the RSSI value received by the user [5]. So that the access point with the best RSSI will serve the user's connectivity to the communication network [6]. In addition, to maintain user connectivity with the communication network, an RSSI threshold value is needed, which is called the threshold. Threshold will be an indicator in determining handover decisions before RSSI has a very low value. So that the user has difficulty in obtaining a connection to the communication network. The RSSI will be compared to the threshold value, if the RSSI value is at a value level below the threshold, the user will make a handover decision. So that the communication service connection will be diverted to another access point that has a value better than the threshold [7]. Based on this mechanism, the handover decision is made to maintain the Quality of Service (QoS) of communication services [8].

In related research published by Siddharth Goutam in 2019, the handover parameters used in the test are network load and user speed in mobility. The simulation results show that handover can overcome QoS problems due to user displacement with varying speed values. Handover occurs at a distance of 300 m with a speed of 5 m/s, while the highest speed variable value is simulated to have a value of 15 m/s at a distance of 550 m. The test results can be concluded that the implementation of the handover can be used in various locations such as baling facilities, terminals with parameter measurement and comparison of RSSI, channel capacity, and user mobility speed by adjusting the propagation environment of each location [9]. Meanwhile, Gang Shao's research in 2019 outlined the results of research that an appropriate handover algorithm can improve QoS for users to overcome network congestion problems caused by the number of users around the communication environment. The algorithm tested is a vertical handover algorithm that is based on the traffic load balance variable on the network caused by the density of users connected to a heterogeneous partial network. The simulation results show that the proposed handover algorithm can select a network according to user needs, besides that the simulated handover algorithm can provide effectiveness in transferring services on heterogeneous networks such as public wireless networks and other communication networks [10]. Then the research conducted by Prasad P in 2020 focused on evaluating handovers that occur on heterogeneous communication networks, using throughput, RTT (Round Trip Time) and packet loss parameters focused on cellular communication networks with the test location on ORBIT radio. So using these variables can provide wider mobility. In addition, the implementation of handover on a heterogeneous communication network with a proof of concept illustrates the test results by obtaining an average throughput value of 12.5% for cellular users and 16% for static users [7].

This research focuses on the WLAN network using the RSSI parameter which is measured manually. In addition, the additional parameter applied in the research is the addition of a threshold parameter as an indicator of handover decision-making on the WLAN network at the Faculty of Science and Technology Building, Campus IV of UIN North Sumatra Medan. The characteristics of the measurement location have a fairly dense number of users. So it is necessary to identify the quality of the communication network connection through the measurement mechanism and handover simulation on the WLAN network in the Faculty of Science and Technology UIN North Sumatra, to obtain network quality information that can support user activities during mobility.

2. Method

The location of sample data collection was carried out in the second-floor corridor of the Faculty of Science and Technology Building, North Sumatra State Islamic University, Medan. The environmental conditions for sampling data are characterized by the presence of two access points (AP), accompanied by the dominance of the line of sight (LOS) propagation model characteristics along the propagation path traversed by the user. The layout of the sampling location is illustrated in Figure 1.

Figure 1. Measurement Location Plan

The RSSI sample data collection scenario is carried out with a user movement mechanism starting from AP1 to AP2 at a constant speed. So that the user mobility mileage will have the same value as the distance between the two access points, which is 27 meters. The distance value is obtained based on manual measurements using measuring instruments. To achieve conditions that match the RSSI value in accordance with the propagation environment, the intensity of data collection was carried out as many as twenty measurements. RSSI measurements are carried out by taking measurement samples every 1 meter along the user's mobility trajectory [11]. The RSSI value measured at each sample distance is viewed through a mobile device which is analogous to a receiver.

2.1 Friis Propagation Model

Each RSSI measurement data at each sample distance will be averaged. This is due to differences in the readings of the RSSI measurement values received by the user even though they are at the same distance. The difference in the RSSI value received by the user is caused by the variation in the density of people who are on the user's propagation path. The impact of the density of people on the propagation path is considered to have contributed to the weakening of the RSSI value received by the user [11]. RSSI measurement data can be averaged by using a mathematical formulation approach in equation (1) [12]:

$$\overline{RSSI(d)} = \frac{\sum_{i=1}^{n} RSSI(d)}{n} \qquad (1)$$

$\overline{RSSI(d)}$ defines the average value of RSSI values measured at each sample distance (d). While RSSI(d) illustrates the value of the RSSI measured at each sample distance (d) measured by the user. While the variable n describes the value of the number of measurements made at different times. The next stage is modeling the propagation environment. This is done to obtain a comparison value of the measured RSSI with the RSSI value of the computational modeling of the propagation environment. In accordance with the propagation environmental conditions of the sample data measurement, the propagation environment model that is used as a compass variable for the measured RSSI value is the Friis propagation model. Friis propagation model describes the environmental model of propagation in free space. The RSSI user mathematical approach to the Friis propagation model can be described through equation (2), (3) [12].

$$P_r(d) = P_t G_t G_r \left(\frac{c}{4\pi df}\right)^2 \quad (2)$$

$$P_r(d) = P_t G_t G_r \left(\frac{\lambda}{4\pi d}\right)^2 \quad (3)$$

The *Pr (d)* variable is the user's receiving power value at a distance d, while the *Pt* variable defines the AP's transmit power value. The variables *Gt* and *Gr* denote the transmitter and receiver gain values. Variable *c* describes the value of the speed of light and variable f is the value of frequency. The relationship between equations (2) and (3) can be obtained through the approach of equation (4) with the variable being the wavelength.

$$\lambda = \frac{c}{f} \quad (4)$$

The value of each variable used in the simulation process is illustrated in Table 1.

Table 1. Parameter Value

Variables	***Value***
d	27 meters
Pt	18 dBm
Gt	6 dBi
Gr	1 dBi
c	3 x 10^8 m/s
f	5 GHz

2.2 RSSI (Received Signal Strength Indicator) Comparison Method

RSSI comparison approach between AP1 and AP2 user measurement results along the propagation path can be illustrated through equation (5) [13].

$$RSSI_{AP1}(d1) < RSSI_{AP2}(d2)\ ;\ Handover \quad (5)$$

The variable $RSSI_{AP1}(d1)$ defines the RSSI value of AP1 that the user receives at a distance of *(d1)*. While the variable $RSSI_{AP2}(d2)$ is the value received by the user at a distance of *(d2)*. The results of the comparison of RSSI values will last as long as the user performs mobility according to the distance traveled from AP1 to AP2. If the RSSI AP1 experienced a significant decrease in value at distance *d* and the results of the comparison of the RSSI AP1 and AP2 values resulted in the conclusion that the RSSI AP2 value was better, then a handover decision would be made. Based on these conditions, AP1's connection to the user will be disconnected, and the user's communication network connection service will be transferred to AP2. Connection with AP2 will be continued until the maximum distance traveled by the user. So that the probability of users getting connection services to the communication network is getting bigger. The greater the probability value of the user getting connection services is influenced by the mobility of the user moving to AP2. So with the presence of the user in the AP2 coverage area, the user will get a service connection provided by AP2. Service switching is very important to maintain the QoS of the communication network. If there is a connection delay for a long time, the user will lose connection to the communication network which causes communication activities carried out by the user to be disrupted or even disconnected. Therefore, the implementation of the handover algorithm will maintain user service connections in anticipation of these conditions, by providing RSSI options from several APs in the vicinity to maintain user connectivity so that they are connected to communication services..The flow chart of the RSSI comparison process can be seen in Figure 2.

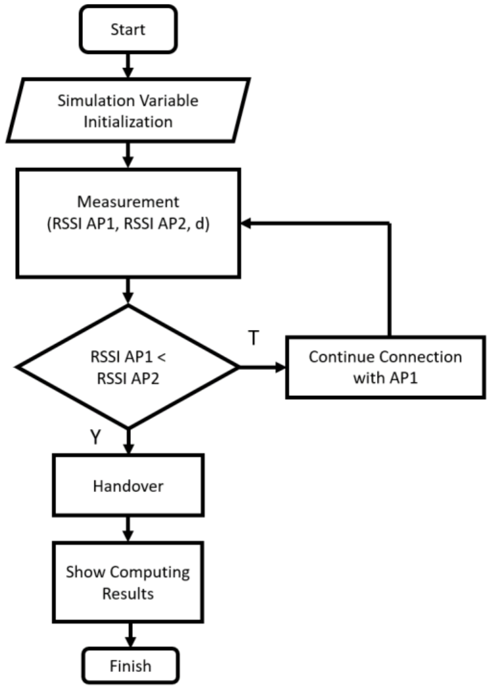

Figure 2. RSSI Comparison Mechanism Flowchart

2.2 Threshold Comparison Method

In addition to comparing the RSSI values of AP1 and AP2, handover decisions can also be made by comparing the RSSI value to the initialized threshold value of -64 dBm. The concept of comparison of values between RSSI and threshold can be seen through equation (6) [5] [7]

$$RSSI_{AP1}(d1) < Threshold\ ;Handover \qquad (6)$$

Based on equation (6), the handover decision will be made if the RSSI AP1 value has a level below the threshold [4]. So that the communication service connection that was originally handled by AP1 will be disconnected, and then the user's communication service connection will be moved to AP2.

3. Results and Discussion

3.1 Comparison of Measurement Results with the Friis Propagation Model

This study analyzes the results of handover performance on a WLAN network using a comparison of RSSI AP1 and AP2 and a comparison of RSSI with a threshold variable. The initial stage of this study was carried out by measuring the RSSI value along the user's path and determining the average RSSI value of AP1 and AP2 received by the user. The results of the average RSSI values of AP1 and AP2 will be compared with the results of modeling the propagation environment using Friis propagation modeling. The results of the comparison of values can be seen in Figure 3 and Figure 4.

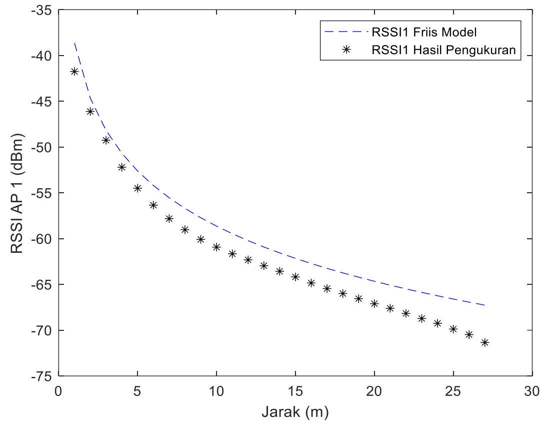

Figure 3. Comparison of AP1 RSSI Values against Friis Propagation Model RSSI

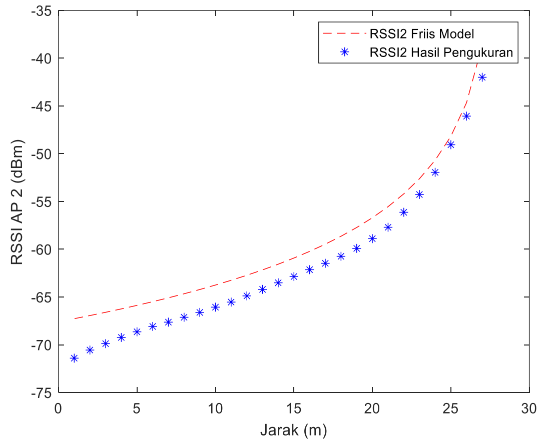

Figure 4. Comparison of AP1 RSSI Values against Friis Propagation Model RSSI

The sample comparison of values between the computational results of the Friis model and the measurement results can be seen in Table 2. and Table 3.

Table 2. Comparison of Measured RSSI AP1 Values against RSSI AP1 Friis Model

Distance (m)	***RSSI AP1 Model Friis (dBm)***	***RSSI AP1 Measurement (dBm)***
1	-38,63	-41,75
5	-52,61	-54,50

Table 3. Comparison of Measured RSSI AP2 Values against RSSI AP2 Friis Model

Distance (m)	***RSSI AP1 Model Friis (dBm)***	***RSSI AP1 Measurement (dBm)***
14	-61,56	-63,51
18	-58,63	-60,74

Based on the results of the comparison between the measured RSSI values and the results of the Friis propagation modeling RSSI, there are differences in values. This is because the friis modeling represents propagation in free space so the presence of random obstacles such as the density of people in the propagation environment is a neglected factor. While the measurement results in the propagation environment are influenced by the density of people along the propagation path. So that this is one of the factors that weakens the RSSI value measured on mobile devices that are accepted by the user. Overall the difference between the measured RSSI average values and the Friis propagation model RSSI has a difference 2.4 dBm. While the measurement results of RSSI AP1 and RSSI AP2 are described in Figure 5.

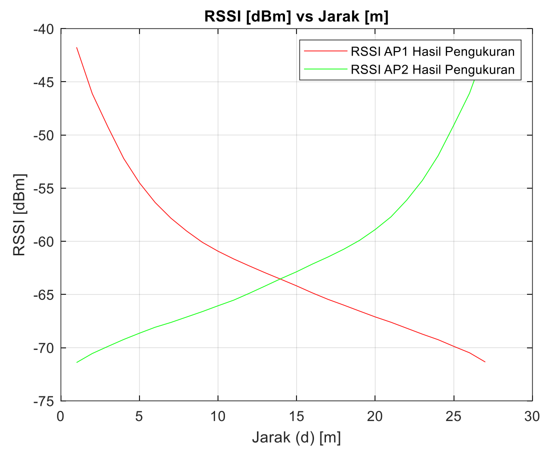

Figure 5. Comparison of RSSI AP1 and RSSI AP2 Values Measurement Results

The sample comparison of the measured RSSI value against the distance variable is illustrated in Table 4.

Table 4. Sample Average Value Comparison of RSSI AP1 and RSSI AP2 to Distance

Distance (m)	*RSSI AP1 Model Measurement Result (dBm)*	*RSSI AP2 Measurement Result (dBm)*
1	-41,75	-71,4
7	-58,15	-67,55
15	-64,35	-62,75
26	-70,25	-46,4

Based on Table 4. the 1 meter distance variable defines the user's distance to AP1. At this distance, the RSSI AP1 value measured on the user's mobile device is -47.75 dBm, while the RSSI AP2 value is -71.4 dBm. The weakening of the RSSI value of AP1 received by the user is getting weaker as the variable value of the distance between the user and AP1 increases and vice versa the escalation of the RSSI value of AP2 will occur when the user gradually moves towards AP2.

3.2 RSSI (Received Signal Strength Indicator) Comparison Method

Furthermore, the process is continued at the stage of the handover performance testing process using the RSSI comparison mechanism measured by the user. In the RSSI comparison test, the RSSIs that will be computed using the handover algorithm are RSSI AP1 and RSSI AP2 which are measured by the user via a mobile device. The computational results of the handover algorithm using the comparison of RSSI AP1 and RSSI AP2 can be seen in Figure 6.

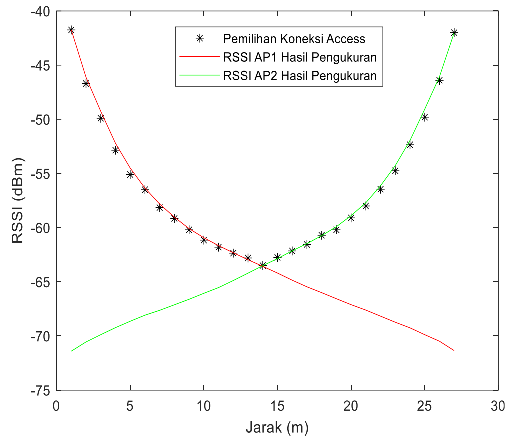

Figure 6. Connection Selection Based on the Value of RSSI AP1 and RSSI AP2 Measurement Results

In Figure 6. you can see a description of the gradual decrease in RSSI levels in AP1. The decrease in the RSSI AP1 value with respect to distance will be in line with the increase in the level of the RSSI AP2 value. So that when the RSSI value of AP1 is below the level of the RSSI value of AP2, the user's connection to the communication network will be transferred to AP2 which has a better RSSI than AP1. The sample comparison of RSSI AP1 and RSSI AP2 values related to handover decision-making is described in Table 5.

Table 5. Sample Average Value Comparison of RSSI AP1 and RSSI AP2 to Distance

Distance (m)	***RSSI AP1 Measurement Result (dBm)***	***RSSI AP2 Measurement Result (dBm)***	***Decision***
14	-63,5	-63,55	AP1 Connnection
15	-64,35	-62,75	Handover

Description of the data in the table. illustrates the RSSI AP1 and RSSI AP2 values at a distance of 14 and 15 meters. At a distance of 14 meters, the RSSI AP1 value is still above the level of the RSSI AP2 value, with a difference of 0.05 dBm in value. So based on these conditions, the user connected to the communication network is still facilitated by AP1. Meanwhile, when the user moves 1 meter away from AP1, the distance between the user and AP2 increases to 15 meters. So that the RSSI value of AP1 has decreased in value, due to the increase in the value of the distance between the user and AP1. In the same condition, the RSSI value of AP2 experienced an escalation in value, due to the movement of users approaching AP2. At a distance of 15 meters, the handover algorithm will calculate the RSSI AP1 and RSSI AP2 values, then perform the computation by comparing the values of the two. The results of the handover algorithm comparison show that the RSSI AP2 value has a large value level compared to the RSSI AP2 value with a difference of 1.6 dBm in value. So that at a distance of 15 meters, the handover algorithm will break the user's connection with AP1 and establish a new connection with AP2 so that the user can connect to the communication network.

3.3 Threshold Comparison Method

In addition to using the RSSI value comparison method between the two access points, another method that can be used to make handover decisions is to compute the RSSI value comparison with the threshold value. The threshold value will act as the threshold value which is used as the basis for determining the handover decision. The results of the comparison test of the RSSI value against the threshold variable are described in Figure 7.

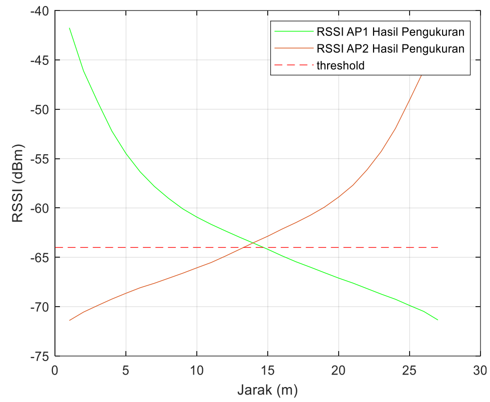

Figure 7. Transfer of Communication Services Based on Threshold

The determination of the threshold value in the handover mechanism has a value level of -64 dBm. Figure 7. shows the value level of the transfer of communication services from PA1 to AP2 at a distance of 15 meters. This is because the handover algorithm will compute the comparison of the RSSI AP1 value to the threshold value during the user mobility process. The sample data for the comparison of RSSI AP1 values with a set threshold of -64 dBm can be illustrated in Table 6.

Table 6. Comparison of RSSI Value with Threshold

Distance (m)	*Threshold (dBm)*	*RSSI AP1 Measurement (dBm)*	*RSSI AP2 Measurement (dBm)*	*Decision*
14	-64	-63,5	-63,55	AP1 Connnection
15	-64	-64,35	-62,75	Handover

The graphic illustration of the distance for determining the handover decision using the threshold variable can be seen in Figure 8.

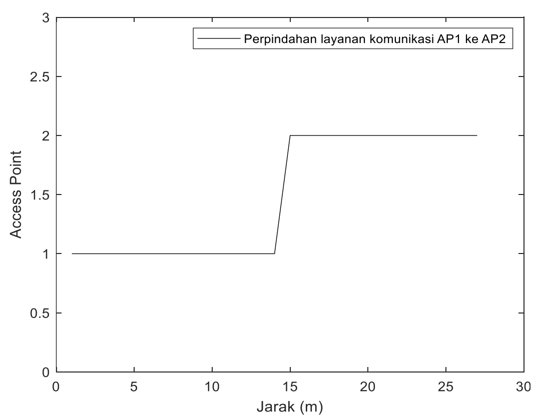

Figure 8. Illustration of Communication Service Transfer Distance Based on Threshold and RSSI

In the Table 6, the handover algorithm will perform a comparison process between the threshold and the RSSI AP1. During the comparison process, the algorithm will wait for the RSSI value to drop to the level of -64 dBm. After these conditions are met, the communication service will be transferred to AP2 provided that the RSSI value of AP2 has a level above the predetermined handover value.

On Figure 8. transfer of connection to communication services facilitated by AP1 occurs from a distance of 1 meter to 14 meters. Furthermore, AP2 will take over the communication service connection to the user starting from a distance of 15 meters to a distance of 27 meters. An illustration of the transfer distance of the communication service connection between AP1 and AP2 in Fig. is a description of the transfer of the communication service connection to the user using the RSSI and threshold comparison method. This shows that there is an equation for the distance value between the two methods used with the representation of the transfer of the communication service connection to the user at the same distance.

4. Conclusions

Simulation modeling using the Friis propagation model provides a representation of the results of the free space loss condition which is linear, thus ignoring random obstacle conditions on the propagation path. This has an impact on the difference in the value of the simulation results with the measurement results due to obstacles in the form of the density of the number of humans found in the propagation environment. The difference in values between the simulation results and the results of the RSSI measurements shows an average value of 2.4 dBm.

Determination of the handover decision for testing the comparison of RSSI and threshold values has the same distance, which is a distance of 15 meters. This is due to the linearity of the magnitude comparison using the RSSI value comparison method between APs and the threshold method. At a distance of 14 meters the two methods used, concluded that the RSSI AP1 was still better than the RSSI AP2 and the RSSI AP1 value was still above the set threshold value level. While at a distance of 15 meters, both methods provide handover decisions based on the results of the comparison of RSSI AP1 which has a level below the RSSI AP2 and the RSSI AP1 value has fallen below the threshold value point.

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