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Performance Analysis of Propagation Models for WiMAX Network

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Abstract:

At present, became the joint action in worldwide about access Microwave (WiMAX) technology, also became more popular and receive growing acceptance as a wireless broadband access system (BWA). WiMAX can success at line-of-sight (LOS) and non-line-of-sight (NLOS) cases that working below 11GHz frequency. However, path loss calculation or estimation is so important criteria to improve the WiMAX network performance. There are many of pr6+opagation models (e.g., COST 231 HATA Model, Hata Mode which can estimate of path loss. This paper we will analysis and compare between three of propagation models (COST 231 HATA, ECC-33, HATA) in various receiver antenna heights (3m, 6m, 10m) in urban areas. Results show that the ECC-33 model is the best compare with HATA model and COST 231 HATA model.

Keywords: WiMAX, Propagation, Path loss, COST 231 HATA, ECC-33, HATA.

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Introduction

IEEE 802.16 working gathering exhibited another broadband remote access innovation it is "WiMAX" this intend to all World will utilize Microwave Access Propagation models are utilized widely as a part of system arranging, especially to conduct achievability concentrates on and amid beginning sending. They are additionally extremely helpful for performing impedance concentrates on as the sending continue [1]. Based on IEEE 802.16 standard support multiple licenses and un license frequencies such as 2.3GH, 2.5GH, 3.7GH and 5.8GH [2]. Using different frequency lower or higher frequencies have a different effect on the system performance, however changing the frequencies will also increase or reduce the path loss based on which propagation model is selected. There are many researchers that have been study the performance of WiMAX network based on different propagation model such as [2] compared between five of propagation models, however they considered ally 3.5 GHz frequency also without HATA model. In [10] compared between six of propagation models, however they considered 2.5GHz, 3.5 GHz frequencies also without HATA model. And [11] compared between six of propagation models, but they considered ally 2.5GHz frequency. However, none of the related work has analysis the performance of WiMAX network based on different propagation model with different operating frequency and different antenna height.

This paper will analysis and compare between three path loss models (HATA model, Cost-231Hata and ECC-33 model) in WiMAX network in urban area, with different frequencies (2.5 GHz, 3.5 GHz and 5.8 GHz) and different antenna height for receiver (3 m, 6 m and 10 m).

Section 2 will discuss the WiMAX and IEEE 802.16 specification and features, while section 3 will briefly explain the propagation and path loss models. Section will explain the simulation scenario section 4, and result will be presented in section 5. Section 6 will analyze and compare between the results and the paper will be concluded in section 7.

WiMAX Standards

Worldwide Interoperability for Microwave Access (WiMAX) is a remote correspondence standard meant to grant 40 Mb/s of data rates, during the 2011 became up to 1 Gbit/s for fixed stations. The "WiMAX " presented by the WiMAX Forum, it was set up in June 2001 to help similarity with interoperability of the standard. The discussion depicts WiMAX gauges-based innovation which can conveyance of last mile remote broadband access as another to link and DSL [3].

WiMAX is a great detection in wireless technology since it gives 40 miles broadband access to versatile clients. WiMAX in view of Institute of Electrical and Electronics Engineers (IEEE 802.16) standard and a media transmission convention permitting full access to portable web crosswise over nations which have an extensive variety of gadgets. Likewise have sorts of these IEEE 802.16, for example, (IEEE 802.16a, IEEE 802.16-2004, IEEE 802.16e-2005, IEEE 802.16J, IEEE 802.16m). These working by various frequencies, for example, from 2.5GHz to 5.8GHz recurrence groups, which commonly are authorized by different government powers. WiMAX, depends on a radio frequency (RF) innovation known Orthogonal Frequency Division Multiplexing (OFDM), which is an exceptionally successful to exchanging information when bearers of width of 5MHz or more prominent. Beneath 5MHz transporter width [1].

In January 2003, new standard was presented by the work team and it was called, IEEE 802.16a.The IEEE 802.16a standard permits to clients to get broadband availability without need to direct line of sight (LOS) with the BS. The IEEE 802.16a takes three determinations with air mediator, these choices furnish to dealers with the chance to alter their item for various types of arrangements [4].

IEEE 802.16-2004, also it's called with IEEE 802.16d (Fixed WiMAX), based on the IEEE 802.16-2004 Air Interface Standard, and has confirmed to be alternate to cable and DSL services. Also cost-effective fixed wireless. IEEE 802.16d MAC supplies 2 ways of process first way is (Point-to-multipoint (PMP)), second way is (multipoint-to-multipoint) [5].

The IEEE 802.16j adjustment to IEEE 802.162009 gives multi-hop relay like extra network structure that allows to increase radio outreach also can used to promote the system to arrive to network. The feature of IEEE802.16j is relay of propagation strategy with give a more cost-effective, less complexity, and simple to setup infrastructure alternate for wireless network radio outreach protraction in a type of cases. The relays give capacity enhancement by the base stations in areas which are not enough covered in a lot of use models, but relays are deployed to satisfy a group of the objectives that above, and reduction of total product energy of the cellular network. For the Aero MACS application, this means lower interference into co-allocated applications [6].

IEEE 802.16m IEEE 802.16m has carry out various features for reaching more objectives for example increment of the data rate, which is also expound in the IMT system requirements. For FDD support stating in WiMAX. IEEE 802.16m target today's frequency bands that are utilized in 802.16e as well as new bands that are specific in IMT systems. IEEE 802.16m combine a multi carrier operation so that an 802.16m mobile station and an 802.16m (BS) are able to utilize more than one carrier to send information. Multi carrier operation namely multi carrier aggregation or multi band. The multi band operation supports in contiguous or non-contiguous scenarios up to 100 MHz [7].

Propagation and Path Loss Models

In general propagation models can be categorized to indoor and outdoor models. Indoor radio spread is not influenced by the territory profile, as outside engendering, yet it can be influenced by the configuration in a building, particularly if there are distinctive building materials. The transmitted signal always to receiver by many ways not from one way. This because refraction, reflection of the radio wave by articles, for example, entryways, windows, and dividers inside a building [8]. On other hand, in outdoor area, there are a number of statistical models appropriate for both (macrocell and microcell) scenarios for the outdoor areas. Propagation is considered in an outdoor area, is firstly in three types of areas urban, suburban and rural areas. Terrain may different from place to other place such as bowed earth or High Mountain. Also, must be trees, buildings, and other obstacles. Also, must consider to reversal from the ground, direct path, diffraction from roofs and the corners of masonry. Also, this paper will study these types of the propagation models [2].

There are many of Experimental proliferation models like Okumura-Hata model, SUI mode and COST231 model that can be used in outdoor, Prediction of propagation is will be a leading element in design any communication systems. Safe propagation model can measure the path loss with little of deviation. Appropriate models will assist engineers to plan, measure and improve the cell scope span and to utilize the right transmitted powers. Empirical models make estimation information and calculate it, these models will reduce from path loss and utilization the thing that are known as predictors [2].

COST231Hata Model

This model is created by Hata model and focus on four parameters even can measure the prediction of path loss: high of a received antenna, high of BS, frequency and the received antenna [9]. We can measure path loss model by Eq. (1).

$$PL = 46.3 + 33.9\log_{10}(f) - 13.82\log_{10}(h_b) - ah_m + (44.9 - 6.55\log_{10} d + c_m \quad \rightarrow \text{Eq. (1)}$$

Were

f: Frequency --- [MHz]

d: Distance between transmitter and receiver antenna --------- [Km]

(h_b): Transmitter antenna height -------------------------------------- [m]

c_m: 0 dB for medium cities and suburban areas and C=3 dB for urban areas.

ah_m: is defined in urban area as

$$ah_m = 3.20(\log_{10}(11.75\, h_r))^2 - 4.79 \qquad \text{for } f > 400MHz \quad \rightarrow \text{Eq. (2)}$$

Hata-Okumura extended model or ECC-33 Model

May be Hata-Okumura model the good usage between empirical propagation models, which lean on Okumura Models. Okumura settled model for the Ultra High Frequency (UHF), as of late. The International Telecommunication Union (ITU) urged this model to more development dependent upon 3. 5 GHz. first Okumura model does not provide whatever information over 3 GHz. In light of former information from Okumura model, a strategy may be connected with model for higher frequency over 3 GHz. The tentatively recommended propagation model of Hata-Okumura model with report is called to as ECC-33 model [2]. Can measure path loss model by Eq. (3).

$$PL = A_{fs} + A_{bm} - G_b - G_r \qquad \rightarrow \text{Eq. (3)}$$

Where:

A_{fs}: Free space attenuation ---------------------------- [dB]

A_{bm}: Basic median path loss --------------------------- [dB]

G_b: Transmitter antenna height gain factor

G_r: Receiver antenna height gain factor

They are individually defined as

They are individually defined as below:

$$A_{fs} = 92.4 + 20\log_{10}(\mathrm{d}) + 20\log_{10}(\mathrm{f}) \qquad \rightarrow \text{Eq. (4)}$$

$$A_{bm} = 20.41 + 9.83\log_{10}(d) + 7.89\log_{10}(f) + 9.56[\log_{10}(f)]^2 \qquad \rightarrow \text{(Eq. (5)}$$

$$G_b = \log_{10}(\frac{h_b}{200})\,[13.958 + 5.8[\log_{10}(d)]^2] \qquad \rightarrow \text{Eq. (6)}$$

For large city:

$$G_r = 0.759h_r - 1.892 \qquad \rightarrow \text{Eq. (7)}$$

Where:

(d): The distance between transmitter and receiver antenna ------- [Km]

(f): Frequency --- [GHz]

h_b: Transmitter antenna height ------------------------------------ [m]

h_r: Receiver antenna height ------------------------------------ [m]

HATA Model

Model is basically the empirical to loss data created by Okumura, and it has frequency range from 150 MHz to 1500MHz. It the middle path loss for the distance d from sender to receiver antenna more than 20 Km and the sender antenna height from 30 m to 200 m and receiver antenna height from 1m to 10m. It provides in the urban area path loss, also it provided correction equations for suburban areas [9]. It can be measured path loss model by Eq. (8).

$$PL(dB) = 69.25 + 26.16\log_{10}(f_c) - 13.82\log_{10}(h_t) - a(h_r) + (44.99 - 6.55\log_{10}(h_t))(\log_{10}(I)) \rightarrow \text{Eq. (8)}$$

Where:

f_c: Frequency --- [MHz]

h_t: Height of base station antenna ---------------------- [m]

h_r: Height of mobile station antenna ------------------ [m]

I: $T_x - R_x$ sepration ------------------------------------ [Km]

$a(h_r)$ Antenna height correction factor for the receiver.
For a small to medium size city:

$$a(h_r) = 1.1(\log_{10}(f_c) - 0.7)h_r - (1.56\log_{10}(f_c) - 0.8) \quad \rightarrow \text{Eq. (9)}$$

For large city:

$$a(h_r) = \begin{cases} 8.29(\log_{10} 1.25h_r)^2 - 1.1dB & f_c \leq 300MHz \\ 3.2(\log_{10} 11.75h_r)^2 - 4.97dB & f_c \geq 300MHz \end{cases} \quad \rightarrow \text{Eq. (10)}$$

For a small to medium size city:

$$a(hr) = 1.1\ (log_{10}fc - 0.7)hr - (1.56log_{10}fc - 0.8) \quad \rightarrow \text{Eq. (11)}$$

4 Simulation Design
This section will explain the simulation scenario and simulation parameters and also the steps that has been followed to implement the simulation.

Simulation Scenario
In this scenario about one base station (BS) with one user as Figure 1.

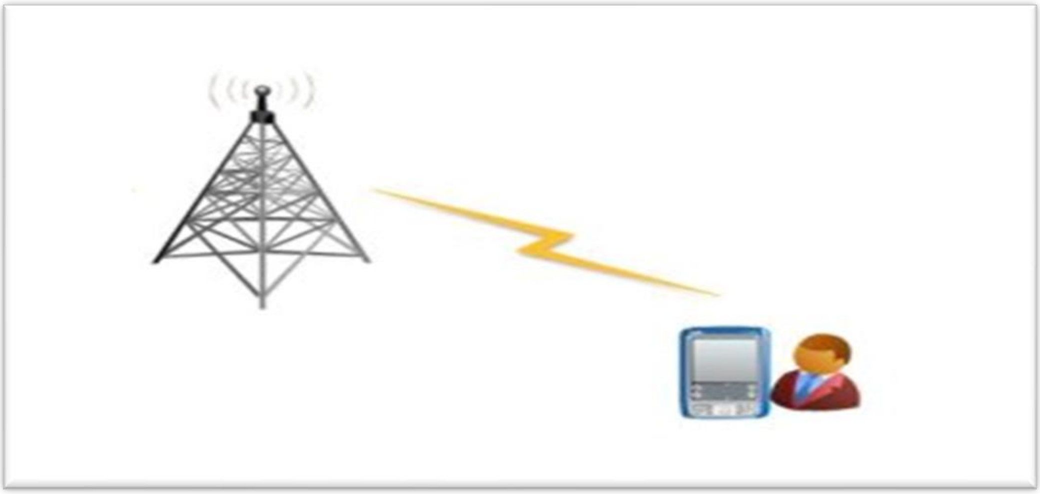

Figure 1: scenario one (BS) and one (user)

Table 1: Simulation parameter

Parameters	Values
Transmitter antenna height	40 m in urban areas
Receiver antenna height	3m, 6m and 10m
Operating frequency	2.5GHz,3.5GHz,5.8GHz
Distance between Tx-Rx	5Km
Building to building distance	50m
Average building height	15m
Street width	25m
Street orientation angle	30° in urban
Correction for shadowing	10.6 dB in urban areas

Simulation process
For analyzing the performance of propagation models for WiMAX, we will use MATLAB software. For evaluating and analyzing the performance of WiMAX propagation models and will use MATLAB simulation. In first step, start with simulation, second step, will input parameters, third step, output parameters then end simulation model is shown in Figure1.

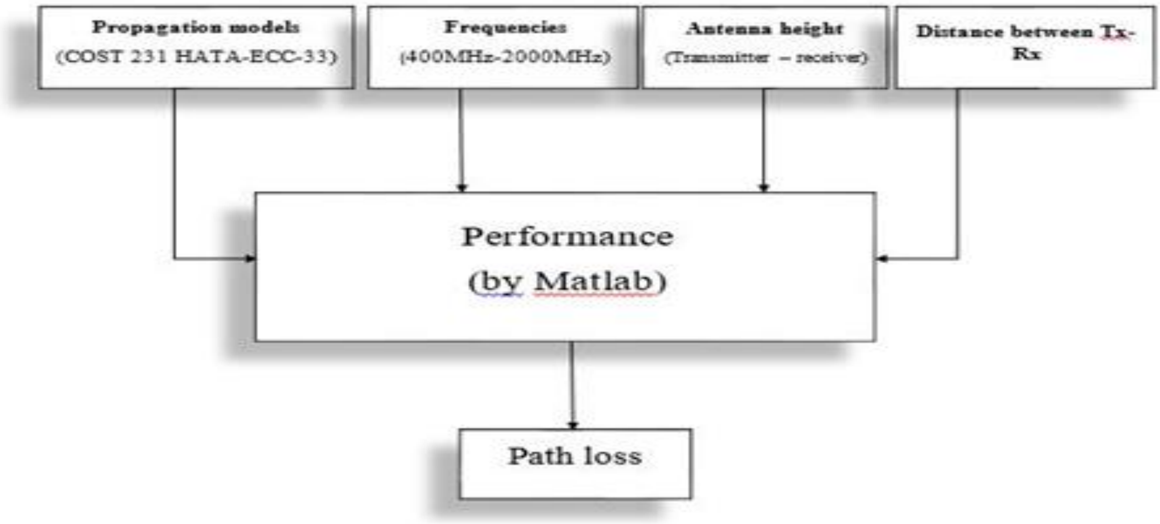

Figure 2: Simulation process for urban environments.

Simulation Results

In this section the simulation results will be presented for different propagation models and different frequencies and antennas heights.

COST 231 HATA MODEL

Firstly the cost 231 HATA model gives different values of path losses with different frequencies and heights for Antenna receiver for example the path loss was at 2.5 GHz as following (163.5290 dB with 3 m, 160.2582 dB with 6 m, 157.4766 with 10 m), but at 3.5 GHz was (168.4827 dB with 3 m, 165.2120 dB with 6 m, 162.4304 with 10 m) and at 5.8 GHz (175.9190 dB with 3 m, 172.6483 dB with 6 m, 169.8667 dB with 10 m).Also we noted whenever the antenna height of receiver highest, was better, and whenever was the frequency the less became the path loss less.

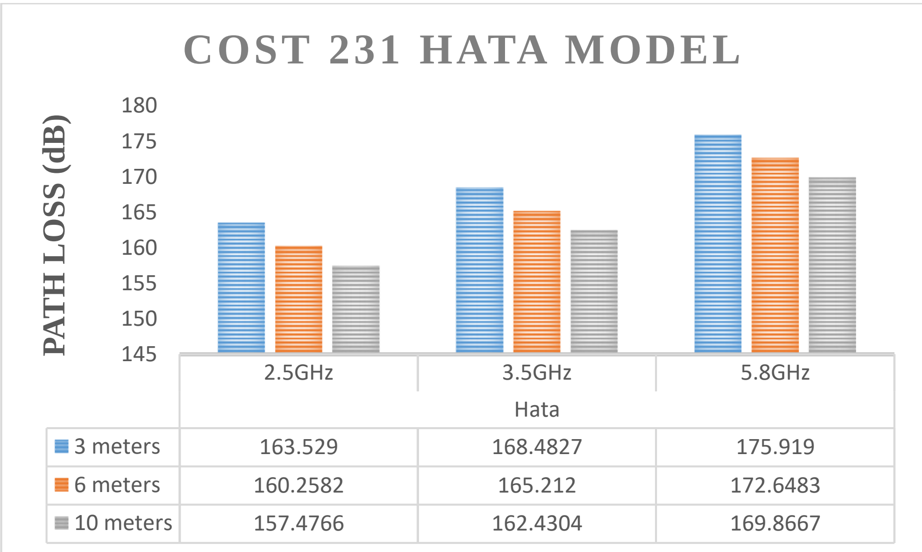

Figure 3: path loss at COST 231 Hata Model

Table 2: path loss at COST 231 Hata Model

Receiver Antenna Height	Different Frequencies for WiMAX (Cost 231HATA Model)		
	2.5GHz	3.5GHz	5.8GHz
3 meters	163.5290	168.4827	175.9190
6 meters	160.2582	165.2120	172.6483
10 meters	157.4766	162.4304	169.8667

ECC-33 MODEL

Secondly whenever we see from the table and figure (1111) the ECC-33 model gives a different path loss from different frequencies and different heights for receiving antenna. The path loss was at 2.5GHz (152.6751 dB with 3 m, 148.3488 dB with 6 m and145.3128 dB with 10 m) we can note whenever increased height for receiving antenna whenever decreased value of path loss. also at 3.5GHz the path loss was As follows (156.0179 dB with 3 m, 153.7409 dB with 6 m and 150.7049 dB with 10 m) same Previous results with meaning the relationship between the receiver antenna height and path loss is an inverse relationship. But the frequency 2.5GHz is the best from others frequencies (3.5GHz, 5.8GHz) because gives less path loss.

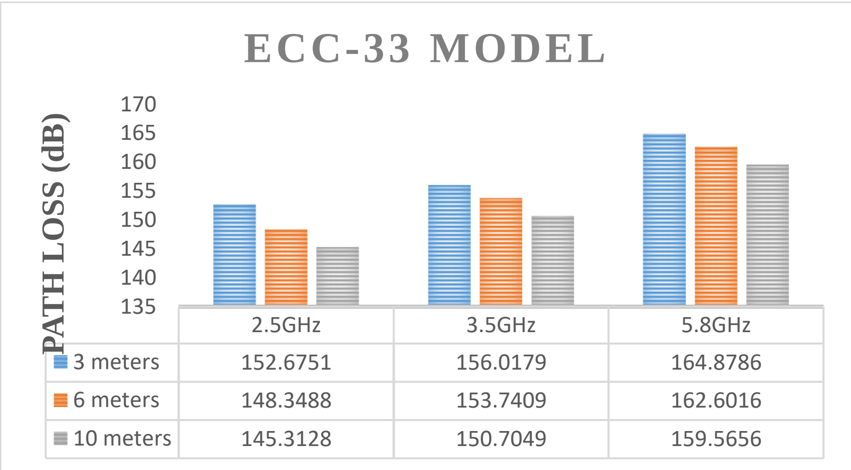

Figure 4: path loss at ECC-33 model

Table 3: path loss at ECC-33 model

Receiver Antenna Height	Different Frequencies for WiMAX (ECC-33 Model)		
	2.5GHz	3.5GHz	5.8GHz
3 meters	*152*.6751	156.0179	164.8786
6 meters	148.3488	153.7409	162.6016
10 meters	145.3128	150.7049	159.5656

HATA MODEL

As seen from the table and figure below we can say as previous time whenever was the frequency less the path loss is less, in the sense it is better, also whenever increased heights antenna for receiver whenever became the path loss less in the sense it is better. in HATA model was our results as following at 2.5 GHz (157.4218 dB with 3 m, 154.1511 dB with 6 m, 151.3695 dB with 10 m) but at 3.5 GHz (161.2445 dB with 3 m, 157.9732 dB with 6 m, 155.1922 dB with 10 m) and at 5.8 GHz (166.9830 dB with 3 m, 163.7123 dB with 6 m, 160.9306 dB with 10 m).

From the above results in different models we noticed that the frequency at 2.5 GHz is the best and also antenna height for receiver at 10 meter is the best because in this frequency and this height the path loss in less condition.

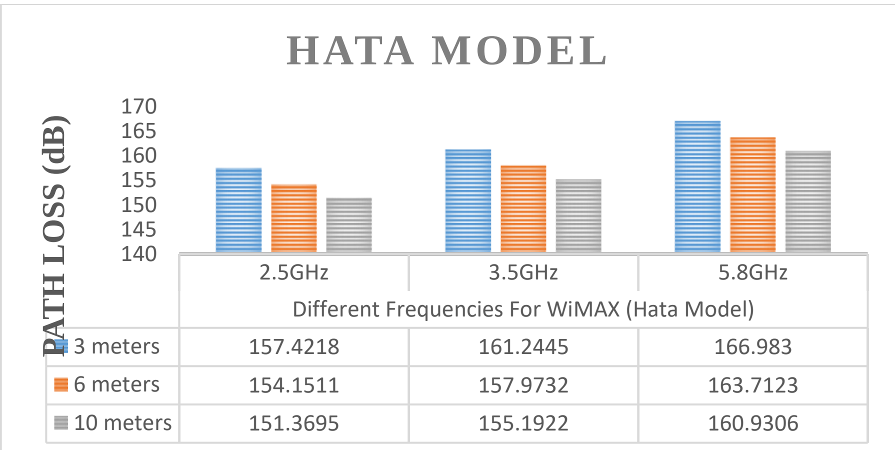

Figure 5: path loss at HATA model

Table 4: path loss at HATA model

Receiver Antenna Height	Different Frequencies for WiMAX (HATA Model)		
	2.5GHz	3.5GHz	5.8GHz
3 meters	157.4218	161.2445	166.9830
6 meters	154.1511	157.9732	163.7123
10 meters	151.3695	155.1922	160.9306

Results Analysis and Comparison

our results as follows, firstly the COST 231 Hata model displays the highest or biggest path loss at all cases of receiver antenna heights (3m, 6m, 10m), and at all cases of frequencies (2.5GHz, 3.5GHz, 5.8GHz). Secondly the ECC-33 model displays the lowest path loss in all the cases (frequencies and receiver antenna heights), in addition to Hata model displays higher than ECC-33 model and lower than Cost 231 Hata model in path loss, so is ECC-33 model is better than other models in terms of path loss.

Also, we noted that the relationship between the frequencies and the path loss is a direct relationship, that means whenever increased the frequency increased the path loss. Soas we can see from the results that the frequency (2.5GHz) specifically is less path loss from other frequencies(3.5GHz,5.8GHz) in the various receiver antenna heights (3m, 6m, 10m) and various of models, so it is considered the best from other frequencies. Also, we noticed that whenever the receiver antenna height increased, decreased of path loss this mean that the relationship between the receiver antenna height and path loss is an inverse relationship.

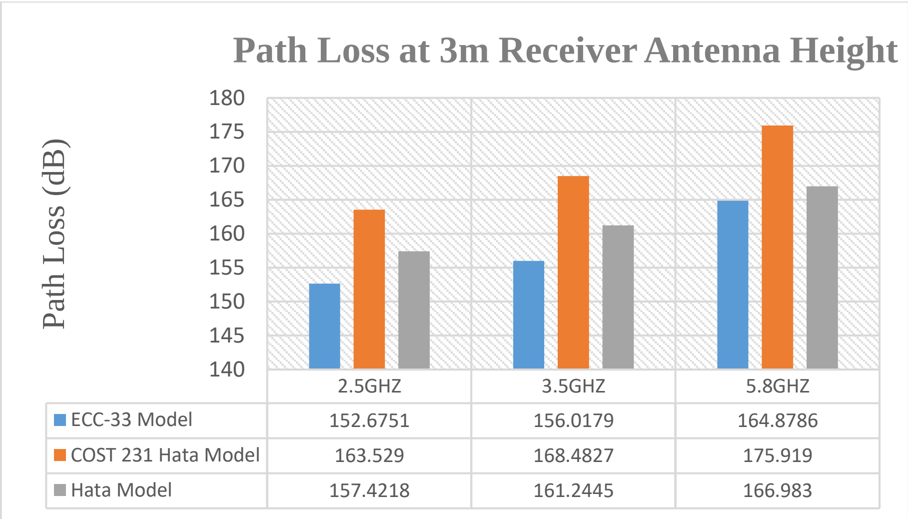

Figure 6: Comparative results for urban environment at 3m receiver antenna height

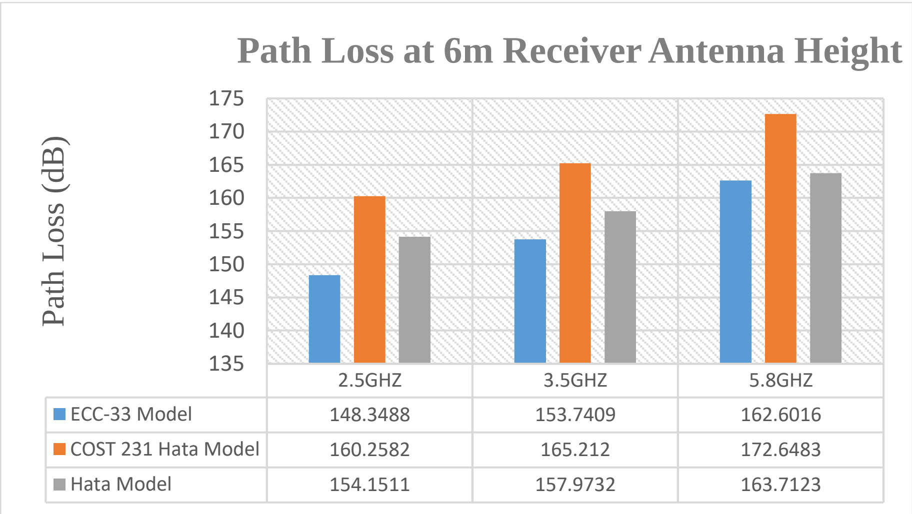

Figure 7: Comparative results for urban environment at 6m receiver antenna height

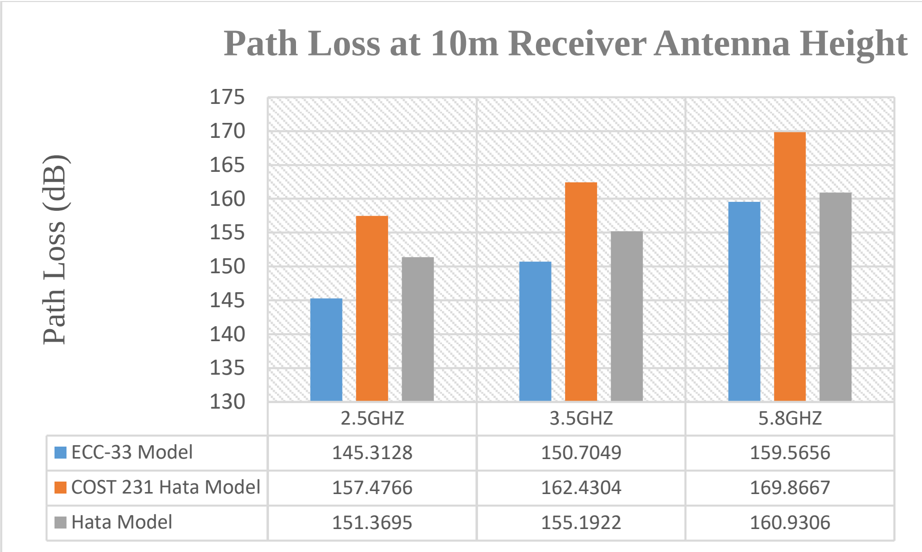

Figure 8: Comparative results for urban environment at 10 m receiver antenna height

Conclusion

From data shown (Figure 6, 7, 8) was results in urban environment the ECC-33 model gave the lowest path loss (152.6751dB, 156.0179 dB, 164.8786 dB with 2.5GHz, 3.5GHz and 5.8GHz in 3 m receiver antenna height). This meaning that path loss was in the rate of (0.066, 0.073 and 0.062) Respectively, (148.3488 dB, 153.7409 dB, 162.6016 dB with 2.5GHz, 3.5GHz and 5.8GHz in 6 m receiver antenna height). This meaning that path loss was in the rate of (0.074, 0.069 and 0.058) Respectively, (145.3128 dB, 150.7049 dB, 159.5656 dB with 2.5GHz, 3.5GHz and 5.8GHz in 10 m receiver antenna height) At a rate of (0.077, 0.072, 0.060) compared with other models. but the COST 231 HATA model gave highest path loss in different frequencies (2,5 GHz, 3.5 GHz, 5.8 GHz) and different receiver antenna heights (3 m, 6 m, 10 m), addition to HATA model gave value higher than ECC-33 model and lower than COST 231 HATA model.
In this study and compare between these models, noted that ECC-33 is the best at urban environment at all of frequencies and receiver antenna heights.

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