Comparative Path Loss Analysis Of Okumura And COST 231 Models For Wireless Mobile Communication Using MATLAB Simulation

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Abstract

Now a day's mobile communication is very much essential for interchanging information's. Mobile communication use radio signal for voice transmission. When radio signal propagates in free space it suffers with attenuation, fading, distortion. Here transmitting antenna height also plays a great role in path loss. In mobile communication handoff is depend upon received signal strength. For proper planning different service providers use different models such as Okumura and COST 231 models. This paper deals with comparative analysis of these two models.

Keywords- okumura model, COST 231, matlab

1. Introduction

The strength of electromagnetic wave decreases as it propagates through space, this happens due to losses exist in path. The signal path loss affects many parameters of the radio communications. Due to this, it is necessary to recognize the reasons for radio path loss, and to be able to determine the levels of the signal loss for a given radio path [1]. Path loss plays vital role to decide the QoS for wireless communication at network planning level. Path loss causes poor signal strength at the receiver side [1].

Path loss may be due to many effects, such as free-space loss, refraction, diffraction, reflection, aperture-medium coupling loss, and absorption. Path loss is also influenced by terrain contours, environment (urban or rural, vegetation and foliage), propagation medium (dry or moist air), the distance between the transmitter and the receiver, and the height and location of antennas [2].

2. Path Loss: Models of "large-scale effects"

The most appropriate path loss model depends on the location of the receiving antenna. For the example below at:

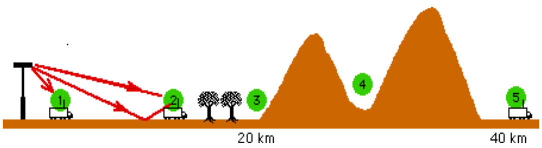

Figure 1. Path loss model depends on the location of the receiving antenna.

location 1, free space loss is likely to give an accurate estimate of path loss.

location 2, a strong line-of-sight is present, but ground reflections can significantly influence path loss. The plane earth loss model appears appropriate.

location 3, plane earth loss needs to be corrected for significant diffraction losses, caused by trees cutting into the direct line of sight.

location 4, a simple diffraction model is likely to give an accurate estimate of path loss.

location 5, loss prediction fairly difficult and unreliable since multiple diffraction is involved [3].

3. Propagation Models:

Propagation models that predict the mean signal strength for an arbitrary transmitter-receiver separation distance are useful in estimating the radio coverage area of a transmitter and are called large-scale propagation model. On the other hand, propagation models that characterize the rapid fluctuations of the received signal strength over very short travel distances or short time durations are called small scale or fading models [4].
The well known propagation models for urban areas are Okumura model and COST 231 model.

3.1 Okumura model:

The Okumura model for urban areas is a Radio propagation model that was built using the data collected in the city of Tokyo, Japan [5]. This model is applicable for frequencies in the range of 150 MHz to 1920 MHz and distances of 1 km to 100 km. It can be used for the base stations antenna heights ranging from 30 m to 1000 m. To determine path loss using Okumara's model, the free space path loss between the points of interest is first determined and then the value of $A_{mu}(f, d)$ is added to it along with correction factors according to the type of terrain. The model can be expressed as [4]:

$$L_{50}(dB) = L_F + A_{mu}(f, d) - G(h_{te}) - G(h_{re}) - G_{AREA}$$

Where,
L_{50} is the 50th percentile path loss in dB.
L_F is the free space propagation loss in dB.
$A_{mu}(f, d)$ is median attenuation in dB.
$G(h_{te})$ is the base station antenna height gain factor.
$G(h_{re})$ is the mobile antenna height gain factor.
G_{AREA} is the gain due to the type of environment. Moving from urban to suburban or open area [4].

$$G(h_{te}) = 20\log(\frac{h_{te}}{200}); \quad 1000m > h_{te} > 30m$$

$$G(h_{re}) = 10\log(\frac{h_{re}}{3}); \quad h_{re} \leq 3m$$

$$G(h_{re}) = 20\log(\frac{h_{re}}{3}); \quad 10m > h_{re} > 3m$$

3.2 COST 231 model:

This model [6] is a combination of empirical and deterministic models for estimating the path loss in an urban area over the frequency range of 800 MHz to 2000 MHz. The model is used primarily in Europe for the GSM 1800 system.

$$L_{50} = L_f + L_{rts} + L_{ms} dB$$

Where:
L_f = free space loss (dB)
L_{rts} = roof top to street diffraction and scatter loss (dB)
L_{ms} = multiscreen loss (dB)

Free space loss is given as:

$$L_f = 32.4 + 20\log d + 20\log f_c dB$$

The roof top to street diffraction and scatter loss is given as:

$$L_{rts} = -16.9 - 10\log W + 10\log f_c + 20\log \Delta h_m + L_0 dB$$

Where:
W= Street width (m)

$$\Delta h_m = h_r - h_m \text{ m}$$

$$L_0 = -10 + 0.354\Phi \qquad 0 \leq \Phi \leq 35^0$$

$$L_0 = 2.5 + 0.075(\Phi - 35) dB \qquad 35^0 \leq \Phi \leq 55^0$$

$$L_0 = 4 - 0.114(\Phi - 55) dB \qquad 55^0 \leq \Phi \leq 90^0$$

Where:
Φ = incident angle relative to the street

The multiscreen (multiscatter) loss is given as:

$$L_{ms} = L_{bsh} + k_a + k_d \log d + k_f \log f_c - 9\log b$$

Where:
b = distance between building along radio path (m)
d = separation between transmitter and receiver (km)

$$L_{bsh} = -18\log(11 + \Delta h_b) \qquad h_b \geq h_r$$

$$L_{bsh} = 0 \qquad h_b < h_r$$

Where: $\Delta h_b = h_b - h_r$, h_r = average buildings height (m)

$$k_a = 54 \qquad h_b > h_r$$

$$k_a = 54 - 0.8h_b \qquad d \geq 500m; h_b \leq h_r$$

$$k_a = 54 - 0.8\Delta h_b(d/500) \qquad d < 500m; h_b \leq h_r$$

Both L_{bsh} and k_a increase path loss with lower base station antenna heights.

$$k_d = 18 \qquad h_b < h_r$$

$$k_d = 18 - \frac{15\Delta h_b}{\Delta h_m} \qquad h_b \geq h_r$$

$k_f = 4 + 0.7(f_c/925 - 1)$ for mid-size city and suburban area with moderate tree density

$k_f = 4 + 1.5(\frac{f_c}{925} - 1)$ for metropolitan area

The range of parameters for which the COST 231 model is valid is:

$$800 \leq f_c \leq 2000MHz$$

$$4 \leq h_b \leq 50m$$

$$1 \leq h_m \leq 3m$$

$$0.02 \leq d \leq 5km$$

The following default values may be used in the model:

$$b = 20 - 50m$$

$$W = b/2$$

$$\Phi = 90^0$$

Roof = 3 m for pitched roof and 0 m for flat roof, and $h_r = 3$ (number of floors) + roof

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In this paper, the performance analysis of Okumura and COST 231 models such as Path loss versus Base station antenna height with different T-R distance, Path loss versus T-R distance with different base station antenna heights, has been compared considering the system to operate at 900 MHz.

4. Simulations and parameters:

Simulations were done in MATLAB 7.5 software.

Sl No	Parameters	Values
1	Base station transmitter power	43 dBM
2	Mobile transmitter power	30 dBM
3	Base station antenna height	30-50 m
4	Mobile antenna height	3 m
5	Frequency/Carrier Frequency fc	900 MHz

4.1 Simulation Results and comparison:

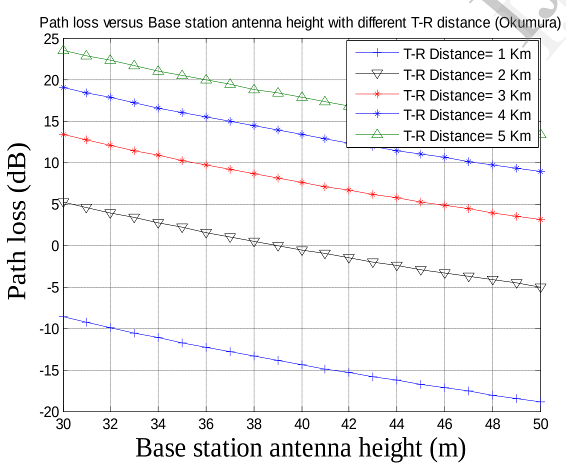

Figure 2. Path loss versus Base station antenna height with different T-R distance (Okumura)

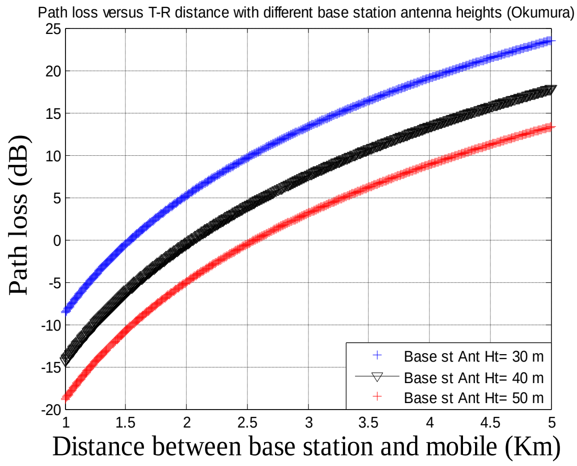

Figure 3. Path loss versus T-R distance with different base station antenna heights (Okumura)

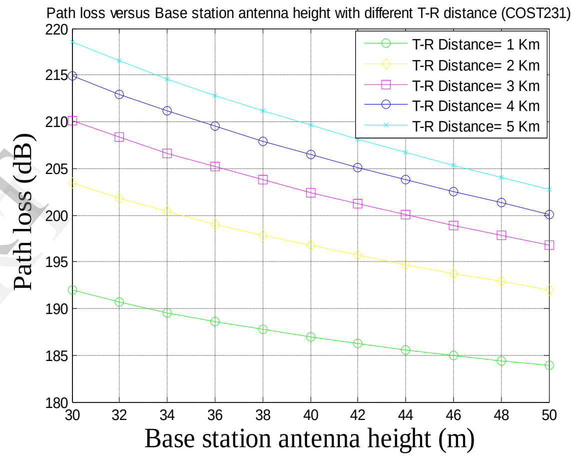

Figure 4. Path loss versus Base station antenna height with different T-R distance (COST231)

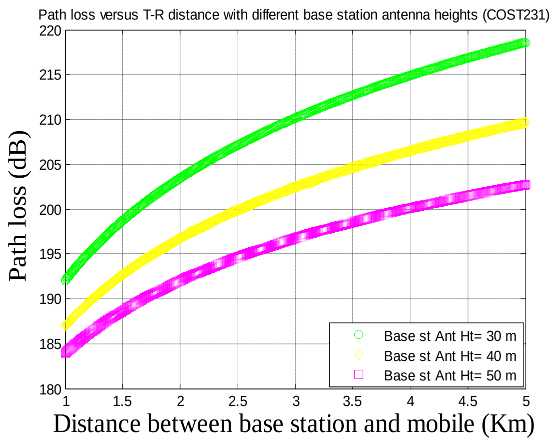

Figure 5. Path loss versus T-R distance with different base station antenna heights (COST231)

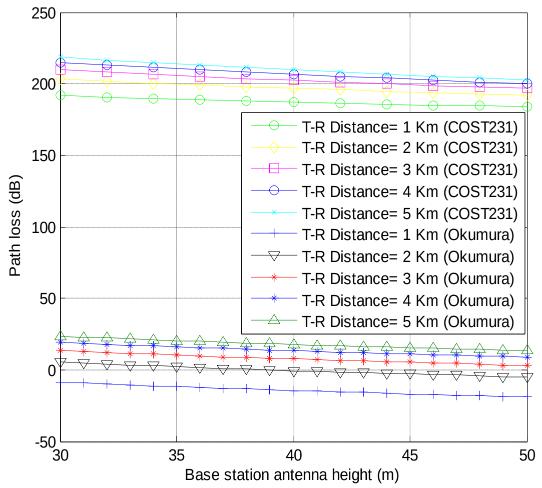

Figure 6. Comparison of Okumura Model and COST231 model (Path loss versus base station antenna heights with different T-R distance)

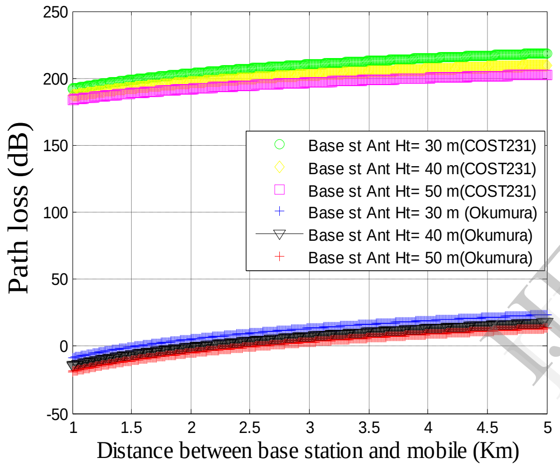

Figure 7. Comparison of Okumura Model and COST231 model (Path loss versus T-R distance with different base station antenna heights)

Figure 2 & 4, shows that the path loss decreases due to the increase in base station antenna height with different T-R distances for Okumura and COST 231 models.

Figure 3 & 5, shows that the path loss increases due to the increase in distance between base station and mobile with different base station antenna heights for Okumura and COST 231 models.

Figure 6 shows the Comparison of Path loss versus base station antenna heights with different T-R distance for Okumura Model and COST231 model. From the graph it is seen that for Okumura model the path loss is lowest.

Figure 7 is the Comparison of Path loss versus T-R distance with different base station antenna heights for Okumura Model and COST231 model. From the graph it is seen that for Okumura model the path loss is lowest.

5. Conclusion:

The simulation results show the amount of path loss by varying the base station antenna height from 30 to 50 m and the varying separation between base station & mobile from 1 to 5 Km. Path loss decrease with the increase in base station antenna height and increases with the increase in T-R distance. From the graph it is seen that Okumura model shows the better performance than COST 231 model. The result of this work gives an idea for telecomm engineer to choose the appropriate model for efficient wireless mobile communication.

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