

# **Analysis of Different Path Loss Model on RSS Based Vertical Handoff Scheme with Comparison of GSM & LTE Advanced Network for K-Tier Heterogeneous Wireless Network**

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**ABSTRACT:** Wireless communication is the transfer of power or information between two or more points that are not connected by an electrical conductor. In the same way wireless network is the method through which we used wireless data connection between nodes. Heterogeneous network shows the use of multiple types of access nodes in wireless network consists of devices using different underlying Radio Access Technology (RAT). Effective spectrum vertical handoff strategies for heterogeneous wireless networks are presented in the thesis. A heterogeneous network consists of multiple tiers of available wireless networks, framed as K-tier heterogeneous wireless network (KHWN). A typical KHWN adopted in the thesis consists of Global System for Mobile communication (GSM), Universal Mobile Telecommunications System (UMTS) and Long Term Evolution (LTE). The handoff scheme considers the Receiving Signal Strength (RSS) and Signal to Interference and Noise Ratio (SINR) with the cost as the key parameters for vertical handoff decision making process. The key parameter RSS is estimated through a proposed path loss model based on local terrain and is observed to be better as compared to the earlier empirical models. Following this a VHO scheme is proposed for voice and data communication. Subsequently this SINR and a KHWN consisting of multi-tier with the four types of services, voice call, video streaming, web browsing and telemetry are considered. In this multi-hierarchy decision making criteria the best suited Analytical and Hierarchical Process (AHP) is applied, for the decision making process in VHO. The proposed scheme of vertical handoff provides higher than the earlier algorithms of Combined SINR based Vertical Handoff (CSVH) and Multi-dimensional SINR based vertical handoff (MSVH). Also the unnecessary VHO are controlled by the proposed scheme. The result shows that the proposed scheme provides low cost trace and overall system throughput with a control of unnecessary handoffs for all kinds of services within the KHWN. It improves the handoff decision accuracy and performance.

**KEYWORDS:** Vertical handoff scheme, k-tier heterogeneous wireless network, receiving signal strength, signal to noise and interference ratio, radio access technology, throughput

## **I. INTRODUCTION**

A new VHO scheme by considering the local terrain as the pre-condition for estimating the path loss, which determines the RSS of the mobile receivers and based on the RSS the VHOS is proposed here. From the extensive review of the recent development in the wireless communication technologies, which spread with the advancement of multiple technologies such as GSM, UMTS, WLAN and LTE to form a heterogeneous wireless network. The heterogeneous wireless network intend to provide the end user an un-interrupted service for voice, data, multimedia, video streaming, telemetry etc. The demand of such services are universally present at all locations. So the heterogeneous wireless network needs to provide ubiquitous coverage at all locations.

Figure 3.1 represents a heterogeneous wireless network consisting of all generations of wireless technology, to provide

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coverage to an Indian environment. This integrated heterogeneous network is multi-tier and with multi-technology in nature. In this study the k-tier heterogeneous wireless network (KHWN) is considered to be the integration of all available wireless networks like GSM, UMTS, WLAN and LTE. The challenge is the interoperability with vertical handoff in KHWN.

The RSS is estimated through various empirical and statistical models. The common terrain with certain model based RF signal loss reacted in the environment, Like Okumara-Hata model, which is widely-used. In KHWN environment, we are certainly using deferent frequency bands with deferent technologies coexist and work together [89]. So there should be certain robust model considering more local terrain and environmental conditions.

Estimating the RSS in KHWN some standard methods like Okumara-Hata and followed Walfisch-Ikegami models were followed [90]. The limitations of such propagation models are; these are not suited for each and every type of environment condition for estimating the path loss [91]. A number of VHOS are studied where the scheme proposes VHOS between either of two networks [92] taking various complex methods. From the literature study in chapter-2, it is well understood that no optimum path loss propagation models are proposed considering the local terrain. Once the local terrain based path loss model will be proposed the same path loss model can be applicable to other local terrains.

In this work the RSS is estimated from the proposed path loss model based on local terrain, considering all types of environments such as lower dense, moderately dense, higher dense, industrial area and market areas as environment conditions with the KHWN. From the proposed path loss model the RSS is estimated through empirical methods.

The proposed VHOS occurs between each tier of the network, after getting the proficiency and accuracy in the RSS measurement through the BCCH channel of the KHWN. The best suited empirical and statistical model is selected with the prior information of Indian terrain considering lower dense, moderately dense, higher dense, industrial area and market areas. The proposed empirical model aligns in accordance to the pre-set data, considering roof height, road width as normal random variables.

## II. RECONNAISSANCE OF RSS USING EMPIRICAL PROPAGATION MODELS

The RSS is the measure of receiving power of a radio link. The measurement of signal strength at a receiving antenna is the method of determining the quality of services. Thus the RSS is a common factor to every kind of wireless communication methods. The RSS is based on certain factors like the transmitting power, receiver sensitivity, antenna gain, connector loss, and antenna height and path loss. Among these factors the path loss is dynamic and complicated to estimate because it directly depends upon the environment of deferent terrain, varies location to location. For this the path low models were proposed earlier [25].

### 2.1 Path loss propagation models

The path loss prediction in micro cell, pico-cell, fem too cell are continued through the propagation models. The various path loss models in the literature comprehensibly presented and discussed. The below mentioned empirical path loss models are analyzed and simulated. The results are compared with the proposed local terrain based path loss models. Below mentioned available path loss models are discussed.

1. Free space path loss model
2. Okumara-Hata model
3. Walfisch Ikegami Model
4. Dual slope model
5. Berg model

#### 2.1.1 Free space propagation model

The field strength of an electromotive wave decreases with a propagation to the distance considering on ideal some of Omni directional transmitter  $T_1 \rightarrow$  Transmitting power  $P_1$  Uniformity in all direction with a radius of  $d_1 \rightarrow$  Of the area the power density will be

$$\gamma = \frac{P_1}{4\pi^2 d_1^2} \frac{w}{m^2} \quad 3.1 \quad \text{In}$$

the ideal case the antennas transmit the main part of the transmitted power in a preferred direction. The relation of antenna gain  $GT$  is with respect to the isotropic radiation. So the effective isotropically radiated power.

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$$\text{EIRP} = P_T G_T = P_1 \quad 3.2$$

An antenna with gain  $G_T$  which transmits the power  $P_1$  on to unidirectional. The power density will be

$$P_d = \frac{4\pi}{P_1 G_T} \quad 3.3 \quad \text{So the}$$

power density flow (Power per unit area) through spherical plain with radius will be

$$P = \frac{P_T G_T}{4\pi d^2} \quad 3.4 \quad \text{The}$$

power received  $R_p$  will be the product of power density, the effective antenna area. The wave length and gain of the receiving antenna.

$$R_p = P_T G_T G_R \left(\frac{\lambda}{4\pi d^2}\right)^2 \quad 3.5 \quad \text{The term}$$

$\left(\frac{\lambda}{4\pi d^2}\right)$  is referred as the free space path loss representing above in logarithmic form, the difference  $T_p - R_p$  is expressed as

$$-10 \log \left(\frac{R_p}{T_p}\right)$$

The free space path loss  $F_L$  results can be derived as

$$F_L = -10 \log(G_T) - 10 \log(G_R) - 20 \log(f) + 20 \log(d) - 20 \log\left(\frac{c}{4\pi}\right) \quad 3.6 \quad \text{Where } C = \lambda f \text{ the expression can be}$$

reduced as

$$F_L = -20 \log\left(\frac{\lambda}{4\pi d_1}\right) \quad 3.7$$

$$F_L = -20 \log\left(\frac{R_p}{T_p}\right) \quad 3.8$$

The model of path loss is estimated is estimated through the logarithmic distance  $P_{di}$  and the  $d_i$  power decaying index from equation 3.7 and equation 3.8.

This model is fixed for one type of scenario and can be expressed as –

$$\text{pathloss} = L_f + 10 P_{d_i} \log_{10} \left(\frac{d}{m}\right)$$

## 2.1.2 Dual slope model

The model intended to find out the path lane behaved differently at c loss distance ranges  $L_1(d) = 10r_1 \log_{10} \left(\frac{4\pi d}{\lambda}\right)$ ,  $a_0$  for  $d < d_{bx}$  3.9

$$L_2(d) = L_1(d_{bx}) + 10r_2 10 \log_{10} \left(\frac{d}{d_{bx}}\right) \text{ for } d \geq d_{br} \quad 3.10$$

$\lambda$  = signal wave length  $d_{bx}$  = break point distance  $r_1$  = power decaying index before

$d_{br}$   $r_2$  = Power decaying index before  $d_{bx}$   $a_0$  = differ bet real loss

Free space loss  $a_0$  varies from 0db to 5db as an effect of wave guiding.

## 2.1.3 Okumara and Hata model

After doing various measurements within deferent environments, the correction to free space model has been model introduced in Okumara Hata model for the frequency band of 400 mhz to 900mhz. The Okumara and Hata model was claimed to be best suited for urban and sub-urban environments, the path loss model is represented in equation 3.12

$$\text{pathloss} \quad L = 69.55 + 26.16 \log_{10} \left(\frac{f}{MHz}\right) - 13.82 \log_{10} \left(\frac{b_m}{m}\right) - acf \\ + \left(49.9 - 6.55 \log_{10} \left(\frac{h_b}{m}\right)\right) \log_{10} \left(\frac{d}{km}\right) \quad 3.11$$

$f$  carrier frequency  $H_b$  = base station antenna height  $A$  (cf) = correlation function

$d$  = distance between transmitter and receiver

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### 2.1.4 Walfisch Ikegami model

Considering the microwave propagation above the roof top, the WalfoshIkegami (or cost 231) model was proposed. This model is based on theoretical analysis of WalfischBritoni model developed by Walfish and Britoni in 1988 to get the multiple diffraction loss for the BS antennas of more height. The model takes into account free space loss and loss due to diffraction down to the street and buildings etc so the path loss loss was expressed as

$$L = L_F - 16.9 + 10 \log_{10} \left( \frac{w}{m} \right) + 10 \log_{10} \left( \frac{f}{MHz} \right) + 20 \log_{10} \left( \frac{\Delta hm}{m} \right) + L(\phi) + Lms$$

W = width of the street Lt = free space loss f = Carrier frequency Δhm = height of mobile antenna Lms = diffraction loss applicable.

$$L(\phi) = \begin{cases} -9.646 & \text{for } 0^\circ \leq \phi < 35^\circ \\ 2.5 + 0.075(\phi - 35) & \text{for } 35^\circ \leq \phi < 55^\circ \\ 4 - 0.114(\phi - 55) & \text{for } 55^\circ \leq \phi \leq 90^\circ \end{cases} \quad 3.13$$

### 2.1.5 Berg model

This model is introduced in 1995 by Berg, which was focused on the outdoor path loss, in an environment where the street surrounds with the high rising buildings and the BS antenna heights taller than the buildings. If the signal originated from the BS is  $S_{bs}$ , the RSS behaves as if the signal originates from a virtual transmitter located in the proximity to the street crossing. So the Berg model introduced a continuous path loss as a form of the angle (-) of the road turning. So the path loss is represented as

$$L = 20 \log_{10}(4\pi * d_f / \lambda)$$

$d_f$  = 'illusory' distance, defined by the recursive expression considering 3 segments of the  $d_0 = 0$  dm = KM

## III. ANALYSIS OF RSS ON PROPOSED PATH LOSS MODEL

As described above from the proposed path loss models the RSS can be estimated through the empirical methods. The empirical method is applicable to all tiers of networks in KHWN.

### 3.1 GSM and UMTS

The RSS for GSM micro cell in the KHWN is expressed in dBm as

$$RSS_{GSM/UMTS} = P_{TX} + \sum G_T - \sum A - P_L \quad 3.19$$

Here RSS of GSM/UMTS is expressed and the transmitted power of the transceiver is expressed in dBm.  $G_T$  is the antenna gain in dB, A is the loss of RF connectors at the transceiver end.

### Wireless Local Area Network

The received signal strength ( $RSS_{WLAN}$ ) in dBm, according to the path loss can be estimated.

$$RSS_{WLAN} = P_{TR} - PL_{WLAN} \quad 3.20$$

The  $P_{TR}$  is the actual transmitted power by the transceiver station, in dBm. The VHO takes place when the RSS obtains above certain threshold interference sensitivity level.

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Modeling of free space propagation model

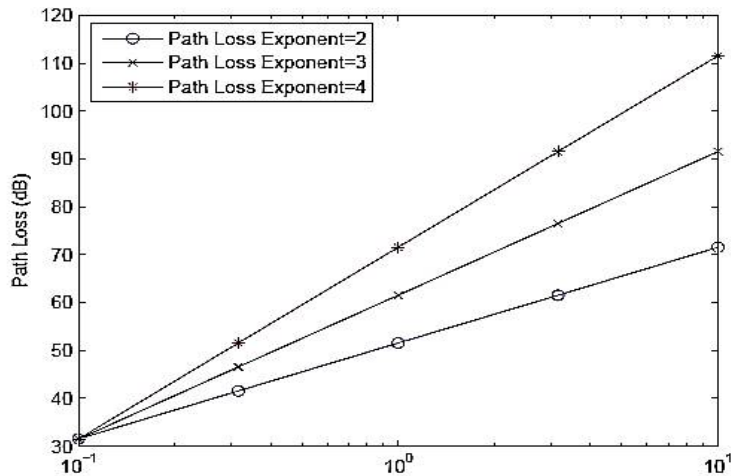


Figure 3.1: Free Space Path loss model: Represents the free space path loss model, the plot seems is straight as there is no loss in a free space model

### 3.2 LTE advanced network

The RSS for advanced LTE is evaluated in dBm as

$$RSS_{LTE} = P_{TX} + G_T + G_{RX} - PL_{LTE} - A \tag{3.21}$$

where  $G_{RX}$  is the gain of the receiver in dB.

### Performance Based analysis of RSS in K-Tier heterogeneous wireless network

The performance of RSS is analyzed based on existing empirical pathloss models with the proposed local terrain based path loss model. With the local terrain data the path loss for different networks are having better values. **Simulation result and performance analysis**

The free space path loss model simulation is represented as in Figure 3.1

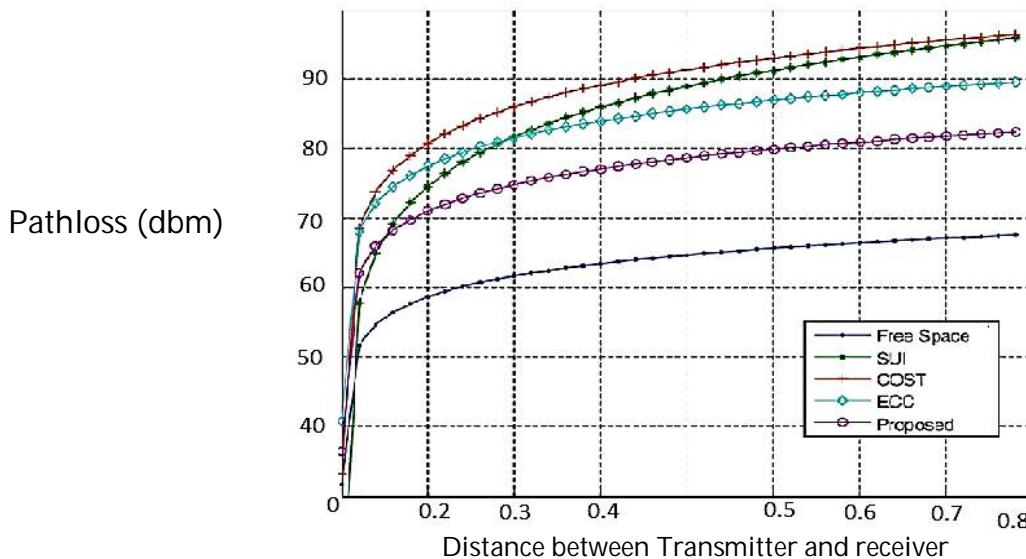


Figure 3.2: Okumara and Hata model: The path loss is simulated using Okumara and Hata model considering the estimated data inputs

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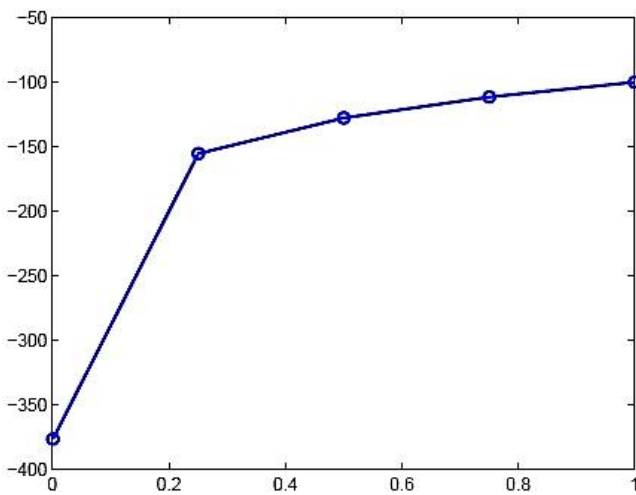
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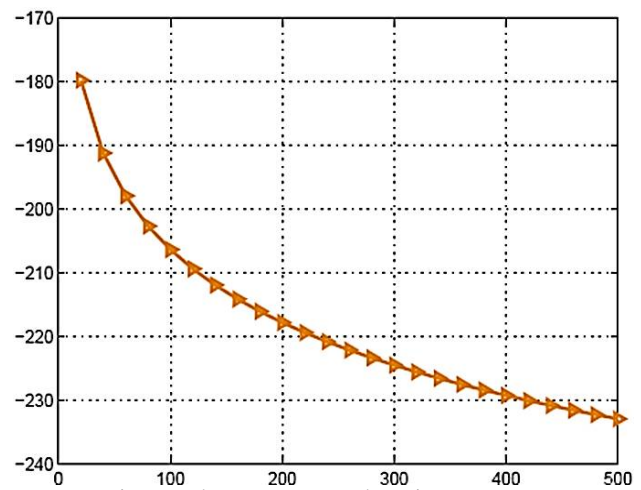
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The two ray model path loss model is represented in Figure 3.3 Walfish11I kegmi pathloss model is demonstrated in the Figure3.4. Considering the Berg Model the path loss simulation is demonstrated in the Figure 3.5. The comparison of the existing pathloss models are represented in the Figure3.6. From the comparison result the W.I model has the better performance which is best suited for urban environment. From the Figures of proposed model it is found that the proposed model has the better performance than the existing empirical models. The proposed scheme is evaluated with the parameters for simulations are presented, considering the urban and sub urban terrain of India.

The performance of pathloss and RSS of KHWN is calculated from the simulation result. The RSS threshold for different Network since estimated inTable-1Table 3.2 shows the environmental and path loss parameters of KHWN based on the Indian terrain data, collected from Municipality Corporation, Rourkel.



Distance between Transmitter and receiver  
Figure 3.3: Path loss using Two Ray model



Distance between Tx and Rx in meters  
Figure 3.4: W.I path loss model

Table 3.1: The KHWN parameter details are represented

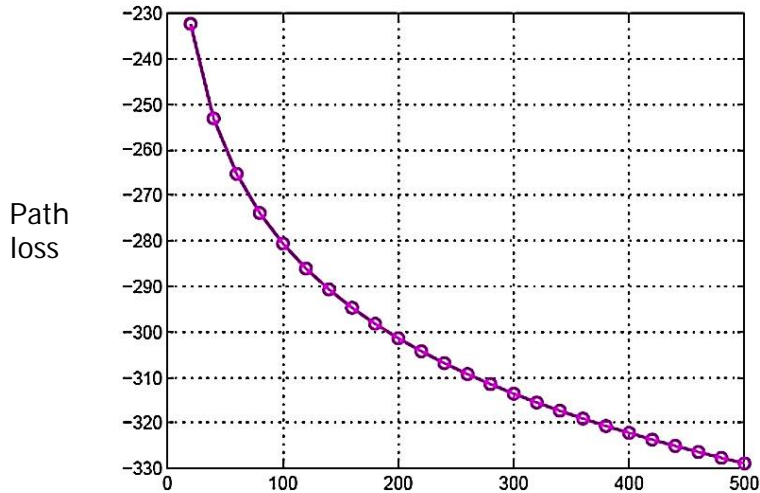
NetworkT ype	Transceiver o/p Power	Frequency Band	Gain of the TX Antenna	Gain of UE's Antenna	Duplexer RF connector loss	RSS Threshold
GSM	-45dBm	900 MHz	15dB	1 dB	2 dB	-115dBm
UMTS	-43dBm	1900 MHz	17dB	2 dB	1.5 dB	-100dBm
WLAN	-47dBm	2500 MHz	18dB	4 dB	0.55 dB	-90dBm
LTE	-23dBm	2400 MHz	14dB	3 dB	0.45 dB	-80dBm

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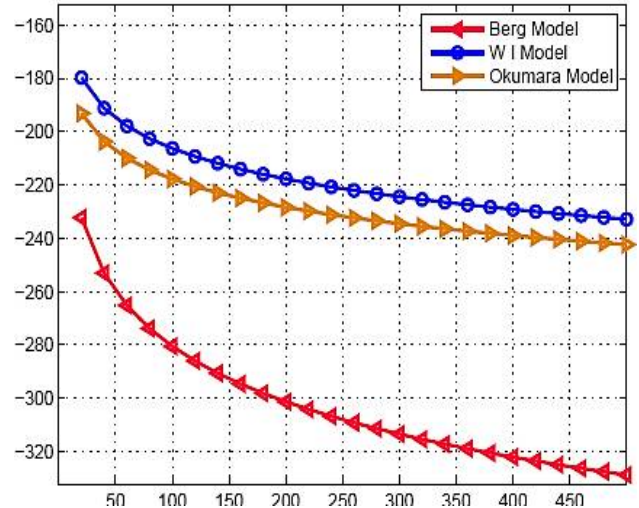
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Distance between Tx and Rx in meters

Figure 3.5: Path loss using Berg Model



Distance between Tx and Rx in meters

Figure 3.6: Comparison of existing path loss models

Parameters	Values
Average Height of the Transceivers GSM,UMTS,WLAN, LTE Networks	45,40, 25, 30Mtrs Spectively
Average height of the Receiver UE	2.5Mtrs
Mean Height of the Buildings	12Mtrs
Mean width of the Road	6Mtrs
Mean Separation of Buildings	8Mtrs
Duplexer and connector loss	2dB
Path loss exponent for highly dense populated area	1.92
WLAN reference distance (30mtrs) mean path loss	49.76dB

Table 3.2: Indian terrain highly dense populated environmental data are represent

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