Study of mobile communication performance by applying empirical models as radio communication channels in two bands

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Abstract. Handover is a facility needed to maintain the continuity of cellular communication services to users. The handover process is influenced by the signal strength received by the mobile station (MS). The condition of the radio propagation channel and the presence of the barrier will affect the signal strength received by the user. This paper investigates the relationship between the parameters of the Empirical radio propagation model and the parameters of cellular communication performance. From the results of the discussion it was found that there is a strong relationship between the antenna height and frequency parameters with the soft handover performance parameters. By increasing BS height and MS height, the characteristics of both radio link degradation and drop call rates will decrease, but conversely increase the characteristics of active set values. The rate of decline in characteristics of both the degradation of the radio link and the drop call will be greater with a lower working frequency. Conversely with a lower working frequency produces higher active set characteristics.

1. Introduction

The decrease in power level that occurs due to refraction, diffraction, reflection, scattering and absorption is called pathloss or path losses [1]. The path losses in the mobile communication network are affected by the contour of the field, the condition of the surrounding air environment, the distance between the transmitter and receiver antennas, and the height and location of the antenna [2]. The irregular configuration of nature, buildings, and weather changes makes the calculation of the losses of propagation paths not easy to predict. Therefore, many propagation models are formulated that approach the real conditions in the field with certain provisions in order to approach the conditions on the field. Among the prediction models that approach the real conditions in the field with certain provisions is Walfish Ikegami [3].

High mobility of users in cellular communication causes the level of signal reception to fluctuate as a result of attenuation of propagation, distance variations and irregular environmental obstacles. To maintain the stability and continuity of cellular communication, a service transfer mechanism called handover is needed [4].

Handoff depends on base station’s signal strength with which communication is being made, along with the signal strengths of the surrounding base stations and the availability of channels. The purpose of handoff as follows. Handoff enhances the QoS, reduces traffic, improves the capacity and also improves the cellular network performance by reducing factors such as the call drop rate and the congestion rate.

Study on signal radio spreading is very important in the wireless network within effort keep quality signal communication and stability continuity communication move between user (handover), beside magnitude funds to prepare infrastructure from communication system wireless. By therefore, this study are focused on investigation of the parameters of Walfish Ikegami propagation model in effort to enhancement performance soft handover in mobile communication, so expected this research give contribution on guarding quality signal communication and stability continuity communication.

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2. Model system
In this study, the modeled BS consists of two base stations. Each BS has the same and separate transmit power at distance D and mobile station (MS) moves on a straight path with a regulated speed as shown in Figure 1 [5]. When MS moves, the signal obtained by the mobile station decreases. This decrease is caused by increasing distance and resistance around the BS to the MS. Calculation of path losses is modeled by Walfisch Ikegami radio propagation model.

![Figure 1. Network model.](image)

The signal strength received by the MS is the magnitude that drives the work of the soft handover algorithm. Soft handover characteristics observed were drop call rates, radio link degradation and active sets. This soft handover characteristic is observed based on changes in radio wave propagation parameters, that is high Antennas BS and MS and the frequency of work of the WI model.

WI model restricted to; Frequency ($f_c$) 800 – 2000 MHz, High antenna BS ($h_b$) 4 – 50 m, High MS ($h_m$) 1 – 3 m and distance BS and MS (d) 0.02 - 5 km. The WI model is a suitable model used for predict unfortunate - loss trajectory in the area city. This model applied for area where transmitter no visible on directly by receiver caused the number object barrier in between transmitter and receiver as seen on Figure 2. The Walfisch Ikegami model has be accepted by body standardization international ITU-R and could applied for high antenna BS above rooftop. Mean error allowed is of ± 3 dB and standard deviation of 4 - 8 dB [6][7].

![Figure 2. Illustration models Walfisch Ikegami.](image)

3. Research methods
The steps of conducting this research begin with; 1.) Library study, 2.) Verifying the radio propagation parameters of the WI model, 3.) Formulating virtual signal generation for two BSs, 4.) Building a comprehensive model of a virtual mobile communication system that links changes in radio propagation parameters of the WI model with characteristic parameters from soft handoff, 5.) Applying the soft handoff algorithm with the hysteresis-threshold model for two base stations [8], 6.) Determining the overall system parameters, both constant parameters and variable parameters, 7.) Designing the overall programming code, 8.) Test the simulation by varying the observed variables from the radio propagation model and analyzing its output against the soft handover characteristic parameters. The system block diagram is shown in Figure 3.
Figure 3. Design of system model.

System parameters for working on the simulation are shown in Table 1. The construction of simulation programming code using MATLAB software. The research data were obtained based on running the simulation program repeatedly. Next, to see the relationship between input parameters and system performance parameters, Microsoft Excel is used.

Table 1. Simulation parameters.

| Symbols | Values               | Descriptions                  |
|---------|----------------------|--------------------------------|
| D       | 2000 meter           | Distance between BS's          |
| Pe      | 23 dBm               | Transmission power per BS      |
| ds      | 1 meter              | Sample point distance intervals|
| Smin    | -90 dBm              | Minimum signal level           |
| f       | 1800 MHz             | Frequency                      |
| Hte     | 30 to 48 meter       | Height of antenna BS           |
| Hre     | 1 to 3 meter         | Height of antenna MS           |
| t       | 8 dB                 | Standard deviation             |
| Hist    | 10 dBm               | Difference in increment level of active set |
| Add     | 10 dBm               | Difference in reduction level of active set |

4. Result and discussion
The soft handover performance study evaluated was based on changes in BS antenna height, MS antenna height changes from Walfish Ikegami's radio propagation model with two variations in work frequency. The first evaluation is to vary the height of the BS antenna from 30 meters to 50 meters with an additional height step of 5 meters. Where for each test the height of the BS antenna is evaluated on the performance of the soft handover at two working frequencies, namely the 900 MHz and 800 MHZ frequencies. The second evaluation is to vary the MS antenna height from 1.0 meters to 3.0 meters with an additional step height of 0.5 meters. As the first evaluation, even in the second evaluation this is the same, where for
each test the height of the MS antenna is evaluated the performance of the soft handover at two working frequencies, namely the 900 MHz and 800 MHZ frequencies.

4.1. Characteristics of performance soft handover with an increase in base station antenna height for 900 MHz and 800 MHZ frequencies

Simulation output data that shows the relation between the increase in BS antenna height and the characteristics of soft handover performance are shown in Table 2.

| High Antenna BS (meter) | Link Degradation Rate (Prob.) 900 MHz | Link Degradation Rate (Prob.) 1800 MHz | Drop Call Rate (Prob.) 900 MHz | Drop Call Rate (Prob.) 1800 MHz | Active Set Average (unit) 900 MHz | Active Set Average (unit) 1800 MHz |
|------------------------|----------------------------------------|----------------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| 30                     | 0.1688                                 | 0.4212                                 | 0.1843                          | 0.4916                          | 0.8158                          | 0.5101                          |
| 32                     | 0.1068                                 | 0.3380                                 | 0.0534                          | 0.4076                          | 0.9480                          | 0.5921                          |
| 34                     | 0.0739                                 | 0.2848                                 | 0.0005                          | 0.3471                          | 1.0445                          | 0.6536                          |
| 36                     | 0.0552                                 | 0.2443                                 | 0                             | 0.2981                          | 1.1245                          | 0.7019                          |
| 38                     | 0.0421                                 | 0.2121                                 | 0                             | 0.2571                          | 1.1892                          | 0.7449                          |
| 40                     | 0.0337                                 | 0.1880                                 | 0                             | 0.2161                          | 1.2156                          | 0.7831                          |
| 42                     | 0.0268                                 | 0.1673                                 | 0                             | 0.1836                          | 1.2162                          | 0.8175                          |
| 44                     | 0.0223                                 | 0.1508                                 | 0                             | 0.153                           | 1.2165                          | 0.8481                          |
| 46                     | 0.0183                                 | 0.1363                                 | 0                             | 0.1273                          | 1.2166                          | 0.8737                          |
| 48                     | 0.0158                                 | 0.1246                                 | 0                             | 0.0997                          | 1.2170                          | 0.8993                          |

Data from Table 2 shows that as the height of the BS antenna increases, the rate of decline of the radio link decreases. This shows that increasing the height of the BS antenna results in increased signal strength at the receiver. By comparing the two work frequencies to the performance of the rate of decline of the radio link, the rate of decline of the radio link at a frequency of 900 MHz is higher or faster. This can be understood because with the increase in the frequency of work it results in increasing the amount of signal attenuation. The characteristic curve between the increase in height of the BS antenna and the rate of decrease of the radio link for both 900 MHz and 1800 MHz working frequencies is shown in Figure 4.

![Figure 4. Characteristics of a decrease in radio link to the height of the BS antenna at two frequencies.](image-url)
If evaluated from the drop call parameters as shown in Table 2, by increasing the height of the BS antenna which results in an increase in the received signal strength resulting in a decrease in the rate of the drop call, so that at an altitude of 36 meters the BS antenna, drop call rate to zero at 900 MHz working frequency. By comparing the two work frequencies to the performance of the drop call rate the drop call rate at the 900 MHz working frequency is higher or faster than the 1800 MHz working frequency. This is also understandable because increasing frequency often results in reduced signal strength due to high radio propagation attenuation. Therefore, the drop call rate at a working frequency of 1800 MHz for each BS antenna height from 30 meters to 50, the mobile communication system continues to experience a drop call. The characteristic curve between the increase in BS antenna height and the drop call rate for both 900 MHz and 1800 MHz working frequencies is shown in Figure 5.

![Figure 5](image-url)

**Figure 5.** Characteristics of a decrease drop call to the height of the BS antenna at two frequencies.

![Figure 6](image-url)

**Figure 6.** Characteristics of an increase in the average value of the active set with the height of the BS antenna at two frequencies.
Furthermore, if evaluated from the parameters of the active set as shown in Table 2, the increasing height of the BS antenna increases the average value of the active set. With the increase in the active value of this set, the maintenance of user communication by the two BSs is increasing, so that the possibility of interrupted communication due to not getting service by at least one of the two BS simultaneously is very unlikely. By comparing the two working frequencies against the active set average value, it is found that the increase in the active set average value for the 900 MHz frequency is higher than the 1800 MHz working frequency. Therefore, the guarantee of communication maintenance by the two BSs at 900 MHz working frequency is higher than the 1800 MHZ working frequency. The characteristic curve between the increase in BS antenna height and the average value of the active set for both 900 MHz and 1800 MHz working frequencies is shown in Figure 6.

4.2. Characteristics of performance soft handover with an increase in mobile station antenna height for 900 MHz and 800 MHz frequencies

Simulation output data that shows the relation between the increase in MS antenna height and the characteristics of soft handover performance are shown in Table 3.

| High Antenna MS (meter) | Link Degradation Rate (Prob.) | Drop Call Rate (Prob.) | Active Set Average (unit) |
|-------------------------|-------------------------------|------------------------|--------------------------|
|                         | 900 MHz | 1800 MHz | 900 MHz | 1800 MHz | 900 MHz | 1800 MHz |
| 1.00                    | 0.1854  | 0.4240   | 0.1901  | 0.4944   | 0.7844  | 0.5062   |
| 1.50                    | 0.1768  | 0.4141   | 0.1865  | 0.4901   | 0.7925  | 0.5074   |
| 2.00                    | 0.1740  | 0.4112   | 0.1809  | 0.4879   | 0.7968  | 0.5112   |
| 2.50                    | 0.1714  | 0.4072   | 0.1728  | 0.4849   | 0.8019  | 0.5149   |
| 3.00                    | 0.1692  | 0.4035   | 0.1679  | 0.4806   | 0.8058  | 0.5192   |

Figure 7. Characteristics of a decrease in radio link to the height of the MS antenna at two frequencies.

Data from Table 3 shows that as the height of the MS antenna increases, the rate of decline of the radio link decreases. This shows that increasing the height of the MS antenna results in an increase in signal strength at the receiver, as well as the increase in the height of the BS antenna described previously. By comparing the two work frequencies to the performance of the rate of decline of the radio
link, the rate of decline of the radio link at a frequency of 900 MHz is higher or faster. This can also be understood because with the increase in the frequency of work it results in increasing the amount of signal attenuation. It's just a decrease in radio link with increasing MS antenna height smaller when compared to increasing BS antenna height. The characteristic curve between the increase in height of the MS antenna and the rate of decrease of the radio link for both 900 MHz and 1800 MHz working frequencies is shown in Figure 7.

![Figure 7](image)

**Figure 7.** Characteristics of a decrease drop call to the height of the MS antenna at two frequencies.

If evaluated from the drop call parameters as shown in Table 3, by increasing the height of the MS antenna which results in an increase in the received signal strength resulting in a decrease in the rate of the drop call. By comparing the two work frequencies to the performance of the drop call rate the drop call rate at the 900 MHz working frequency is higher or faster than the 1800 MHz working frequency. This is also understandable because increasing frequency often results in reduced signal strength due to high radio propagation attenuation. The characteristic curve between the increase in MS antenna height and the drop call rate for both 900 MHz and 1800 MHz working frequencies is shown in Figure 8.

![Figure 8](image)

**Figure 8.** Characteristics of a decrease drop call to the height of the MS antenna at two frequencies.

Furthermore, if evaluated from the parameters of the active set as shown in Table 3, the increasing height of the MS antenna increases the average value of the active set. With the increase in the active value of this set, the maintenance of user communication by the two BSs is increasing, so that the possibility of interrupted communication due to not getting service by at least one of the two MS simultaneously is very unlikely. By comparing the two working frequencies against the active set average value, it is found

![Figure 9](image)

**Figure 9.** Characteristics of an increase in the average value of the active set with the height of the MS antenna at two frequencies.
that the increase in the active set average value for the 900 MHz frequency is higher than the 1800 MHz working frequency. Therefore, the guarantee of communication maintenance by the two BSs at 900 MHz working frequency is higher than the 1800 MHz working frequency. Although it can be observed that the contribution of increasing active set value due to increasing MS antenna height is not as high as BS antenna height. The characteristic curve between the increase in MS antenna height and the average value of the active set for both 900 MHz and 1800 MHz working frequencies is shown in Figure 9.

5. Conclusion
This study has successfully demonstrated the relationship between antenna height parameters and work frequency of the Walfish Ikegami empirical model with the performance parameters of mobile communication systems. that there is a strong relationship between the antenna height and frequency parameters with the soft handover performance parameters. By increasing BS height and MS height, the characteristics of both radio link degradation and drop call rates will decrease, but conversely increase the characteristics of active set values. The rate of decline in characteristics of both the degradation of the radio link and the drop call will be greater with a lower working frequency. Conversely with a lower working frequency produces higher active set characteristics.

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